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5 Editorial

Optical media and optical interconnection are rapidly becoming familiar aspects of the mastering and copying industry. Tim Goodyer issues a word of warning

6 Installations

Facility news from the recent refit at London's Chop 'em Out and the expansion of the Belgian-based Digipro group

8 Future Formats

The war being waged over the acceptance of new consumer formats continues—industry opinion on the likely winners

11 In Search of the Master

Bill Foster navigates the confusing world of 'masters' and explains the APRS-SPARS labelling system

14 MCA Music Media

Presently taking receipt of an extensive ODME replication system, LA's MCA Music Media is one of California's premier facilities. James Douglas tells the inside story



21 Who's Master?

Mastering formats are on the move from the familiar Sony PCM-1630. Bill Foster discusses the options vying for the future standard



22 REPLtech Preview

A comprehensive rundown of the exhibitors and their exhibits at the forthcoming Santa Clara REPLtech Show

30 Reflected Glory

ODC's Ralph Oshiro explains high-density optical storage technology and examines its application to video CD formats



35 Sound Restoration

Patrick Stapley visits the restoration facility at London's Abbey Road Studios and talks to the operators of their CEDAR and Sonic Solutions systems

42 Going Outboard

What makes a premastering room special is its particular selection of outboard gear. Bill Foster talks format converters, interfaces and the other tools of the trade

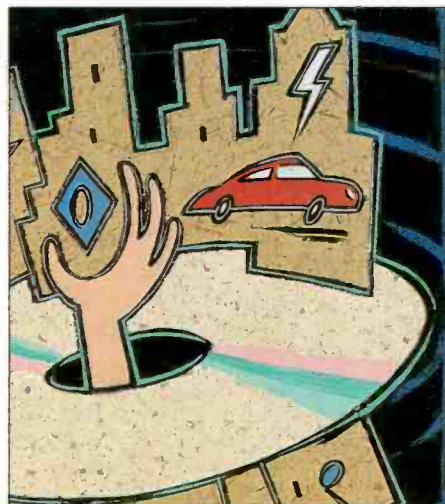
45 The Cutting Edge

John Watkinson explains the technicalities of the readout principle of the compact disc and shows how it determines the factors affecting the cutting process



50 CD-ROM

US columnist Martin Polon looks at CD-ROM and finds a contemporary format well suited to life in the next century—and beyond





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MASTERING
DUPLICATION
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June 1994
Issue 3

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NEWSTRADE DISTRIBUTION (UK)

UMD, 1 Benwell Road, London N7 7AX, UK. Tel: +44 71 700 4600. Fax: +44 71 607 3352.

© Spotlight Publications Ltd 1994.
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Origination by Craftsmen Colour Reproductions Ltd, Unit 1, James Street, Maidstone, Kent ME14 2UR.

Printed in England by Riverside Press, St Ives plc, 2 Grant Close, Gillingham Business Park, Gillingham, Kent ME8 0QB, UK.

Subscription Enquiries

UK: Subscription Dept, Studio Sound Magazine, Spotlight Publications Ltd, 8th Floor, Ludgate House, 245 Blackfriars Road, London SE1 9UR.
USA: Studio Sound Magazine, 2 Park Avenue, 18th Floor, New York, NY 10016.

US Postmaster

Please send address corrections to: Studio Sound Magazine, c/o Mercury Airfreight International Ltd Inc, 2323 Randolph Avenue, Avenel, New Jersey NJ 07001.
US second class postage paid at Rahway, N.J.

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Total average net circulation of 19,120 issues during 1992. UK:8,194. Overseas: 10,926. (ABC audited)

un
A United Newspapers publication

Optical options

One of the sessions at the recent Munich REPLitec Show discussed various aspects of in-line CD replication. Among the questions raised was that of the ability of existing CD lines to manufacture CD-ROM, MiniDisc and other 'post-audio' CDs. This question, however, represents just the tip of the optical iceberg lying directly in our path.

In an increasing number of areas of audio and computer technology, we are being asked to accept optically-based technology as an integral part of our expanding digital systems. The tapeless recorder-editors now being used for compilation and PQ editing, for example, are moving away from magnetic disks to the greater storage capacities offered by optical discs. Then there is the hotly-debated format offered by Sony's *PCM-9000 MSdisc*. And while optical equipment links are still considered to offer a poor alternative to traditional copper interconnections, longer communications links—including the telephone system—are making considerable ground with the aid of fibre-optic cables. Perhaps it is here that optical technology will have the greatest impact on our working lives.

When the telephone system was first formalised some decades back, the system's bandwidth was set at 3.1kHz (300Hz–3.4kHz) on the grounds that it was the minimum necessary to allow adequate voice recognition. The uses of this international communications network, however, have spread far beyond the possible appreciation of Herr Strowger and other pioneers, and the requirements for multiple speech paths within one connection, and for data links have pushed the bandwidth requirements ever higher. The various telecomms systems around the globe have generally responded well, and now we find ourselves with the prospect of ISDN (the Integrated Services Digital Network) and the American T-data links. In short, we can now readily send high-quality digital audio—along with associated control data—all over the world in real time. Already these developments are having a significant impact in music recording and audio-for-video dubbing, and are being discussed in premastering and mastering circles.

Sadly, not all is as simple or as satisfactory as it may sound—for while it is certainly possible to use these systems for the applications above, data reduction systems must be used to meet the present transmission bandwidth restrictions (128kbit/s for a single ISDN link); the signal is processed and some of the data are identified as 'expendable' and discarded (as is the case with both the MiniDisc and DCC formats).

As long as the audio travelling over these links is used as a guide of some sort—allowing a video editor to generate an EDL remotely from the location of the sound and picture recordings, for example), all is well. But should the actual soundtrack be subjected to a data reduction process, it will be permanently compromised. The obvious problem this potentially presents to the CD mastering industry is that use of such a system can similarly compromise the standard of the CD product.

If the product is not CD but one of the formats itself involving data reduction, then the compromise becomes significantly greater as subsequent passes through different coding systems produces unpredictable artefacts based on the systems used and the musical programme itself.

Through a glass darkly, perhaps? ■

Tim Goodyer

Cover: The Optical Disc Corporation's high-density compact disc

NEW FACILITIES

Dave Foister and Bill Foster report from new and nearly new facilities from the world of mastering and manufacture

Chop 'em Out

United Kingdom: to meet the growing demand for mastering from 20-bit digital recordings, West London facility Chop 'em Out have opened a new room capable not only of handling 20 bits, but also of producing from these tapes the 16-bit masters required for CD production.

The nerve centre of the new suite is a Sonic Solutions editor. In fact, compared to the complex's four other mastering rooms, there is only a keyboard and a screen in the room, which can then be patched to any one of the facility's four other Sonic Solutions systems.

Twenty-bit recordings are noise-shaped to 16-bit using Sony's Super Bit Mapping (SBM) processor. Chop 'em Out were one of the first facilities to adopt SBM, and it is largely due to the number of successful projects they have undertaken so far—including a major 6-CD box-set retrospective of Brian Eno's oeuvre for Virgin Records—that this new room has been opened.

Although not yet part of the permanent inventory, a preproduction prototype of Sony's PCM-9000 MasterDisc recorder is currently being

evaluated. Irrespective of whether the company ultimately decides to purchase one of these machines, on one thing they are all agreed; the 20-bit D-A converters are some of the best currently available.

The centrepiece of the room is a wooden console constructed from 200-year-old oak taken from the bottom of a French cattle truck. This provides desk space for the various keyboards and houses the metering, while two drawer units in the centre of the console allow a selection of analogue outboard gear to be easily hooked in. These are mainly for use when remastering from analogue tapes; among the current favourites are the Summit Audio valve EQ and compressor, and Dolby's *Spectral Processor*. Digital equalisation and dynamics are handled by the Sonic system and a Sony SDP-1000.

Monitoring is taken care of by a pair of Quedsted speakers, driven by a Quedsted D1500S amplifier. The speaker cabinets are a customised design, each containing two 10-inch drivers, plus mid-range and tweeter. A pair woofers, driven by a BGW amplifier, give a flat response down to 30Hz.

Between the speakers are four video monitors. Two of these are for the Sonic, providing the engineer with a greater degree of information and control than is possible with a single monitor. The SDP-1000 has its own monitor, while the fourth screen is a TV monitor which is used when working on audio restoration for video and film.

Tie lines link the room to the complex's central machine area which houses a wide range of peripheral equipment. This includes dCS 900B A-D converters, Audio Design 18-bit sigma-delta D-A, an ADT 24-bit sample rate convertor and a pair of Mitsubishi 20-bit 2-track digital machines. There is also space for a Nagra D 4-track digital recorder, which is shared with the company's mobile recording unit. ■

Bill Foster

Chop 'em Out, Trinity Mews,



Chop 'em Out's new nerve centre with 200-year-old oak console

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Digipro

The Belgian-based Digipro group was founded in 1984 by Sound Engineers Patrick de Lannoy & Jacques Krischer to specialise in premastering. Their approach is quite specific: 'We are not a recording studio, but the last stage where we listen to the music before its industrial production.' Digipro's numerous European facilities have several features in common: 'We used the same kind of monitoring everywhere—rock on Genelec and Yamaha, classical on B&W, 2AE, Triangle and so on—giving us a precision tool for mastering as well as a good idea of how it will sound in the consumer's house.' The only standard aspect of the rest of the kit is its diversity—all the sites offer a huge range of formats for playback, editing, processing and recording. It is, perhaps, the need for this diversity which prompted Digipro to host their Blue Forum at SACEM's head offices in Paris in early June to discuss the present digital format situation and to consider the future for mastering and premastering formats.

The group continues its expansion in the European premastering market with the recent opening of a new facility in Milan and a move to larger premises in their home country. The Belgian facility now comprises ten studios, of which 7 are audio and video postproduction rooms with a vast selection of digital tools. Equipment includes two Lexicon *Opus* editors, two DAR *SoundStations*, three PCM-1630s with both DAE-1100 and DAE-3000 editors, Digidesign editing and a fully-fitted CEDAR sound-restoration system. There is also a Neve DTC-1 console, two Sony DSP-1000 processors, Studer PQ editing, CD-R machines, analysis equipment and analogue recorders with Dolby SR,

together with an array of effects and other processors.

Two other studios cover recording and 'musical creation' for postproduction, and a final room handles development and premastering for CD-ROM and CD-I.

This kind of variety and flexibility runs right through the organisation; the Paris base currently boasts a Sony PCM-9000 magneto-optical recorder-editor alongside six PCM-1630s, *Pro Tools* 2.0, 1/2-inch analogue, both Sony and Studer PQ editors, and another full CEDAR system. The new Milan facility carries the tradition on and adds *Photo-CD* and CD-Video capabilities.

Besides these bases there are two in Holland and another new facility due soon in Geneva; later in the year, a further branch is due to open in Lisbon. This rate of expansion speaks volumes for Digipro's confidence in the continued requirement for the professional premastering market, despite many people's concerns about the trend towards DIY mastering on possibly less-than-ideal formats. It is also encouraging that an organisation like this which might have much to gain from flexibility in a constantly-shifting market should be initiating discussions about new standards. The position they are in has brought them up against all the formats people currently want to master from, including CD-R and Exabyte, and this, in conjunction with their Europe-wide spread, makes them exactly the kind of company who should be promoting informed debate about the future in which they are investing so heavily. ■

Dave Foister

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FUTURE FORMATS

MDR looks into the success of the new consumer formats and the industry opinions surrounding them

At the AES in Berlin last year, most of the cassette duplication equipment manufacturers were optimistic that the launch of DCC would stimulate a certain amount of new business for them. Twelve months on and the general consensus would appear to be that not only has DCC failed to excite the public—and therefore not produced any significant increase in duplication business—it is also unlikely to generate much in the way of hardware sales for the duplication equipment manufacturers—at least in the immediate future.

New avenues must therefore be sought to fill the gap and it seems that the industry is turning to the compact disc in order to do this.

As Orjan Svedberg, MD of Lyrec, explains: 'Making compact discs is a lot less complex than it was five years ago. An increasing number of cassette duplicators are therefore looking at CD production to replace declining cassette sales.'

It is not only sales of music CDs that are on the increase; a growing number of computer game titles are also being released on CD, creating a new market which the cassette people have been quick to tap into—especially as many of the computer games companies are already customers.

The majority of independent cassette duplicators are choosing one of the in-line systems. They are generally easier to install, and have proved to be ideal for handling the size of production run usually required by the computer games companies and independent record labels.

Rather than seek out new suppliers, many duplicators are looking to their trusted cassette duplicating equipment manufacturers for provision of the necessary CD production hardware.

This demand has prompted companies such as Lyrec to form marketing alliances with manufacturers of CD equipment—in their case with fellow Scandinavians, Toolex Alpha, which gives the latter company access to Lyrec's network of customers in the cassette business.

Despite this diversification Lyrec still intend to remain a full audio-cassette duplication system supplier and will, according to Svedberg, continue to manufacture DCC equipment as required. However, due to the uncertainty of the future market an increasing number of Lyrec's products—such as their C3000 slave and the Duplitronics solid state master which they distribute—will be capable of conversion between analogue (ACC) and DCC.

This policy is also being adopted by Gauss, who are distributed in Europe by London-based dBm. The Gauss Max system couples Gauss slaves with Concept Design's solid state master and can be configured in either ACC or DCC format.

dBm are another company who recognise their clients' need to expand into the compact disc market. To this end they have recently acquired European distribution for Nobler, the American manufacturer of CD in-line machines, and Emerald, also American, who make both CD and cassette packaging equipment.

Tapematic, one of the first manufacturers to embrace DCC technology, are also diversifying with the introduction of 'a revolutionary modular CD packaging system'.

'Analogue music cassettes have managed to maintain a reasonable market share,' says Tapematic's Ron Goodwin, 'but in 1992 CD sales reached the level of MC, and from now on they can only go up. But, I don't believe the MC will die overnight; it will probably still be going strong in the year 2000.'

Goodwin is also unconvinced that DCC, or for that matter MiniDisc, will take anywhere near the market share that CD now enjoys, hence Tapematic's move into the CD market. He considers that 'it will be at least five years before these new formats reach even a 15% share.'

Understandably, many cassette duplicators are playing the waiting game, unwilling to invest in new cassette production equipment—especially the more expensive DCC-convertible devices—until there is a clearer market direction.

As a result, Tapematic will continue to make their popular 2002-series loader available in two versions. The CR (right handed) version is designed for ACC only, while the more expensive 2002CL can be converted for DCC operation. Their new 200 Mini series also comes in a number of configurations, capable of winding various combinations; ACC and DCC, 8mm and VHS-C, and R-DAT.

To complement their existing SAM (Static Audio Master) system, which will handle two separate ACC or DCC programmes, Tapematic are introducing a new model with a only a single memory. This can store one programme of up to 120 minutes, although Goodwin expects orders to be typically for around 90 minutes of RAM.

Otari have to date stayed away from the DCC arena. 'We have all the necessary licenses,' says

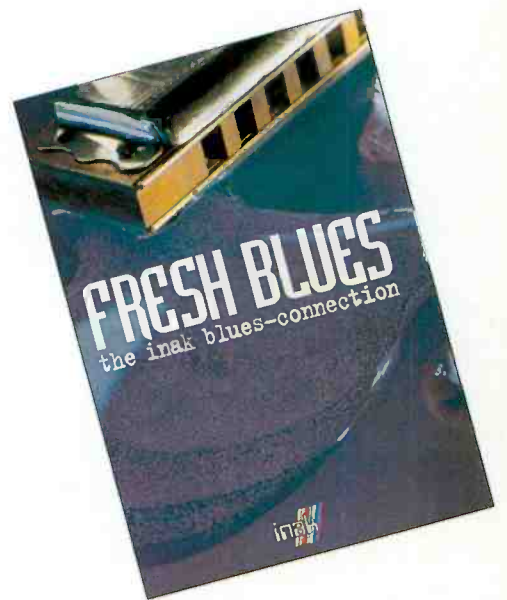
Burkhard Jaeger, 'but we prefer to wait and see how the market develops. Interestingly, Otari are keeping an eye on R-DAT, which in Germany has enjoyed a modest revival in recent months.'

'We prototyped a THD machine for DAT replication some time ago and we also make a DAT loader,' Jaeger continues. 'If DAT sales were to take off we would have to give some consideration to making equipment available.'

All manufacturers agree that in addition to a marginal improvement in the North American market, Eastern Europe and the Middle East are the primary growth areas for sales of conventional analogue equipment.

They are hoping that there will be a strong attendance from these territories at this year's AES to see the equipment on offer, especially the new low-cost systems which should be attractive to the many start-up operations now appearing in Eastern Europe.

As far as Western Europe is concerned, the only impetus for a duplicator to replace or upgrade their equipment at the present time would seem to be when machinery wears out or a customer demands newer technology; the latter being mainly in the area of solid state masters, where cassettes duplicated digitally from SSMs can, perhaps, give record labels a marketing advantage. ■



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IN SEARCH OF THE MASTER

The word 'Master' is without doubt one of the most abused, words in the recording industry's vocabulary. Bill Foster offers some advice on how to differentiate between a master... and a master

Anyone in the business of mastering has suffered the problem of multiple *master* tapes. Production Master, Original Master, Safety Master, Inter-Master and—still my favourite—a Final Master dated two months before another Master, both of which are sent along for the mastering session.

One reason why I believe there can be so many versions of a *master* is paranoia on the part of many engineers, studio assistants and librarians that a tape, even when it contains only out-takes, might be discarded if it is not marked with the magic word 'master'. Little do many of them realise that the addition of that one word can cause untold confusion further down the production chain.

Of course, each stage of the recording and production process often requires a different tape from which to work, and as a result there is always going to be more than one master tape. However, it is important that those involved in the various stages understand exactly each function that each of these masters performs.

During the latter part of the 1980s, in an attempt to bring order to the chaos, the UK's studio trade association, APRS, working closely with the British Record Producers Guild (now Re-Pro), devised a

colour-coded tape-labelling system. The TLS, as it became known, was quickly endorsed by SPARS, and all the main recording tape manufacturers agreed to include TLS labels with their tapes. A modified version was later developed for DAT, taking into account the small size of the format.

The TLS comprises eight basic labels. It would be impossible for these to cover every eventuality, but since a minor revision in 1982 it is generally agreed that they meet the requirements of most users. (See below.)

One little known facet of the TLS's design is its ability to track the progress of a tape. For example, an analogue 2-track Session Tape might be edited to become the Original Master. Should it require no further EQ, it is quite possible that this same tape will also be used to produce the parts for manufacturing, say, both vinyl and cassette.

Were a new label to replace the old one at each successive stage, there could be confusion at a later date if someone were to require the Original Master. With no tape labelled as such any more, it might be ▶

SESSION TAPE

For use with multitrack or 2-track work tapes. These may contain out-takes.

Space is provided for additional information about the tape; for example, whether it is one of a series of tapes, tracks 1-24 of a 48-track pair, and so on.



ORIGINAL MASTER

This is intended to be used on the earliest possible generation of the final stereo product. It does not necessarily mean that the tape is suitable for use as a Production Master; the producer should be consulted before using a tape bearing one of these labels.



PRODUCTION MASTER

All necessary EQ and other audio treatment (if any) has been applied to the programme material and it is ready for the production of the release format(s) ticked. However, in the case of CD, DCC or MD, a 'PQ encoded Tape Master' must be prepared before manufacturing (see below).



PROD'N MASTER COPY-CLONE

A duplicate of a Production Master which has been prepared in one of two ways. A digital tape that has been digitally transferred from a digital source is usually referred to as a *Clone* (see sidebar), while any transfer made using an analogue conversion or from an analogue source is known as a *Copy*.

All transfers onto analogue tapes are *Copies*, irrespective of the source, and further *Copies* should not be made from these without first seeking the approval of the producer.



assumed that it had been lost. By adding each label slightly to the right, the tape's history is recorded, giving a quick visual indication that this particular tape was in fact not only the Production Master, but also the Session Tape and Original Master.

The importance of careful box marking cannot be stressed often enough. One of the reasons that there always appear to be so many 'masters' is because takes and mixes which are subsequently superseded are so often not marked as such.

Very often this is because the tape in question has already been sent back to the client or the library, but even then it is vital that the person holding the tape is asked to update the box. At worst, DO NOT USE written over the word 'master' will suffice, although a more detailed explanation such as 'see new mix 25/5/94, box number XX' will, of course, be far more helpful—especially in years to come if the artist in question becomes famous and a *Greatest Hits* or anthology is to be compiled.

The same rules apply if a title is added to, or extracted from a reel. Not only will this save wasted

time looking for a take that doesn't exist, it might also avoid the wrong take being used. For example, if Take 3 were to be extracted without this fact being noted, and the reel also contained a rejected Take 4, this would suddenly become Take 3—and this would still be marked as the master.

These are some other essential pieces of information which should always be marked on the tape box label:

Analogue: Client, artist and title details; Tape speed; Recording characteristic (that is, NAB-IEC); Type of Noise Reduction (if any); Details of line-up tones (that is, 1kHz at head @ 0VU 250nWb/m).

Digital: Client, artist and title details; Format (1630 and so on); Sampling frequency; Emphasis (Y/N); Type and location of time code (SMPTE code on Track 2, for example); Tones (Y/N).

This may seem tedious, especially at the end of an all-night session, but the Mastering Engineer or whoever receives the tape next will thank you for it. Who knows, he might even buy you a beer! ■

C L O N E S

A subject that is guaranteed to raise the temperature of many engineers and producers is the thorny one surrounding the definition of a *Clone*. Following publication of the *Master Tape Book* in 1992 there were howls of protest from some quarters about the way we had defined a *Clone*. The protesters argued that the only true *Clone* is one produced on the same digital tape format as the original.

Their argument is perfectly valid, and even in the book I am afraid we have added to the confusion by contradicting ourselves somewhat. When discussing the care of master tapes we recommend (quite correctly in my opinion) that a digital recording should be cloned at least once onto a different format in case the format on which the original was recorded proved to be unreliable in the long term.

And, while explaining the copying process, we say that 'by using compatible interfaces, or a suitable format convertor, digital clones can be made between two digital machines of different types—provided that the sampling frequency and word length of each are the same'.

In the book's Glossary, however, a *Clone* is defined as 'a digitally transferred copy of a digital tape, which is exactly the same in all respects.' Not much help for those seeking a definitive answer.

Having had two years to reflect, and following some further discussion with my co-authors Alan Parsons and Chris Hollebhone, we have come to the (diplomatic?) conclusion that there are actually two answers—one text book, and one real world.

The text book definition of a *Clone* must be the one contained in the Glossary. Strictly speaking a *Clone* has to be identical in all respects, both physically and electrically.

However, in the real world this is not always possible. The aforementioned risk of tape deterioration makes it prudent to backup onto another medium, and then there is the fact that, for example, a DAT master is frequently not accepted for use at a CD production plant, making it necessary for a *PCM-1630 Clone* to be produced in order to meet their requirements.

To call a straight digital-domain transfer between two formats—when all the bits are transferred without any change to the level or equalisation—a *Copy* is, in my opinion, selling the final product short. Probably the best solution is therefore to mark the relevant tape label *Clone* and then add the words 'from DAT'. This will warn any purist that it is more than a *Copy*, but is technically speaking less than a *Clone*. ■

PQ ENCODED TAPE MASTER

Fully prepared and PQ encoded tape ready for the manufacture of CD, DCC or MD. Parameters for each format are usually different and so only one format can normally be indicated on the label.



SAFETY COPY-CLONE

Strictly for safety. These should only be used when the tape from which the safety was made has either been lost or damaged. It is advisable to inform the Producer if it is intended to produce manufacturing parts from a Safety Copy-Clone. The label provides for an indication of the safety's source—that is an Original Master, Session Tape—which will help to ascertain its suitability for production purposes.



NOT FOR PRODUCTION

Self-explanatory. This label was specifically requested by a number of producers who had seen their work released using rough mixes or work tapes that had been supplied to the record label solely for listening purposes. Any mastering house or manufacturing plant receiving a tape marked with a Not for Production label should return it with a request for the correct tape.



MEDIA VERSION

Supplied for the specific purpose indicated. Often contains time code or pulse, which should have been marked on the box. The label is also coloured yellow as the material contained on the tape is not intended for manufacturing purposes.



Bill Foster co-author (with Chris Hollebhone and Alan Parsons) of the *Master Tape Book* and chairman of the APRS Technical Subcommittee at the time their Tape Labelling System was introduced. *The Master Tape Book* is published jointly by the APRS and Re-Pro, and is available by post from the APRS, Tel: +44 734 756218. Fax: +44 734 756216.

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We named it CD CATS SA3 Advanced.

Surface presentation

Surface presentation maps parameter variations as they are distributed over the disc's surface area. Parameters BLER, E11 - E32, I3, I11, REF, RN and SYM are displayed on a graphical image of the disc, one at the time, showing where the trouble areas are physically located. The variations are displayed in different colours for easy detection of problem areas.

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the jitter and temporal deviation of recorded features on the disc. Standard deviation and Length deviation for I3 to I11 is measured individually for land and pit areas, giving a total of 36 new parameters.

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From summer '94 the CDM4 chassis, the mini diecast version with HALL motor, will be standard in all CD CATS systems.

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MAKE MINE MEDIA

James Douglas visits a Hollywood facility serving the mastering and restoration, and soon, the replication, needs of the mighty MCA label

In much the same way that the majority of record companies found it cost-effective to make use of independent recording studios rather than operate their own in-house facilities, so it is a rare exception that a major label elects to design and operate a set of state-of-the-art mastering and restoration suites. After all, so the conventional wisdom goes, an independent facility can respond more quickly to market trends, and can react more readily to changing technical requirements. In this respect, and many others, MCA Music Media Studios are a fascinating exception to the rule.

Based in North Hollywood, a suburb of Los Angeles' San Fernando Valley, MCA Music Media comprise a series of seven main production rooms, plus companion administration and clerical offices. According to Paul West, the facility's Vice President of National Quality Assurance and Studio Operations, the work that passes through the location can be divided into three main areas.

'Some 40% of what we do here covers transfer and editing of stereo and 4-track source material,' he explains, 'and another 40% is devoted to mastering and/or restoration for CD and cassette manufacture. Of the remainder, we have a video duplication and editing area that is mainly used for in-house, short-run production of, for example, [VHS and U-matic] sales and corporate video tapes. We also have the ability to produce reference CDs and CD-ROMs using our Sonic Solutions CD-R systems.'

And not all of that admixture of work is for MCA Records; around 30% of the mastering, editing and restoration sessions are for non-MCA clients.

'Two years ago,' explains Nick Dofflemyer, Studio Manager and Director of Quality Assurance, 'we changed our name from MCA Recording Studios to MCA Music Media which, we feel, better

describes what we actually do here. The 'Recording Studios' label was inappropriate—mainly because we don't operate a multitrack studio!—but our main intention was to attract outside work. By aggressively marketing out services, we plan that, in the near future, roughly half of our work will be for outside clients. Following the recent earthquake here—incidentally, we were back in operation in an alternative location within just four days—we have been refurbishing some of our production rooms, as well as enhancing our peripheral services.

'MCA producers and artists have never been forced or coerced to use these facilities—although a lot of them do. We have decided to target outside clients, by offering what we consider to be a unique combination of digital technology, and highly talented mastering engineers.'

'Our creative edge,' considers Paul West, 'stems from the fact that we were the first facility to enter the digital era with state-of-the-art audio workstations and digital processing. We took delivery of the world's first Sonic Solutions *Sonic System* [Macintosh-based hard-disk recorder and editor] back in July, 1988, and a second system later that same year. Since that time, we have continued to work with Sonic in developing and refining the concept of a computer-platform editing system for CD mastering.'

According to Mary Sauer, Sonic Solutions' Senior Vice President of Marketing, 'We first started

working with MCA through our *NoNoise* service; we cleaned up a number of MCA album releases, from the Andrew Sisters to Liberace. MCA was instrumental in helping us develop [Sonic System], and they tested and helped refine new features, including scrubbing from hard disk, background loading and unloading from hard disk, background *NoNoise* processing, recordable CDs, mixing and EQ functions. We have continued to collaborate with MCA on new features such as double-speed CD recording and 8mm [Exabyte] premastering. Although their initial [Sonic Systems] cards have been upgraded, MCA's two original systems are still in daily use.'

Mastering and restoration

In addition to traditional editing and mastering for CD and cassette release, which forms the heart of MCA's day-to-day business (no vinyl cutting is performed here), the facility also specialises in audio restoration.

'We have a number of engineers that are particularly experienced in this type of work,' Paul West continues. 'For us, restoration comprises a number of sequential stages, including editing and the use of special effects. First, we need to prepare the source materials, which may come to us on a



The production team at MCA Music Media (clockwise from lower-left): Paul West, Vice President of National Quality Assurance and Studio Operations; Technical Support Engineer Ed Abbott; Mastering Engineer Eric Labson; and Nick Dofflemyer, Studio Manager and Director of Quality Assurance



Ampex ATR-104 analogue mastering decks, Sony PCM-1630 digital processor with companion DTA 2000 digital tape analyser, and Sony DMR4000 U-matic VCRs

variety of formats, from stereo quarter-inch, 3-track and 4-track half-inch, as well as number of digital formats—and even metal acetate and lacquer parts—depending upon the vintage of the project. Having transferred the materials to hard disk via one of our high-quality A-D conversion units, we can then use the Sonic Systems' editing and restoration capabilities, including *NoNoise*, which takes out repetitive noise as well as 'ticks', 'pops' and 'crackles.' Finally, we prepare a master that is used for CD or cassette manufacturing.'

One of MCA Music Media's recent projects was for a 4-CD set of vintage Judy Garland recordings, 'some of which were sourced from the original metal parts [used to prepare the master vinyl stampers],' West adds. 'But restoration is not just removing noise and clicks. We need to consider the overall sounds that will result from the reissue, and whether it fits in with contemporary tastes. We might need to enhance the equalisation, for example, by forming a bigger low end, as well as adjusting sound levels and stereo balance. In reality, we consider it a mastering process; restoring the analogue master is just the first step.'

'The new cobalt formulations, in conjunction with our digital loop-bin systems, allow 5dB more level on tape, even at our 80:1 duplicating ratios.'

Cassette or CD?

For the engineering staff at MCA Music Media, there is little difference between the master tape prepared for CD manufacture, and that which passes to the cassette-duplication plant.

'In terms of overall levels, dependent upon programme content, we might back off just a shade in low-end energy,' West says, 'but in just about every other respect, we do not reduced the overall dynamic range for cassette.'

'We have found that the new cobalt [cassette-tape] formulations, in conjunction with our digital loop-bin systems, allow 5dB more level on tape, even at our 80:1 duplicating ratios.'

MCA's cassette masters are prepared on a customised Duplitronics *MM-100 Digital Mastering System*, which produces specially-formatted Super-VHS video cassettes. At the input to the system, analogue or digital source reels are digitised, and level adjusted. Then, prior to a copy being made of the stored data, the signal passes back into the analogue domain for Dolby B encoding. The ►



The Duplitronics MM-100 digital mastering system

signal is the re-digitised, and passes to a buffer memory that holds six minutes of digitised audio.

'The computer front-end,' Nick Dofflemyer comments, 'automatically scans the digitised material, and produces a print-out of any anomalies, such as the occasional click that might confuse the mastering system. During the transfer to Super-VHS video tape, a parity check is performed, and compares the stored data with that entering the system. If, for some reason, there is a difference in bits [caused by a parity error], then the system

simply rerecords that section of information and enters the fact in a separate directory. The system will make five attempts to rerecord the same data packet, before the transfer is aborted.'

On playback into memory at the cassette-duplication plant, information stored on the video tape's special directory will allow the system to delete the incorrect data and reconstruct the data stream. The special Super-VHS video tape holds both the A and B-side audio data; during duplication the B-side is simply played back in reverse. The data

transfer into the digital loop-bin from the Super-VHS data tape runs at 10x real time.

A-D transfer

The key to any mastering process is the accurate replication of an analogue source tape into its digital equivalent. At MCA Music Media, Paul West confides, his engineering crew continues in its search for the 'perfect' A-D convertor.

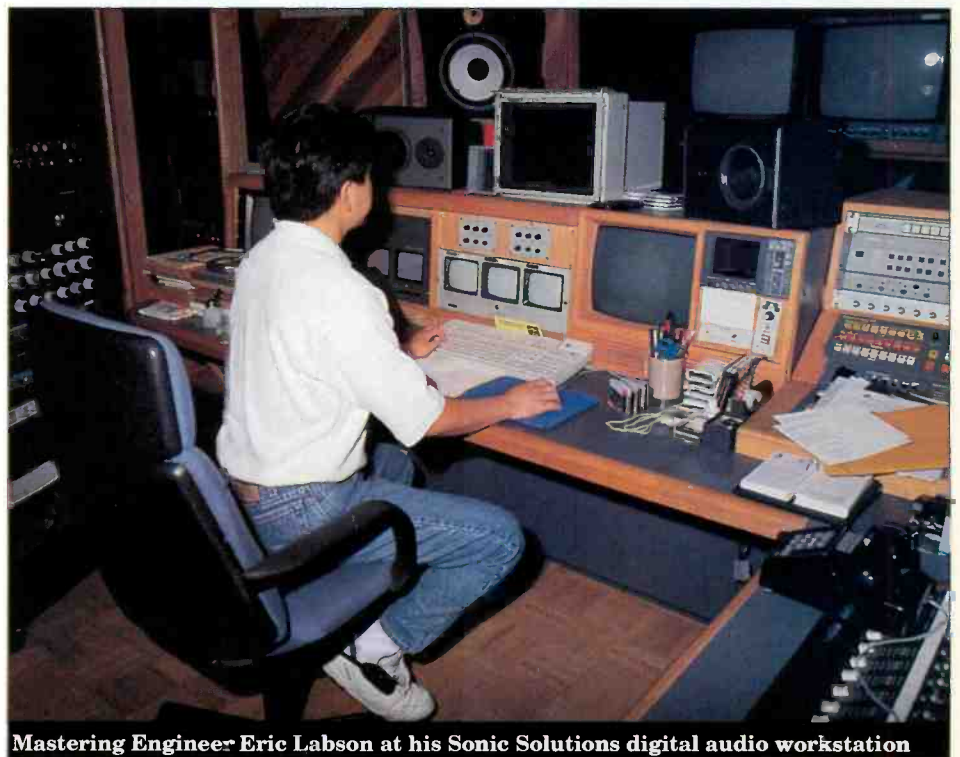
'We have pretty much standardised on Apogee Electronics DA-1000 Reference D-A convertors for our digital sources, but are still evaluating a number of A-Ds. It is a critical component in the signal path.'

At the time of our visit, West's staff were evaluating a new Moffett A-D convertor, which utilised military-grade components—but which costs around \$20,000.

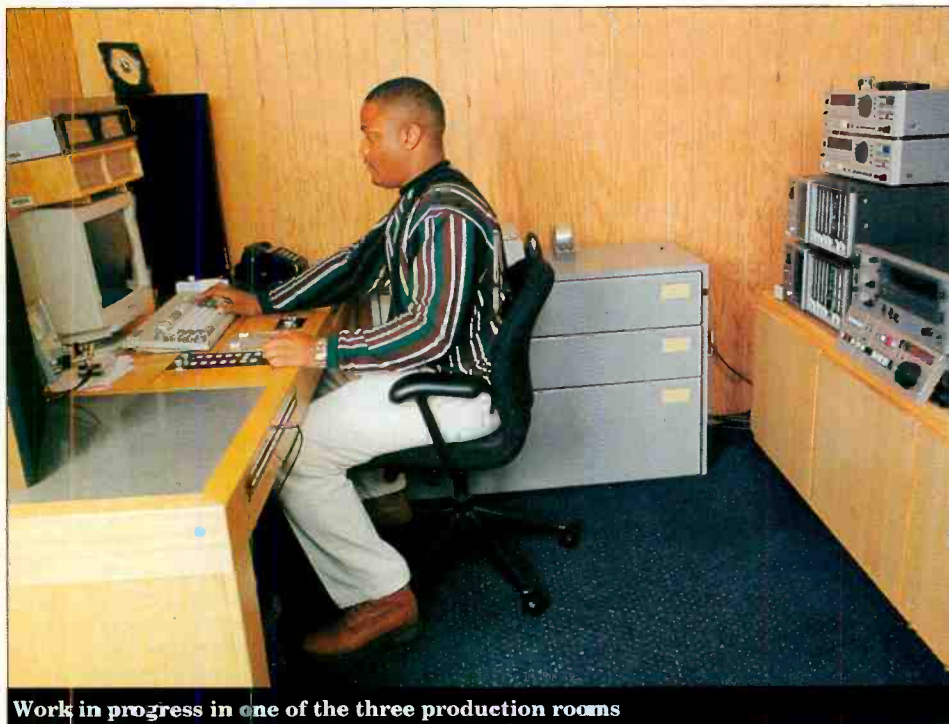
'We're still pushing the outside edge of the technology envelope,' West considers. 'From our early experiences with the original PCM-1610-30 convertors, through the Lexicon 480XL [digital reverb unit]—which, at the time, we thought offered outstanding convertors—to today's Prism AD-1, Apogee AD-500, Lexicon 20-20 units, and on to the new systems from GML and Moffett, we can detect subtle but important differences with each new generation of convertor. The downside, I suppose, is that we will reach a stage at which these new developments become less and less cost-effective, and then we'll settle upon a standard. But saying that we have reached 'perfection' can be dangerous; a new development may be just around the corner!'

The company encourage the staff to experiment wherever possible with new technology, West says, and stay up to date with current developments.

'We have pretty much standardised on Apogee Electronics DA-1000 Reference D-A convertors for our digital sources...'



Mastering Engineer Eric Labson at his Sonic Solutions digital audio workstation



Work in progress in one of the three production rooms

'Everybody can experiment and "look under new rocks," so that we remain competitive. Our early experiences with disk-based systems have stood us in good stead.'

And MCA's staff have one or two interesting ideas about products they would like to see developed for the mastering industry.

'For cassette-master production, I would like to see a digital low-frequency limiter,' Nick Dofflemyer suggests. 'We have good analogue devices, but so far we haven't come across a digital equivalent. We have been evaluating a new unit from Valley Audio, the *Model 730*, which offers all-digital processing [and features AES-format I-O.] But it currently lacks a low-frequency limiting function [below 4.4kHz] which, I understand, is very hard to achieve with today's DSP technologies. But I assume that it will only be a short time before somebody, maybe Valley Audio, comes up with a solution.'

Mastering Engineer Eric Labson, who operates one of MCA Music Media's Sonic-equipped editing and mastering rooms, feels that there is still room for improvement in the design of A-D converters.

'In terms of quality improvements, each new box that we evaluate here sounds just a little better than the last one. The differences can be subtle—enhanced linearity and transparency; fully extending reverb tails; a sense of *air* and *breadth* in the stereo image—but are very important. In addition, clock and interface jitter can cause severe coloration and a serious narrowing of the stereo image. So, aside from choosing a good-sounding convertor, you have to make sure that the systems are interconnected properly, and referenced to a stable, highly accurate clock reference.'

At the top of Technical Support Engineer Ed Abbott's list is a 'Digital Mult Box that would allow the distribution of jitter-free AES-format signals from a single source to multiple destinations. ►

'Each new box that we evaluate here sounds just a little better than the last one.'

MCA MUSIC MEDIA EQUIPMENT

DIGITAL-ANALOGUE PRODUCTION ROOMS

- Ampex *ATR-104* analogue mastering deck
- Hafler power amps ● Panasonic *SV-3500* and *SV-3700* DATs ● Technics 3-head cassette decks
- Sony *PCM-1630* with *DTA 2000* digital tape analyser ● Sony *DMR4000* U-matic VCRs ● CRL single-ended noise reduction system. ● Custom-designed stereo, 4-channel monitoring console

DIGITAL (CUTS-ONLY) PRODUCTION ROOM

- Ampex *ATR-104* analogue mastering deck
- Hafler power amps ● Panasonic *SV-3500* and *SV-3700* DATs ● Sontec Parametric Disk Mastering EQ ● Sony *DAE-1100* editing systems ● Sony *PCM-1630* with companion *DTA 2000* digital tape analyser ● Sony *DMR4000* U-matic VCRs ● Technics Three-head Cassette decks ● Custom-designed stereo, 4-channel monitoring console

SONIC SOLUTIONS RESTORATION ROOMS

- Ampex *ATR-104* analogue mastering deck
- Panasonic *SV-3500* and *SV-3700* DATs
- KRK 3300 Monitor speakers-Bryston crossovers-Hafler power amps ● Sonic Solutions workstation with *NoNoise*, *Timetwist* and *Varispeed* (full digital EQ and filtering) ● Sonic Solutions CD-Premaster with 8mm *Exabyte* and *Start Labs 2x CD Printer*. ● Sony *PCM-1630* with *DTA 2000* digital tape analyser ● Sony *DMR4000* U-matic VCRs ● Studer *A-80* analogue mastering deck ● Technics 3-head cassette decks ● Custom-designed stereo, 4-channel monitoring console

MASTERING ROOM

- Ampex *ATR-104* ● Apex *Dominator II*
- Aphex *Compellor* ● Apogee *UV-1000*
- Ampex *ATR-104* ● GML 8200 Parametric EQ
- Lexicon *20/20 A-D* convertor ● Panasonic *SV-3500* and *SV-3700* DATs ● Sonic Solutions workstation with *NoNoise*, *Timetwist* and *Varispeed* (full digital EQ and filtering) ● Sonic Solutions CD-Premaster with *Exabyte* and *Start Labs 2x CD Printer* ● Sontec Disk Mastering EQ (modified) ● Sony *PCM-1630* with *DTA 2000* digital tape analyser ● Sony *DMR4000* U-matic VCRs. ● Studer *A-80* ● Technics 3-head cassette decks ● Custom-designed stereo, 4-channel monitoring console ● Assorted digital-tube compressor-limiters

CASSETTE MASTERING

- Ampex *ATR-104* analogue mastering deck
- Duplitrronics *MM-100* digital mastering unit with custom software ● JBL 4412 monitors
- Hafler power amps ● Lexicon *20/20 A-D* convertor ● Panasonic *SV-3500* and *SV-3700* DATs ● Studer *A-80 Mk II* 1-inch 4-track (2) with *Dolby HX Pro* ● Sony *PCM-1630* with *DTA 2000* digital tape analyser ● Sony *DMR4000* U-matic VCRs ● Technics 3-head cassette decks ● Custom-designed stereo, 4-channel monitoring console

All Production rooms, in addition to conference and lounge area, are interconnected via a multichannel glass-fibre optic network based on Sonic Solutions' MediaNet FDDI systems. ■

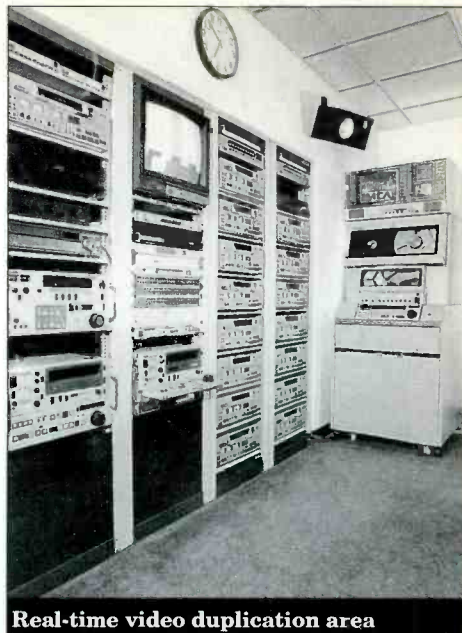
'For me, Exabyte represents a far more reliable transfer medium,'

In this way, we could ensure that our signals are not compromised each time they need to be connected to more than one destination.

Exabyte transfer

In terms of new technology, Paul West would like to see the end of *PCM-1630* systems, and is advocating the use of a more reliable mastering and data-transfer format.

'The *PCM-1630* is old technology,' he stresses. 'It can be unreliable and doesn't sound too good! MCA are currently finalising the construction of a new CD manufacturing plant in Pinckneyville, Illinois,



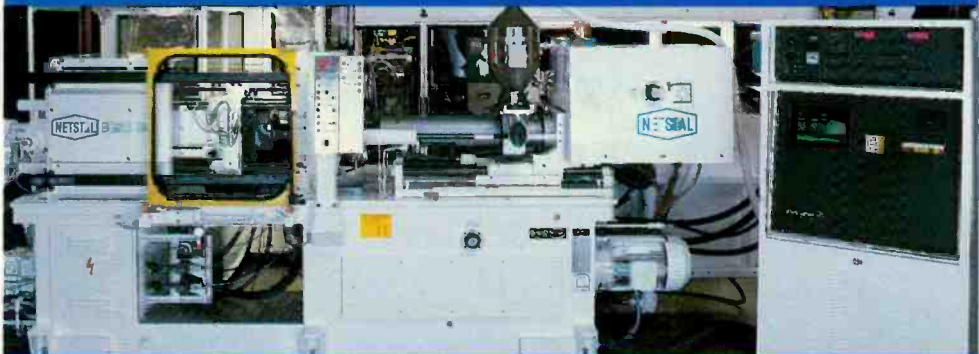
Real-time video duplication area

which will utilise systems from ODME.' Scheduled to open by late June 1994, the plant includes an *AMS 100* automatic mastering and stamper-making system, along with an initial complement of six *Mk IV Monoliner Replication Units* (see *MDR* issue 2). When a seventh *Monoliner* is installed towards the end of September, the plant's capacity will be expected to approach 40 million CDs and related media per year. Unlike conventional mastering systems, however, ODME's *AMS 100* system is designed to utilise 8mm Exabyte drives for in-loading digitised audio information.

'For me, Exabyte represents a far more reliable transfer medium,' Paul West emphasises. 'Currently, using *PCM-1630* masters, we have to transfer 16-bit data stored on hard disk via the *PCM-1630*'s processor to U-matic, and then reformat the data at the plant into 16-bit CD digital audio. At each stage in the conversion



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Each restoration room houses a Sonic Solutions system plus custom-designed, 4-channel monitoring console. All production rooms are interconnected via a multichannel fibre-optic network based on Sonic Solutions MediaNet

process, we run the risk of lost or corrupted data. Exabyte, on the other hand, is a conventional computer-style format that simply copies the data from hard drive in 16-bit format, and stores it on an 8mm data cartridge in DDP format. Aside from a few additional bytes of parity, the information is a mirror image of what we had on our Sonic Solutions hard drives.

'In addition, the data transfer takes place at two-times play speed. At the manufacturing plant, the AMS 100 features an automatic loading system that holds ten Exabyte cartridges [and 20 CD substrates]. Now the production of CD stampers can be fully automated'—ODME quote a minimum production rate of six stampers per 8-hour day shift.

What about recordable-CD production masters? 'Unfortunately, CD-R only holds 74 minutes of audio; Exabyte holds much more information,' West comments. 'Also, the data stored on a CD-R contains extra signal-processing and error-protection data that can be corrupted during recording and playback.'

'Exabyte simply represents a far more reliable, robust medium. We have performed tests with ODME, using PCM-1630 masters, Exabytes produced at the plant from those PCM-1630 masters, and our own Exabyte masters. In all cases, the evaluation CDs produced from our Exabyte tapes sounded far superior—better imaging and sonic quality.'

Towards the future

The future for MCA Music Media, according to Paul West, hold some interesting developments.

'The nature of mastering has changed dramatically during the last several years,' he considers. 'Aside from ensuring that an artist's music is transferred as faithfully as possible from the master tape to the CD or cassette media, today we are handling a lot more functions. We are often called in, for example, to handle last-minute editing of a project, or to add some special effects. We have received 4 and 8-track materials on ADAT, and have been asked to edit the various reels and remix the elements.'

'Also, for a recent release from [a well-known MCA band], we were asked to change the ending of one of the songs. Instead of an abrupt ending to the track, the producer wanted it to swirl off into space—as if it was disappearing into a 'Black Hole.' We used a

480XL digital reverb to create several types of rotating sounds that were blended, processed and mixed using the Sonic Solutions editor.

'MCA Music Media are becoming part of the newer generation of mastering facility, because we have the staff and resources to handle not only the conventional functions that the title implies, but also the sophisticated sound design that today's producers and artists are looking for. It's an exciting time to be in this business.' ■

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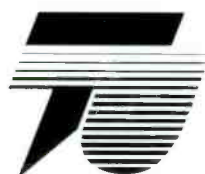


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WHOSE MASTER?

Who is serving whom? Bill Foster unravels the contradictory world of 'master' media

After more than a decade as the de facto standard for CD premastering, 1994 may very likely see the end of the PCM-1630s supremacy in this field.

But despite attempts by some cash-strapped premastering facilities and a handful of CD plants to give DAT some credibility in this field, this 'cheap and cheerful' medium now appears unlikely to make it as the 1630's successor.

There is a distinct possibility that it may not be Sony's new PCM-9000 either—even though one of the stated aims for this machine when it was introduced by Sony last year was for it ultimately to become the replacement format for their own popular PCM-1630 format.

While a few CD manufacturers have always been willing to accept masters on some of the lesser digital formats, most have insisted that CD master tapes be supplied on PCM-1630 U-matic cassettes for the direct production of glass masters. However, over the past year or so there has been a quiet revolution, with an increasing willingness on behalf of many mastering houses to accept other formats for direct production—as opposed to carrying out an intermediate transfer onto PCM-1630.

One company who are heavily supporting the diversification into new mastering formats is San-Raphael-based Sonic Solutions. A few years ago, Sonics introduced their PreMaster CD, a write-once CD format produced by downloading programme material from their Sonic System onto a Sony WORM drive.

Initially, the industry expressed a degree of scepticism as to the viability of using a WORM CD as a premaster format, but it was quickly discovered that the error rate on these discs is extremely low—frequently exceeding that of the PCM-1630.

A number of plants worldwide are now accepting PreMaster CD, with one major CD manufacturer in the United States claiming to receive as many of these as U-matic tapes.

To make WORM discs suitable for CD production (which should not be confused with the Orange Book CD-Rs produced by recorders such as the

Marantz CD-R machines) requires the premastering studios to invest in new equipment—something they may be reluctant to do if they already own a complete Sony system. But, for the many studios who already use Sonic Systems for editing and other postproduction duties, the upgrade is a relatively cost-effective exercise.

Help is also on hand for those who are yet more cost conscious. From the beginning of this year, those pioneers of lower-cost postproduction systems, Digidesign, have entered the CD premastering arena with a system they call MasterList CD. This allows the assembly of fully-specified, PQ encoded CD masters on Digidesign's existing recording and editing systems.

By connecting a CD-ROM writer—such as the Philips CDD521 or Sony CDW-900E—to the SCSI port of the host computer, a write-once CD can be produced which is suitable for direct transfer to glass master at the plant.

Another format that is supported by both Sonic Solutions and Digidesign systems is Digital Data Protocol (DDP). This is an Exabyte standard stolen from the computer industry, and tapes downloaded in this format can again be transferred directly to a glass master.

A growing number of CD plants are now equipped with DDP equipment as it is already one of the standard formats used for the mastering of CD-ROM.

It might be construed from this that Sony are about to lose their position as the number one suppliers of CD premastering equipment. But even if this is to be the case, it will certainly not be without a fight on Sony's behalf.

At last year's European AES Show, Sony showed a prototype of the PCM-9000 Master Disc System recorder (now known as MSdisc). The PCM-9000 is based around a magneto-optical (M-O) disc drive and can serve as both a master recorder for mixdown—in either 20 or 24-bit recording modes—or as a CD premastering medium running at the more usual 16-bit word length.

MSdisc recorders are capable of integration into the existing Sony premastering chain and will act as a player within the current DAE-3000 editing system.

However, to realise the full benefit if the new technology, this year Sony will be introducing the DAE-D5000 as a successor to the DAE-3000. (See reviews of both the PCM-9000 in MDR issue 1 and the DA-5000 in MDR issue 2.)

The DAE-D5000 is

more a workstation than an editor, but unlike many of its rivals it uses dedicated hardware (with real knobs and buttons) rather than computer control surfaces (with 'virtual' knobs and buttons).

In addition to being an editor, the DAE-5000 can mix two stereo digital inputs, has EQ and dynamics processing, and 'full' PQ coding facilities. An optional external hard-disk drive offers the increased flexibility of random-access editing.

Either a PCM-1630/DMR-4000 or a PCM-9000 can be used as the destination recorder, enabling assembly of CD masters onto whichever format is required. The DAE-5000's SCSI port, normally used to feed the PCM-9000, shares the same protocol as Sony's CDW-900E CD Writer, making write-once discs another mastering option.

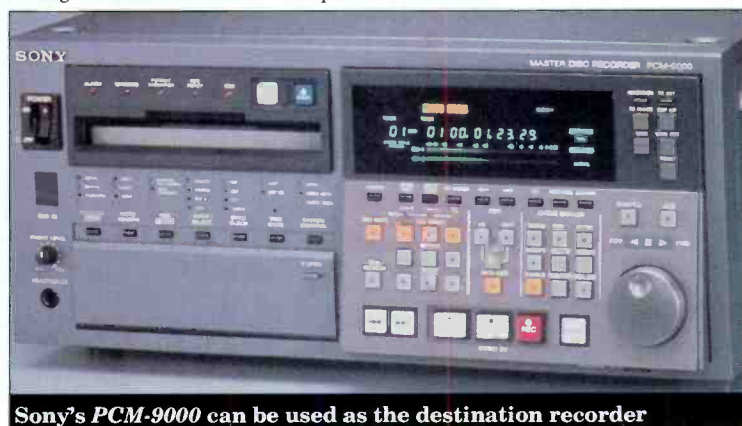
Breaking free from the U-matic format onto either an optical or computer tape medium offers an additional production bonus for the CD manufacturers, always pushed to meet customer deadlines.

By using CD players based on the new double-speed CD-ROM drives—or DDP drives which can output at much higher than standard CD data rates—coupled with the latest generation of laser beam recorders, it is now possible to produce glass masters at double, or even quadruple speed.

This will allow a much faster turnaround in an area which has traditionally been seen as a bottleneck in a large number of production plants, and could also result in considerable cost savings for the manufacturers, who might otherwise have been faced with a hefty bill to add another laser beam recorder.

So far it has not been possible to spin CDs at higher than two times playback speed, and so to achieve transfers at four times speed will require masters to be supplied in the DDP-Exabyte format.

With Video-CD—the new CD-i-CD-ROM Bridge format which some plants are now gearing up to produce, also being mastered to Exabyte, it would seem that over the coming months these little 8mm cassettes could start taking more (or should that be less?) shelf space than the ubiquitous U-matic. ■



Sony's PCM-9000 can be used as the destination recorder

REPLITECH SHOW PREVIEW

*Bill Foster
presents a
roundup of
exhibitors at
the REPLitech
Show, Santa
Clara 14th-16th
June 1994*

A ● **Accurite Technologies:** Diskette-drive test and alignment tools. Alignment and reference diskettes, diagnostic diskettes and software. New options for the *Drive Probe Advanced Edition Tester*. ● **Accurate Sound Corp:** AS-200B audio-cassette duplication system. Model 315/925 duplicator electronics and bias generator. AS-6000 audio-video, reel-to-reel, cleaner-conditioner. ● **Ace Label Systems:** Custom-printed and blank labels for the audio, video and computer industries. ● **ADE Technologies:** Instruments for the precise measurement of CD-stamper thickness by means of noncontact capacitive technology. ● **Alpha Enterprises:** Shipping boxes for CD, MC and video. ● **AME:** Diskette analysers and evaluators. ● **Amaray-Joyce Moulding:** Injection-moulded plastic, video-cassette albums for VHS, Betacam, D-2 and U-matic. Norelco and poly audio cassette boxes, CD jewel-boxes, and plastic and cardboard video-cassette slip sleeves. ● **American Videotape Warehouse:** Bulk-loaded VHS tapes and video accessory products. ● **Ames Speciality Packaging:** Software packaging, including retail boxes and mailers for diskettes and CD-ROM. ● **Anacomp Magnetics:** No information available. ● **Apex Machine Company:** Audio and video on-cassette printers. The *HSCD-1* prints multicolours on CDs at production rates of 120 pieces per min. Also showing, the *CA-20* two-sided audio-cassette printer with UV dryer. ● **Applied Innovation America:** Manufacturers of the *PE-5 Program Evaluator* for automatic test and analysis of VHS cassettes, and *Control Track Encoding System* for product traceability during duplication. ● **Archon Company:** Arcoset imprinting systems: a double-sided audio-cassette imprinter and a VHS-cassette imprinter for face and spine. Also the

APES 6000 N/P platemaker. ● **Ashby Industries:** Pneumatically controlled, gravity fed, diskette and duplication equipment. ● **Audiopak:** Manufacturer of audio-cassette components, including antistatic leader-tape and die-cut liners used in the assembly of audio C-0s. Also, the Audiopak range of broadcast cartridges. ● **Audio Development:** The *CD CATS* line of QC and measurement equipment for CDs. ● **Audio Matrix:** Audiopack electroforming and spin-coating equipment. Supplier of turnkey pressing systems. ● **Audiolab Electronics:** Range of manual and automatic continuous-duty degaussers for tape and diskette. ● **Auriga-Aurex:** Audio-cassette pancakes. ● **Automated Packaging Systems:** Showing the *Autobag HS-100* automatic bagger and the *Autolabel PI-4000* in-line thermal transfer imprinter. ● **Automatic Inspection Devices:** Optical-disc inspection equipment for CD and optical-storage media manufacturers, including the *SL100* tabletop, single drive, CD analyser for Red, Yellow and Green book discs. ● **Autoroll Machine Corporation:** Exhibiting the latest Rotoflex screen printer for CD and showing a video of the *560* 6-colour screen-printing system, with picture disc capability, in action. ● **Axiomatic Technologies:** No information available.

B ● **Balzars:** Manufacturers and suppliers of thin-film technology and high-vacuum systems, including the recently introduced *CDI 905 Metaliser*, with a reduced cycle-time of better than 1.8s, and the new generation *SDS 100 M-O Production System* for both 2½-inch and 3½-inch formats. ● **BASF:** New video duplication tapes. *VT19 SPRS*, specially designed for Shuttle Sprinters and available in SHG and HG grades. Also, *VT16TMD 7,250m* super-long pancake, which uses BASF's revolutionary concept in thin tapes. ● **Basler Image Processing:** *CD-Ident Code Reader* with improved optic. *Label Inspection System* using high-resolution CCD camera and new system for paperwork inspection (PWI) which will ensure correct match and positioning of booklet and inlay. ● **Berkshire:** Disposable products for clean rooms. Introducing *BCR Burnish Wipe* and *BCR Media Wipe*, engineered specifically for floppy diskette and audio-video tape cleaning. ● **Billboard Magazine:** Entertainment industry weekly and publishers of the *1994 International Tape-Disc Directory*. ● **Blackbourn:** No information available. ● **Blair Industries:** No information available. ● **Bowers Record Store:** Envelopes and mailers. ● **Brady Coated Products:** No information available. ● **Brandon International:** Pressure-sensitive labels and tags, available in standard or custom shapes and up to seven colours. Own full capability art department. ● **Brian Instruments:** Disk-drive test and measurement systems.

C ● **Calumet Carton:** No information available. ● **Carl Rodia & Assoc:** No information available. ● **CD Associates:** *SP100 Advanced Measurement Stamper Analyser* and *SL100 CD Analyser*. 'Quick test' CD Analyser tracks and records critical Red, Yellow and Green Book measurements up to 6x real time. ● **Champion Duplicators:** Diskette duplication equipment. Among new products is the *Envirodisk*, an 'ecologically correct' recyclable diskette. ● **Cintas Technologies:** CXX cassette pancakes. ● **Clover Systems:** CD analysers, including the *CDA950* with 'Quik-Scan'. Also introducing the *QA-101* low-cost CD and CD-ROM tester. ● **CMC Magnetics/Fivent:** Manufacturers of duplicator-grade, licensed, 3½-inch diskettes. ● **CMMPI:** US agent for Verity Systems' range of degaussers. ● **Concept Design:** Products for the audio and video duplicator. The *MAX* and *DAAD* digital duplicating units will be shown, along with the *CD-9002* and *CD-9000V* audio and video loaders. ● **Concord Data Media:** Manufacturers and suppliers of diskettes for professional duplicators, software developers and publishers. ● **Convac:** Complete range of spin-coating systems. ● **Corbell Publishing:** Publishers of specialist reports and directories for the video duplication and distribution businesses. ● **Costas Systems:** *Copybus 3* diskette duplication system. ● **Creative Data Products:** Supplier of bulk diskettes for duplicators. ● **Creative Disc:** Formerly *Audioidisk*. Products for the diskette duplicator include disk collators, counting machines, autoloader and stacker for degaussers, and a write-protect tab remover. ● **Cybertechnics:** No information available.

D ● **Data Disc Systems:** Range of technology for the production of CD and MiniDisc; for startups as well as established replicators. ● **Data Disc Spritzgiesstechnik:** Robot systems. ● **Datapulse Technology:** Manufacturers of 3½-inch MFDS and semi-assembled diskettes; audio webs and pancakes; diskette and cassette duplication capability; OEM projects. ● **Data Services International:** No information available. ● **Del Mar Avionics:** Manufacturers of *FireTrac* CD mastering system, a lower cost alternative to conventional glass mastering. Uses a preprocessed polycarbonate substrate to produce masters in the CD-Audio, CD-ROM and CD-I formats. ● **Design Axis:** No information available. ● **deVille Integrated:** Worldwide agents for EAM automated assembly and packaging systems. The range includes a 40+ ppm CD packaging machine designed for short runs and a one operator automatic cardboard boxer for multiple styles of jewel boxes. ● **DIC Digital:** Recordable CDs, 3½-inch, rewritable, M-O discs,

5¼-inch optical discs and a complete line of DAT, 4mm and 8mm, helical-scan, computer back-up media. ● **DIC Trading USA:** CD coating materials, offset printing systems. ● **Digipress:** *Century Glass Master* CD mastering technology, available either as a service or user license.

● **Disc Manufacturing:** Mastering, electroforming and replication service for CD audio, CD-ROM, CD-i, Video CD and CD-R. Write-once and erasable media for both standard and high-density experimental recording.

● **Dubuit of America:** Machinery for silk-screen printing CDs in up to seven colours. Exhibiting a two-colour printer for both in-line and off-line production. ● **Duplitronics:** *DHS-1 Platform Digital Master Duplication System* digital bin for audio cassette and DCC duplication.

● **Duplication Equipment Brokerage:** Suppliers of secondhand audio and video duplication equipment and systems. ● **Dwight Cavendish Developments:** Designers and manufacturers of complete video-cassette duplication systems. Recently introduced is an unattended duplicator which has the ability to dub without operators.

E ● **Edelstein Diversified:** Tear tapes which offer ease of opening and tamper evidence for film-wrapped products.

Available in all colours with custom printing of logo or message if required. ● **EIT Instrumentation Products:** CD and CD-stamper quality analysers, CD laser stack-counters and UV measurement instrumentation. ● **El Mar**

Plastics: Custom-wound blank audio and video cassettes, shells and library cases. ● **E-Media:** US distributor for the Gima range of C-0, DCC, VHS and 8mm assembly machines. Design and manufacturing consultants. ● **Emerald Technology:** Packaging automation for cassettes and optical discs. Among products on show are the new *OD-8000* CD jewel-box inserter and the *JC-7000* integrated cassette-inserting system.

● **Enterprise Corporation:** *Disc Detective* software tools for verification of the quality and integrity of data on CDs. Gives access to every sector of the CD and comparison against the source tape, disc or image file on hard-disk drive.

FG ● **Filam National Plastics:** Injection moulding for the audio, video and computer industries. Manufacturers

and distributors of CD jewel-boxes, Norelco boxes, soft poly boxes and C-0 cassettes. ● **Fuji Photo Film USA:** Manufacturers of blank audio-cassettes, video-cassettes, pancakes and diskettes. ● **Galic Maus Ventures:** CD and other optical disc moulds. Higher output conversions of Krauss Maffei CD moulds to run sub-6-second-cycle times and eliminate Remac robot arms. ● **Garner Industries:** Complete product line of conveyor-belt-style degaussers for the audio, video and computer diskette manufacturer and duplicator. ● **Gauss-Electrosound:** Complete high-speed, audio-tape, duplicating systems; analogue and DCC. ● **Gelardi Design:** No information available. ● **General Audio**

Video Cassette: No information available.

● **Global Zero:** Manufacturer and distributor of the G-Zero video cassette. The V-O shell is available in a range of colours and is 33% lighter than a conventional shell. ● **Goding & Partner:** No information available. ● **Goldstar**

Electronics International: Audio and video pancakes. ● **Greystone Peripherals:** *DataBlaster* family of hard-disk duplication equipment. IDE, SCSI and PCMCIA versions, plus host controller. Desktop PCMCIA reader-writers.

● **GTS Fabrications:** Audio and video cassettes and cases, including a wide range of coloured and transparent C-0s and cases. DCC D-0s.

H ● **H2O Plant Automation:** Pure-water and waste-water systems for optical-disc electroforming and mastering operations; complete range of fully and semi-automatic cleaning systems for use with Balzer and Leybold metalliser masks.

● **Heino Ilsemann:** CD packaging machines, plus information on CD-handling equipment and the company's range of packaging machines for audio and video cassettes. ● **Hercules:** No information available. ● **High Purity Chemical:** Distributor of cleanroom products specifically designed for the duplication-replication industry. Cleaning tapes, swabs, solvents, garments and other ▶



Balzers introduce the CDI 905 a CD metalliser

clean-production related products. ● **Hightree Media:** High-speed, compact, in-cassette, VHS duplicating system running on standard 120V AC supply. ● **Hion Industries:** Suppliers of 8mm videotape and shells, DAT tape, Beta shells, library

cases, videotape pancakes, cleaning tapes and rewinders for Video8 and VHS ● **Hollingsworth & Vose/MJM Assoc:** Introducing *Hovoliner*, new generation of embossed diskette-liners (*1500 series*), and *Hovowipe* cleaning tape featuring low lint,

thickness uniformity, precise slitting and antistatic properties. ● **Hoon:** No information available.

I ● **ICT Axxicon:** Single and multicavity moulds ranging from 64mm to 300mm. MiniDisc cartridges and DCC shells. Test equipment for optical discs. ● **Integral Vision:** *Compact Disc Advanced ID Code Reader* with learning facilities and a 'show and go' full-colour label inspection system. ● **I-O Solutions:** Introducing Zebra Technologies' new *1700xi* 300dpi thermal transfer printer, capable of printing up to a maximum label width of 6.6-inch. ● **ITA:** Trade association for the duplication and replication industry, and cosponsor of REPLtech. ● **Jackin Magnetic:** Diskettes, video tapes and V-0s. ● **JEC Vision:** V-0s, blank video-cassette tape, video pancakes, wooden CD tower. ● **JRF/Magnetic Sciences:** Magnetic recording-heads and T-Bar mounts for ElectroSound-Gauss-Otari. Information on relap services and NXT Generation R-DAT repair service.

K ● **Kammann Machines:** Exhibiting a 4-colour, automatic, screen printer equipped with a new idet and label inspection system. Also information and video showing new 4-colour offset/screen printer combination press. ● **Koch Digitaldisc:** New time-base, error-analyser board for the *CDCS-4* which allows measurement of jitter and effect length deviation to the latest Philips specification. Also the *CDCS-4/SA* stamper adaptor which ensures both protection and flatness of the stamper. ● **Kolon-Scena:** Blank video-cassette pancakes and V-0 shells.

L ● **Labeling Systems:** High accuracy labellers and printer applicators for video cassettes, audio cassettes, CD boxes, diskettes and hard disks.

Semi-automatic, hopper fed and automatic systems. ● **Laudholm Automation:** Autochanger adaptors for industrial VCRs and video-packaging equipment. ● **Lenco:** Sonic audio cassette C-0s, Soft poly, crystal, Norelco and Ampex-style audio display-boxes. Hinged poly, video display-boxes. 3½-inch micro diskettes (colour available) for OEM and duplicators. ● **Leybold Technologies:** Displayed products include a CD replication line, as well as mastering, stamper making and production metallising. ● **Lyrec Manufacturing:** Audio cassette and DCC duplication equipment.

M ● **Mag-Zon:** Zonal loading tapes, CD-R, DATs, magnetic audio-tape and film for sound recording studios. ● **Magdia America:** Blank video cassettes and V-0 shells, and R-DAT cassettes.

● **Marclyn Designs:** Introducing the *CopyRight* user-defined, self-calibrating disk drive. Also exhibiting the *Tronix Digital Media Analyser*, a blank and duplicated media tester, and the *Sigma Drive* for testing radial alignment. ● **Marubeni America:** Turnkey contractor and supplier of equipment for CD, MD and other types of optical-disc manufacturing. ● **Media Automation:** No information available. ● **Media**



Concept Design's DAAD

Service International: Test equipment for the quality control of magnetic media. Kits for the control of floppy disc drives, Augmenter and degaussers. ● **Medialogic:** Displaying the *ML4500B* modular evaluator for use with multiple media technologies, the *AccuCopy* drive for duplication applications and the *ML 3800* 4-bin, 6 and 12-spindle, certify-format systems for certification and formatting. ● **Mediaform:** Manufacturers of turnkey software duplication and packaging equipment, from high-volume industrial systems to low-cost desktop systems for small volumes. The new *Genesis Elite Network* allows control of up to 120 autoloaders simultaneously. ● **Memtek Products:** Complete range of OEM and professional magnetic media products featuring 1/2-inch computer tape, data cartridges, 4mm and 8mm products, bulk diskettes and V-0 video cassettes. ● **Metro Magnetics:** Audio cassettes, pancakes and C-0s, and Norelco boxes. ● **Michelex Industrial Group:** Jewel boxes and special packaging for CDs. Cassette shells and cases. ● **Microtech Conversion Systems:** Duplication and verification systems for CD manufacturing. Supplier of scalable computer media duplication and conversion systems for the software and software services industry. ● **MTC America:** Video duplication and QC equipment. ● **Multi-Media Publishing & Packaging:** Vinyl audio and video albums, vinyl binders and alternative packaging. ● **Multi Media Masters & Machinery:** Mastering, engineering and project management services. Range of CD replication machines including new *MCL 5000* for CD-R production and *MCL 8000* for recordable MiniDisc.

N ● **Netstal Machinery:** Moulding subsystems for 64, 80, 120, 130, 200 and 300mm optical and M-O discs. Product range includes injection-moulding machine, mould, take-out device and mould temperature-control unit. ● **Nimbus Technology & Engineering:** Manufacturers of the Nimbus-Halliday Laser Beam Recorder. ● **Nobler Technologies:** CD replication equipment. New *NTG170 Galvanic Electroplating System* offers precision to within 5 microns. Each plating cell is equipped with its own reservoir tank. Unique 'carry case' design permits Glass, Father and Mother changeover in less than 30s. ● **Noncontact International:** No information available. ● **Nor-cote International:** No information available.

O ● **Ocean Development America:** C-0 and V-0 shells, T-120 video tape, 3 1/2-inch HD and 5 1/4-inch HD and DD diskettes. ● **ODME:** The *Monoliner MkIV* in-line CD replication unit, *ABC 200 DS Test System*, and the *ODME Media Conversion System* for mastering CD-Audio and CD-ROM. ● **Olamon Industries:** Sonic opaque and crystal C-0s, screw-type crystal C-0s, chrome notch, metal notch. Clear audio box, heavy-duty CD jewel-box. ● **Optical Disc Corporation:** Turnkey glass-mastering systems (with 2x and 4x speed capability) for CD-Audio, CD-ROM, Video CD, MiniDisc and MD-Data disc manufacturing.

Direct-Read-After-Write (DRAW) process permits real-time monitoring. ● **Otari:** New additions to the *TMD* video duplication range; the *Mini-Pro'* *TMD* production code system; a redesigned 1/2-inch audio master-tape recorder; new bidirectional *QC* machine and double pancake loaders for VHS, audio cassette and DAT.

P ● **Packaging Dynamics:** Complete packaging systems for the M-O media industry, including cartoners, sleeves, labellers, inserters, tuck 'n' fold overwrappers and bundlers, shrink tunnels and case packers. ● **Panasonic Broadcast & TV Systems:** Full duplication product line including; D3 master and 2x slave for real-time duplication, mid-line duplicator and automatic tape-loader. ● **Philips Consumer Electronics:** DCC production and verification equipment for high-speed and in-cassette duplication. 18-bit, 4-track, surround-sound player and 20-bit, 4-track, recorder. ● **Phillips Business Information:** Publishers of newsletters and magazines for the data, telecommunications, multimedia and document imaging markets. ● **Pilkington Micronics:** Manufacturers of all types of glass-mastering discs and direct-write substrates, to any specification for any mastering system. ● **Pilz:** Fully automatic production equipment for CDs and jewel boxes; automatic packaging equipment; screen and offset printing equipment and handling system. Production of CD-Audio and CD-ROM discs. ● **PME/Price Manufacturing & Engineering:** VCR racks, distribution amplifiers, machine control and wiring. ● **Polywest:** Audio, video and software packaging and mailing products, plus reels and boxes. ● **Ponica Industrial:** V-0 and C-0 cassette shells, CD jewel-boxes. ● **Preco:** Master US distributor for the Weircliffe range of bulk-tape erasers and degaussers. Showing selection from the range relevant to duplicators, including the new *Model*

320 conveyor system. Test equipment for duplicators and replicators. ● **Pride Plastics:** Manufacturer of injection-moulded packaging for CD-Audio, CD-ROM, video game and VHS entertainment media. ● **Prime Standard/Benelux Manufacturing:** Manufacturers of diskettes, CD jewel-boxes, microcassettes, audio and video cassette-housings and components. ● **Production Automation:** Microprocessor-controlled cassette-inserting machine folds J-card and inserts cassette and J-card into a Norelco box. ● **Pro Sound News:** News magazine for the professional sound recording and duplication industries. *PSN* also publish *EQ*, *Videography*, *TVB* and *GMV* magazines. ● **Proteq Magmedia:** DCC—D-0s, L-covers outer boxes and pancakes for duplicators; 'Goldtron' brand and OEM blank DCC cassettes for the consumer market; 3 1/2-inch floppy disks—cookies and bulk; video cassettes—V-0s, bulk and OEM.

R ● **Record Products of America:** OD-ID stamper-punch and stamper-sander, targets, CD-plating and glass-cleaning systems. ● **Reflekt Technology:** No information available. ● **Research Technology:** Manufacturers of *TapeChek* videotape test, evaluation and cleaning systems. Products include video-tape dropout counters, and the *ProLine-series* of tape evaluators for a wide range of video, instrumentation and data formats. ● **Reynolds Tech Fabricators:** No information available. ● **Rimage:** Manufacturers of equipment that automates diskette duplication, label printing and application, sleeving, collating and set separation. Other products include CD-R systems and tape duplication equipment. ● **Robi Systems:** The *Robi Rondo-Line* is the latest RobiSystem CD replication line, designed for flexibility and versatility. Capable of producing up to 1,200 discs per hour. ● **Roldex Industries:** Audio and ▶



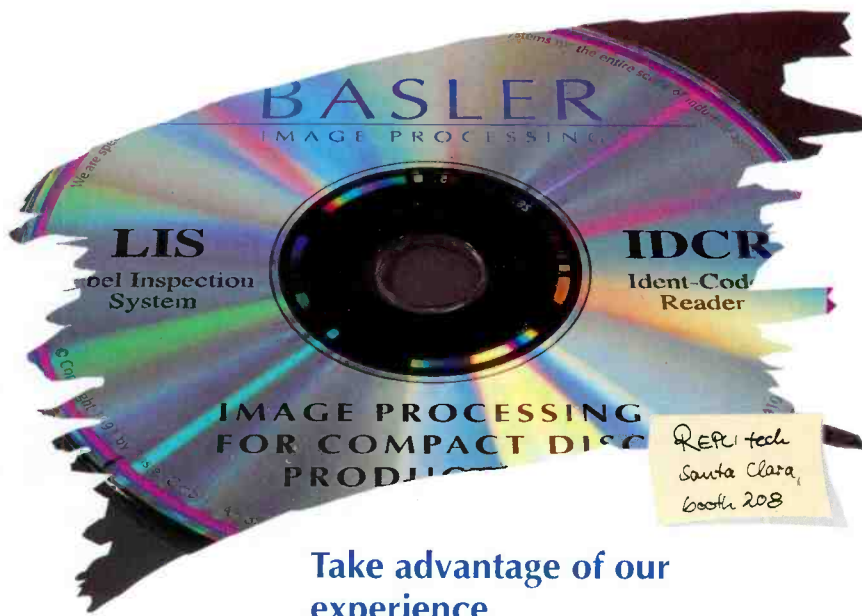
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video cassette-imprinting equipment.

● **Rose Packaging & Design:** Showing examples of products they have produced to package audio and video cassettes, and CDs. Also, their new line of stock audio and video cassette albums.

● **RZG Technologies:** No information available.

● **Saehan Media:** No information available. ● **Saki Magnetics:** Range of longlife ferrite heads for studio recorders and high-speed duplicators, plus heads for Telex, Kaba and Otari in-cassette duplicators. A full relap service is also offered. ● **Scandia Packaging Machinery:** Overwrapping, box loading and cartoning machinery for CD, MC and R-DAT. ● **Semitool-Semitherm:** Spray tool for cleaning, etching, developing and stripping photoresist. ● **Serigraph:** Offset-quality colour transfer graphics for decorating CDs. ● **Shape:** Mark 10 audio-cassette C-0s, standard C-0s, full range of VHS V-0 cassettes, Norelco boxes, DAT cassette D-0s and DAT boxes, PCMCIA packaging, CD jewel-boxes and other alternative CD storage and packaging products. ● **Shar-V Imports:** No information available. ● **SKC America:** Full line of video pancakes for real-time, Sprinter, TMD and long-play applications, plus V-0 shells.

● **SKMA:** Range of audio-cassette duplicating tape consisting of ECX chromium dioxide, HCS cobalt ferric, SKX premium ferric oxide and SH ferric oxide. ● **Soleras:** Manufacturers of targets, backing plates, masks and spare parts. ● **Sollas:** Showing media products which have been overwrapped, bundled and banded on their range of machines. ● **Sony Corporation of America:** Sony will be promoting the various features of the MiniDisc format, which they have developed as the intended replacement for the analogue cassette.

● **Steag Industrie:** Modular and stand-alone disc coating systems for CD-Audio, CD-ROM, M-O and CD-R, including CD-R dye-apply. ● **Storeel:** No information available. ● **Success Speciality Sales:** Audio and video splicing tapes, loop bin splicing tapes, sensing tape and tape wipes.

● **Sun Logic:** No information available.

● **Sunrise Packaging:** Stock and custom packaging for audio and video cassettes, computer software, CDs, vinyl specialities, turned edge albums, and seal and cut albums. ● **Systek:** No information available.

● **TAM Packaging:** Manufacturers of overwrapping and multipacking equipment for all media. On show will be the *Model W373N* overwrapping machine for CDs, video tapes and audio cassettes.

● **Tapematic USA:** New *Miniseries* of loaders for audio, and 8mm and VHS-C video. Also new is the *Re-Loader*, which recycles loaded VHS cassettes by removing unwanted tape before loading new program. Duplication systems include SAM and the Dupcentre analogue bin/two-slave combination.

● **TDK:** Showing their full range of audio and video duplicating tapes, as well as their studio and industrial audio and video cassettes.

● **Teca-Print:** Manufacturer of automated 5-colour screen-printing system, featuring patented optical sensor for colour-to-colour registration ▶

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HEKUMA ROBOTS/AUTOMATION LINES FOR:

DATA PRODUCTS

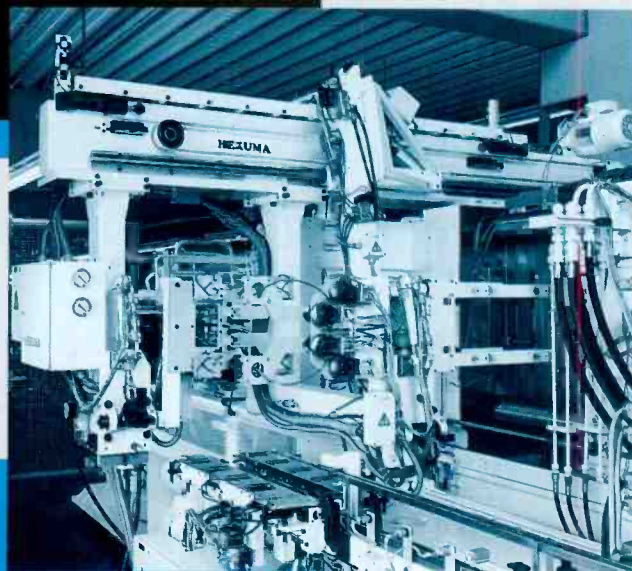
3.5" Micro Floppy Diskette,
Data Cartridge Case.

VIDEO PRODUCTS

Cassette Cover and Base,
Window, Reel Hub, Reel
Flange, Front Door.

AUDIO PRODUCTS

C/O Cassette cover and case,
Library Case (L/C, Norelco
Box, C/O Box), CD Jewel Box,
CD Brilliant Box, CD Two
Piece Box, CD Twin Box, CD
Multi Pack, CD Tray, Compact
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and visual inspection station. Handles up to 3,600 CDs per hour. ● **Tetko:** Line of Swiss precision-woven screen-printing fabrics and screen-making equipment. ● **3M Convention Services:** No information available. ● **Tomei Industries:** C-0s, V-0s, 3 1/2-inch MFD, pancakes, preloaded audio and video cassettes, audio pancakes, Norelco and soft poly boxes, and CD jewel-boxes. ● **Toolex Alpha:** Injection-moulding machine for CD-Audio, CD-ROM and CD-i; plating systems and equipment; complete CD replicating, monitoring and control systems. ● **Trace:** Manufacturer of professional diskette and CD-ROM duplication systems, media formatting and

certification equipment, labellers, printers and collators. Products range from large-scale to desktop systems. ● **Triptych CD:** No information available. ● **Truminco of California:** Supplier of video heads and spare parts, video tapes, pancakes and V-0s.

UVW ● **Univenture:** Safety-sleeve packaging products for CD and other optical disc formats, plus inserting equipment for safety-sleeve products. ● **Veratec:** Manufacturer and supplier of nonwovens for use in magnetic media applications,

such as computer diskette liners. The company also supplies disposable computer disks. ● **Versadyne International:** High-speed audio-cassette duplication systems. Complete turnkey installations. ● **Victory Enterprises Technology:** No information available. ● **Videolux Canada:** Custom-loaded VHS and S-VHS cassettes, and related products. ● **Vinylweld:** Vinyl packaging solutions for multimedia and software, plus stock audio and video packaging. ● **Waxxon:** Audio cassette shells, CD jewel-boxes, Norelco boxes and V-0s. ● **Webster Communications:** Publisher of magazines and guides for the software industry. ■

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REFLECTED GLORY

Adapting the CD for picture. ODC's Ralph Oshiro looks at high-density optical storage and compression solutions for digital Video CD formats

Searching for a new consumer platform, consumer electronics manufacturers have been vying to create new markets and new applications for the basic CD-DA (compact disc digital audio) player architecture. Thanks to advancements in compression presented by compression-chip developers, single-chip video decoders are now widely available at low cost. These decoders make possible the playback of

1.1Mbit/s–1.4Mbit/s video from a standard density, 120mm CD, spinning at normal speed.

Considering that a full-bandwidth, CCIR 601 digital video bitstream requires sustained data rates of up to 270Mbit/s, the need for highly efficient video compression technology is clear. Although CD manufacturers are already gearing up for standard CD data-rate video CDs, pressure is mounting for higher data-rates and the resulting requirement for higher physical densities.

Source format and output quality

Many factors can affect the final quality of the compressed video bitstream, starting first with the quality of the input source. Even though digital video-tape formats are becoming more pervasive in video-acquired motion images, the highest-quality acquisition medium is still 35mm film. When acquiring source from film, the resulting image quality after compression is nonetheless higher than video due to film's lower frame rate of 24fps (frames per second). The dynamic range and resolution of film is far superior to standard television resolution and is still better than HDTV. When encoding material which has already been transferred from film to video tape (using the 3:2 pull-down process to reconcile the difference in frame rates from 24Hz film to 29.97Hz for NTSC), a process known as reverse telecine is required to take advantage of the lower film frame-rate.

The preferred source input format for compression is the D1 digital videotape format, the

storage medium generally used to store full-bandwidth, CCIR 601-resolution video information. D1 stores uncompressed, digital component video and is typically used in telecine environments and in high-end postproduction applications (component video retains signal quality by keeping the colour information separate from the luminance information). Among other reasons, this is the preferred input format because none of the artefacts (noise, colour fringing and so on) of composite video are introduced into the source signal.

The ISO-IEC 11172 MPEG I standard was developed to accommodate compressed data representing motion video at data rates of about 1.2Mbit/s, the approximate CD-ROM-user data-rate, and in fact is optimised to this specific data-rate. The MPEG II standard will address much higher data rates and will be able to accommodate broadcast video applications.

MPEG encoding

Although several MPEG encoding systems are on the market, most of the high-end work is being performed by highly specialised service bureaus and postproduction facilities which have acquired special expertise in this kind of work. Among the busiest compression facilities today is one of Hollywood's largest post houses, Laser Pacific Media Corporation in Los Angeles, California. Laser Pacific have invested in state-of-the-art technology specifically designed for motion image compression for CD data rates. Based on IBM's *Power Visualization System*, a massively powerful parallel, 32-processor, super

1x Density



8x Density



AFM Profiles of standard and ultra-high-density NPR CD masters



CCIR 601-resolution digital videodisc image

minicomputer, Laser Pacific have combined custom-designed prefiltering software with powerful hardware to produce what many say is some of the best low bit-rate video around.

Less expensive VME-bus (*Unix*-based) and ISA-bus (*PC*-based) MPEG I encoding systems are also being offered by several vendors. Although quality varies, MPEG I encoders are improving, and when used in conjunction with noise reduction or 'prefiltering' techniques, output can be quite good. Noise is one of the greatest contributors to poor quality output due to the resulting artefact worsened by the compression algorithm's attempts to process the noise as information; therefore, desktop MPEG encoders are best used with prefiltering or preprocessing of the source video. BTS' *MNR-10* noise-reduction box has become the prefiltering system of choice for many owners of ISA-bus MPEG encoders.

While the high-end MPEG encoders typically accept a D1-type SDI (Serial Digital Interface) input, most desktop encoders only accept *Betacam*-style component inputs (Y, R-Y/B-Y), or even worse, an S-Video Y/C-type input. Keep in mind that *Betacam* and S-Video formats are analogue formats (with the exception of Digital *Betacam* which uses compressed video at 2.7:1) and do not match the quality of D1 source.

After video compression, premastering for either the *White Book* format or CD-i FMV is required. OptiImage in West Des Moines, Iowa supply complete CD-i authoring and *White Book*

premastering tools—*White Book* Video CD premastering capability is also available from a number of other premastering software vendors and can be integrated with other desktop premastering systems.

Once video compression and premastering is completed, the disc image is typically written to a CD-R (recordable CD) for input into an optical

mastering system (glass mastering recorder), the first step in the disc manufacturing process. Although Exabyte data-type cartridges are also used, CD-Rs are becoming increasingly popular since they are so well suited for rapid prototyping.

All of the video compression we have been discussing so far is what is called SIF-resolution (Source Input Format) video. The quality of this ▶





SIF-resolution White Book video CD image

video is roughly equivalent to VHS, and in fact, if not done well, does not match VHS, especially when motion and computer graphics or titles are involved. Defined by the ISO-IEC MPEG I standard, SIF-resolution video contains 352 x 240 pixels at 29.97Hz (352 x 288 at 25Hz). This is a quarter of the information contained in a CCIR 601-resolution picture which has a resolution of 704 x 480 pixels. Video compression systems which encode CCIR 601-resolution images are not yet widely available.

Future high-density video CD formats

Although Japanese player manufacturers are already shipping White Book-format Video CD players (which employ a video data-rate of 1.1519Mbits/s), many are looking toward better quality images and longer play times. This means higher video data rates and higher physical densities. While many factors can affect the final image quality of a compressed image, one of the largest is, of course, data-rate—the higher the data-rate, the higher the video quality. Given some of the desired features for the next generation high-density CD format, some suggest that 4x density and higher will be required for a new, higher quality video CD format. Presented to the IEC meeting of TC60 in Bucharest, Romania in April 1994, ODC have developed an open

specification which outlines basic parameters for a high-density, 120mm CD format which uses currently available technology. The specification allows for backward compatibility to existing formats and does not require playback using blue (shorter wavelength) lasers. As a leading CD mastering-equipment supplier, ODC developed this specification to address requests from the firms in other CD-related industries. ODC were asked to supply realistic information to aid them in their business decisions regarding the future of CD technology, and the result was the ODC *Blue Book*, a proposed standard for a HDCD (High-Density Compact Disc) format.

Hoping for a 'VCR of the 1990s', consumer electronics manufacturers are expectant of the new formats and are carefully selecting the appropriate mix of features and benefits which will support long-term consumer adoption of yet another home entertainment format. Even though ODC have demonstrated high data-rate video (employing a video data-rate of 5.6Mbits/s) at 2x standard density, ODC have also developed technology which makes 4x density and even 8x density mastering a demonstrated capability today. Since many in the industry are hoping for new technology to make the dream of single-disc movies at higher data-rates possible, ODC have been working on the enabling technology for both high-density and ultra-high-density CD mastering. At 8x standard CD density, movies of very high quality could be stored on a single side

of a 120mm CD—although at this density, shorter wavelength lasers are required for playback.

Because the challenge for disc manufacturers will increase as physical density grows, ODC developed optical systems and process technology which positions our customers with a significant competitive advantage for high-density CD manufacturing capability. ODC's unique high-definition mastering process produces a characteristic pit geometry specifically optimised for high-density moulding. And because accurate signal recovery in playback becomes even more critical in high-density CD manufacturing, ODC's patented jitter-reduction technology further enhances our customers' manufacturing capability for future formats.

Although the dominant player-manufacturers will eventually determine the feature mix and physical densities for the next generation video CD standards, ODC regard themselves as having made the first move toward making such standards publicly available. Serious investment decisions are being made at the studios, in consumer electronics, software publishing, electronic gaming, telephony, and CATV—and decision makers need the most accurate information available. Looking toward the future, ODC have extended their commitment to continue to develop leading-edge capability to provide the industry with the most open-ended mastering technology available. ■



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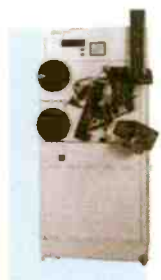
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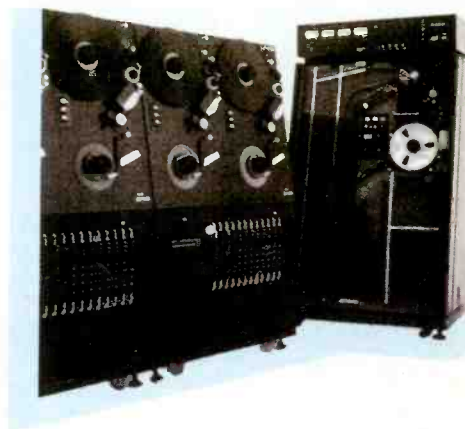
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THE RESURRECTION MEN

Patrick Stapley visits Abbey Road studios to investigate the systems used in their many audio restoration projects

Once upon a time audio restoration was a pretty crude affair. It involved the laborious, often hit-or-miss, procedure of manually editing clicks from analogue tape using a razor blade and the equally unsatisfactory process of reducing hiss with filters that inevitably dulled the programme. The last few years have seen something of a revolution in the restoration business, however, with the American Sonic Solutions and British CEDAR audio companies leading the way with their respective computer-based systems.

One studio that takes audio restoration very seriously is London's Abbey Road—hardly surprising when one considers the studio's first recording was made 63 years ago, and given the sheer size and age of EMI's archives. Abbey Road offer both Sonic Solutions' *NoNoise*, and a full CEDAR (Computer Enhanced Digital Audio Restoration) system. *NoNoise* has been incorporated into the main Sonic Solutions remastering room operated by Peter Mew, while the CEDAR system has been installed in the studio's historical remastering suite run by Andy Walter.

Although no-one at Abbey Road suggests that one system is better than the other, the general consensus is that for more intricate work *NoNoise* is preferred, and for jobs requiring fast throughput, CEDAR is the more suitable system.

'One of the major differences between *NoNoise* and CEDAR is that CEDAR doesn't allow the operator anything like the same amount of control', says Peter Mew. 'It basically offers two parameters. In some ways this is a good thing in that it makes the system a lot easier to operate, but it does restrict user input.'

Where the CEDAR system scores heavily over the Sonics system, however, is in its cost-effectiveness—because it operates in real time,

the studio time invested in a CEDAR-processed project can be dramatically less than one processed by the Sonic system.

NoNoise

Sonic Solutions' *NoNoise* processing falls into three areas—declicking, decrackling (bacon frying) and denoising (hiss and background noise reduction). The order in which processing is performed is to begin with the big things first—clicks followed by crackle and lastly noise. The processing itself works in non-real time apart from denoising which can be a real-time process; however according to Mew 'smoother results' are achieved by denoising in non-real time, and he will normally leave this along with the other processes to 'cook' overnight—but isn't this working a blind?

'You can usually gauge from experience how things are going to sound; there are a lot of parameters that you have to tinker with and after a while you get a feel for how to optimally set them. Also the system provides a manual declicker, so if there are any clicks that get through the net they can be removed afterwards.'

Declicking is performed in two stages—first the system works its way through the programme detecting where the clicks are, and then it removes them on a second pass. There are various parameters associated with recognising and defining clicks, such as Threshold, Centre Width (spike or attack) and Wing Width (ringing or interference either side of the spike). For removal there is another set of parameters concerned with the amount of the click that should be replaced (Replacement Width), how much information the computer refers to either side of the click in order to interpolate replacement audio (Context Width), and how much time the system will spend processing (Replacement Order).

For decrackling, the operator must first tell the system what to expect in terms of good and bad samples—thus if the Clip Fraction is set to 0.9, *NoNoise* will expect 90% good samples and process the 10% bad ones.

'You've got to be careful how you set this,' warns Mew, 'as the more bad samples you tell it to look for the more likelihood that it may in fact start processing good ones. Generally speaking I very rarely drop the Clip Fraction much below 0.7; if the programme is so bad in the first place, there's no way you can expect to get back pristine material, you'll get an improvement but it's directly relative to the original.'

Like declicking, decrackling also has a parameter (Synthesis Order) that determines how much time will be spent on processing and ultimately how good a job will be done. According to Mew there is a continual trade off between the time the system takes to process and the quality of the end result. High Synthesis settings and high percentages of bad samples can result in processing

taking up to 20x real time.

Denoising works by dividing up the audio spectrum into 2,000 bands; the system then checks each of these bands against a noise sample or 'fingerprint' taken from the source material, and attempts to gate the noise down where it can without adversely affecting the programme.

'To denoise you first have to tell the machine what noise looks like,' explains Mew. 'This ideally means finding a section of isolated noise between a half and one second long—for instance if you're working on an edited album, this could be just before or just after a track. It is possible to do it without using isolated noise but it's more difficult that way.'

Successful denoising is dependent on a number of parameters: Maximum Noise Reduction, the Threshold setting, Release Time (Sharpness), and Bandwidth which sets the amount of sharing between adjacent frequency bands functioning rather like a frequency 'gang' control. The high and low frequency cut off points between which processing will occur can also be set by the user.

'Because there are so many parameters that can be adjusted, you can get hugely varying results with the same noise sample, and if you're not careful there are a lot of artefacts that can creep in very early on. This is where the real-time processing comes in useful, allowing you to try out different combinations and arrive at an optimum setting before processing in non-real time.'

Leaving aside the overnight processing time (which is not charged to the client), how long does it take to *NoNoise* the average album?

'If it's just denoising then it takes around four hours. You can add another hour for click and crackle removal and a bit extra to cover any manual declicking. Unfortunately, there's always this ►

'The more bad samples you tell it to look for the more likelihood that it may in fact start processing good ones.'



Peter Mew restoring Captain Beefheart to life in the Sonic Solutions remastering room at Abbey Road

thing in the back of your mind about the budget, and although it would be nice to devote about nine hours per album, by taking noise samples from every track and testing them in different ways, it's not feasible in the majority of cases.'

Because of the remastering expense involved, the projects that Mew tends to work on are the releases that record companies consider will be big enough sellers to justify the extra expenditure. A typical case being the *Red* and *Blue* Beatles CDs which Mew remastered from the original tapes.

'One's recollection of those tapes were that they sounded really good, but listening to them now they're actually quite bland. What you find with tapes of this era, is that in order to make them sound "better" you invariably have to brighten them up—which, of course, accentuates the noise. So really the *NoNoise* processing in this case is not to get rid of hiss because it's obtrusive, but rather to allow you to add top without bringing the noise up. At the end of the day you may not finish up with any less hiss than if you'd left the tapes flat, but you do end up with a much brighter result.

'The Beatles' tracks, apart from top, required quite a lot of EQing in different ways to make them sound more modern and punchy—there was, of course, more work necessary on the *Red* album which contained the older material.'

Other projects Mew has worked on recently include

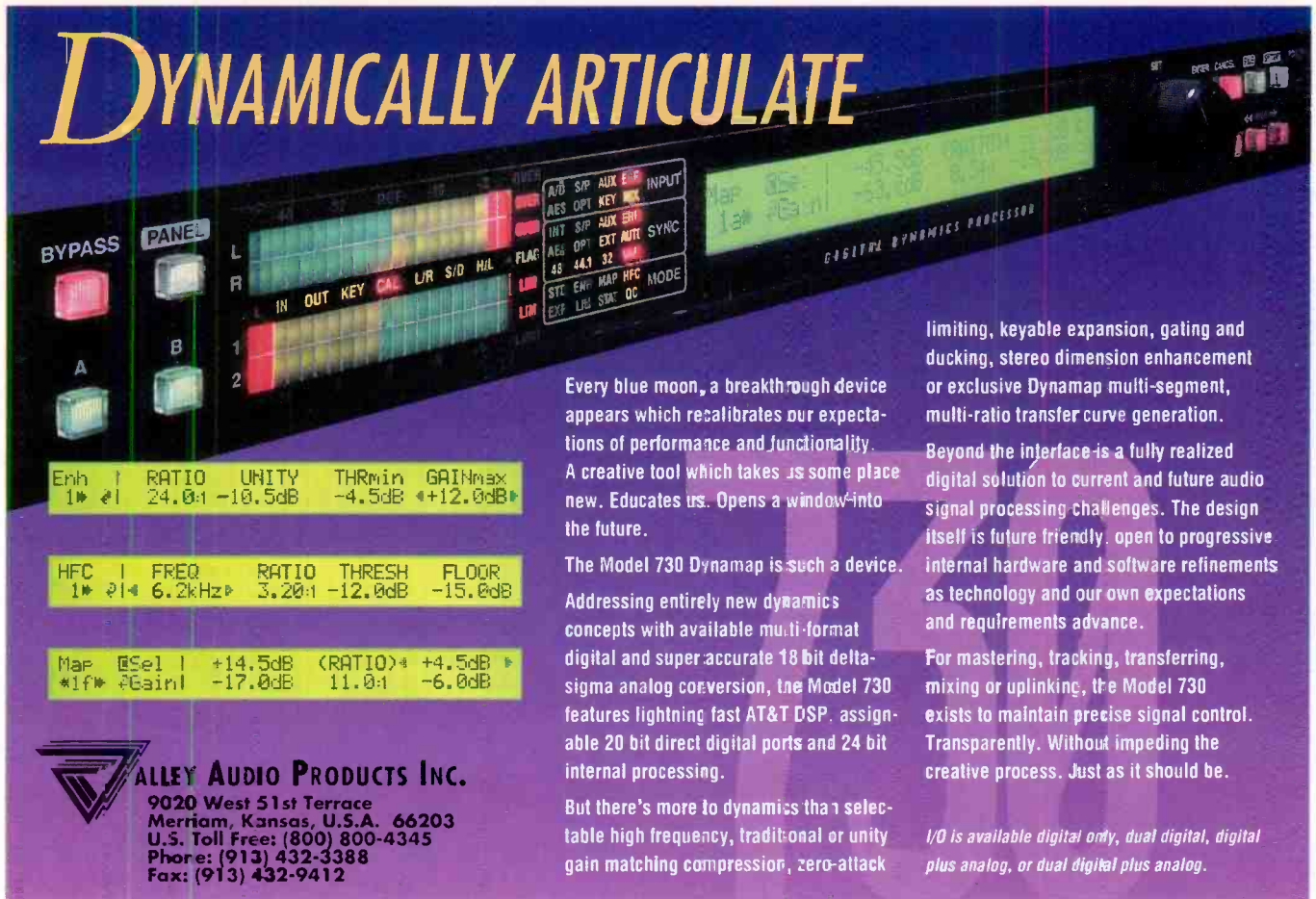
'The Beatles' tracks required quite a lot of EQing in different ways to make them sound more modern and punchy'

The Sue Story—a 4-CD set containing 100 vintage R&B tracks many of which had to be taken from disk as the original masters no longer existed, and all of the Wings albums. He has also restored some of the records he engineered himself in the 1960s and 1970s with such artists as Kevin Ayers and Roy Harper, which he describes as an enlightening experience. However, by no means all the restoration work Mew does is from back catalogue, and a lot of it involves brand new material.

'There are all kinds of examples of newly made recordings where problems have crept in: I get things which have excessive desk noise, air conditioning noise, lighting buzz, chair squeaks, time-code spill *etcetera*. I even had this soundtrack the other day which was supposed to be a group of Incas worshipping in a temple—the only problem was that when it had been recorded, someone in a next door room was listening to *The Archers*, and this had been picked up in the background complete with signature tune. That was actually quite difficult to remove and impossible to do without affecting the original programme—however, the client was quite prepared to accept some compromise in speech quality in order to get rid of *The Archers*!'

The Archers and the Incas is an extreme case where overprocessing is acceptable, but normally Mew would back-off processing as soon as he ►

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Room 13—Andy Walter restoring historical recordings using the CEDAR remastering system at Abbey Road

became aware of any artefacts creeping in.

The effect of overprocessing is quite odd; it starts off by sounding like a very slight phasing effect and at its worst sounds like someone talking under water. You can actually get away with quite a lot of it on music, but on speech the artefacts tend to be much more noticeable because our ears are so highly tuned to the human voice. I work on a principle that if you can hear the quality being affected you've done too much; I always explain to people that the process isn't magic, and that if you end up with noise and stuff at the end then that's tough because I've done as much as I possibly can without compromising the programme.'

CEDAR

I left Mew trying to restore life to Captain Beefheart and went in search of Abbey Road's CEDAR system and Andy Walter.

Room 13 at Abbey Road deals exclusively with restoration work from historical recordings, the bulk of which are transferred from 78 via CEDAR. In charge is Andy Walter who does most of his

*The focal point
in Room 13 is an
EMT 927 record
deck built in
the 1950s*

work from EMI Classics, mainly covering the period between the mid-1920s and early-1950s —although he has restored discs dating back as far as the 1890s. Walter's source material is usually from 78s (discs as well as positive and negative metals), but he also works from early vinyl and early tape; consequently a considerable portion of his time is taken up with finding the best available material.

'Although a lot of the records I work with come from the EMI archives, a lot also originate from specialist collectors, The National Sound Archive, and the BBC. I've even gone to America, Australia, New Zealand, South Africa and India to get pressings that may be better. The better the source the easier the job and the better the end result. I'm always waiting for a record here and a record there with the net result that I can often be working on ten projects at once.'

The focal point in Room 13—looking somewhat anachronistic beside CEDAR—is an EMT 927 record deck built in the 1950s with a massive 15-inch turntable. The deck has been specially modified to cater for restoration work, and a facility that Walter makes frequent use of its ability to ▶

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play backwards.

'Being able to play a disc in reverse is very useful. A lot of the disks we use can be quite worn, and by playing them from the inside out, the stylus plays against the wear and therefore gives much better results. One of the neat things about CEDAR is that it allows you to record programme into the system and then reverse play it—so we end up with things the right way round without having to do an analogue copy in between.'

The EMT deck also incorporates varispeed which again is regularly used, as Walter explains.

'I've hardly ever found a record that plays at 78.0 RPM spot on, so I'm always having to varispeed discs back into their correct pitch. This is normally quite straightforward but occasionally the intended pitch isn't that obvious, and this can involve a bit of extra research and a few phone calls to musicologists.'

Various sizes of elliptical and conical Stanton styli are used, and Walter quite often finds that a different stylus will suit different parts of a record. As a result, it is not uncommon to transfer a disk up to three times using different styli, taking the best parts from each transfer.

From disc to CEDAR the audio first goes through a proprietary 78 filter that optimises the high-end curve, and then through A-D conversion via a Lexicon 300 system which Walter prefers to the internal DAT convertors of his Sony 2500 and 7010 machines.

The CEDAR system then offers three main processes: descatch, decrackle and dehiss. Although the system operates in real time, each process requires a separate pass, so quite often it will take three passes to properly clean up a 78, the procedure involving DAT-to-DAT copying through CEDAR.

As with Sonic Solutions, the CEDAR system requires a noise sample to calculate noise reduction, and again this works best if the sample is taken from isolated noise. However, Walter is very careful about just how much surface noise he removes, and never removes it entirely.

'There's a very fine balance between reducing surface noise and perceived brightness. It's important to remember that the programme frequency range on a 78 is pretty restricted due to the technical limitations of the day, and the effect of taking away too much hiss can leave a very dull, lacklustre sound. To try to retain the perception of brightness and life in the sound it's actually important to leave a degree of surface noise in at the high end. I tend to remove noise that is in the programme frequency range and leave the high end stuff as it is.'

'It's interesting that when I've transferred something from metals rather than the actual discs, I've had reviewers comment that the sound is duller than the original 78, but this is because the metal is naturally a lot cleaner than the record so it effectively sounds duller. You get into this strange thinking of "perhaps I should be adding more hiss to give the illusion of brightness!"'

Another side effect of reducing surface noise can be to make the programme material sound quite dry, and Walter will compensate for this by adding a little digital reverb ('very subtly') to help. As he says, 'the golden rule is not to change the

characteristic so that it sounds like a modern recording, but to try to make improvements in as sympathetic a way as possible.'

As mentioned earlier by Peter Mew and confirmed by Walter, CEDAR allows occasional clicks through when associated with 'really big clunks'. These will be removed at Abbey Road during the assembly of the CD using Sonics Solutions' manual declicker.

Forensic work

Another area of restoration that Abbey Road get involved in is forensic work—here again Mew has plenty of experience.

'Forensic jobs tend to be extremely difficult because they've got to be pretty diabolical to be sent here in the first place—for example, I had one

'Stan Tracey had problems with the masters for his Under Milk Wood album, so he brought in three mint-condition LPs from which we remastered the CD'

where a plain-clothed policewoman had interviewed a suspect with a Dictaphone hidden in her handbag while standing next to a very loud jukebox. All we could really do was use the Sonic EQ to bring out the voice and lose as much as the background as possible. Another case involved a bug that was built into a fake mains plug; these are extremely sensitive and are designed to work from a distance. What had happened in this case was the bug had been positioned far too close and had badly overloaded—we managed to smooth it out as best we could and get some intelligibility back. Buzzes and hums covering voices are quite common and tend to lend themselves pretty well to denoising.

'However, whatever it is you're doing whether it's forensic work or remastering, the one thing that really determines how good the results will be is the quality of the original programme. I've had some stuff from the early-1980s, which because its pretty damn good in the first place, sounds superb

once its been processed. It's also much better for us to receive the original source material rather than someone dubbing it off for us—a properly aligned tape can make all the difference.'

Another use Walter finds for the Sonic system is in joining together 78 sides.

'By using long crossfades and equalisation one can seamlessly match one side to another. What happens towards the end of a 78 is that the surface noise drops in level, so there can be a sudden jump in noise of around 4dB or 5dB when joining sides. What I also try and do is compensate for this through CEDAR by gradually increasing the hiss towards the end of a side.'

A restoration job that Walter's is particularly pleased with is the EMI Records 9-CD set of *The Elgar Edition*. It includes all the historical recordings made by the composer himself, and was pieced together over a period of a year, with Walter searching high and low for the best material to work from. One of the more famous recordings contained in the set is the violin concerto recorded by a very young Yehudi Menuhin at Abbey Road in 1931. This already existed on four separate CDs, but Walter felt the quality of the previous releases was not good enough.

'I received the metal work from EMI's archives that had been used for all the other reissues, but it was in pretty poor condition. I knew from records that copy metals had been made from the mother stamper in the 1930s, so on the off chance I got in contact with RCA in American to see if they could locate them. After quite a bit of searching they turned up a pristine set, and from these I had vinyl pressings made which I used for the remastering.'

Walter also does a certain amount of remastering directly from vinyl LPs on occasions where record companies have lost their master tapes.

'I think we'll see more of this kind of thing in the future as the results have been very successful. For example, the jazz pianist and composer Stan Tracey had problems with the masters for his *Under Milk Wood* album, so he brought in three mint-condition LPs from which we remastered the CD for Blue Note. I think it would be very hard for people to tell that it had been remastered from disc rather than tape.'

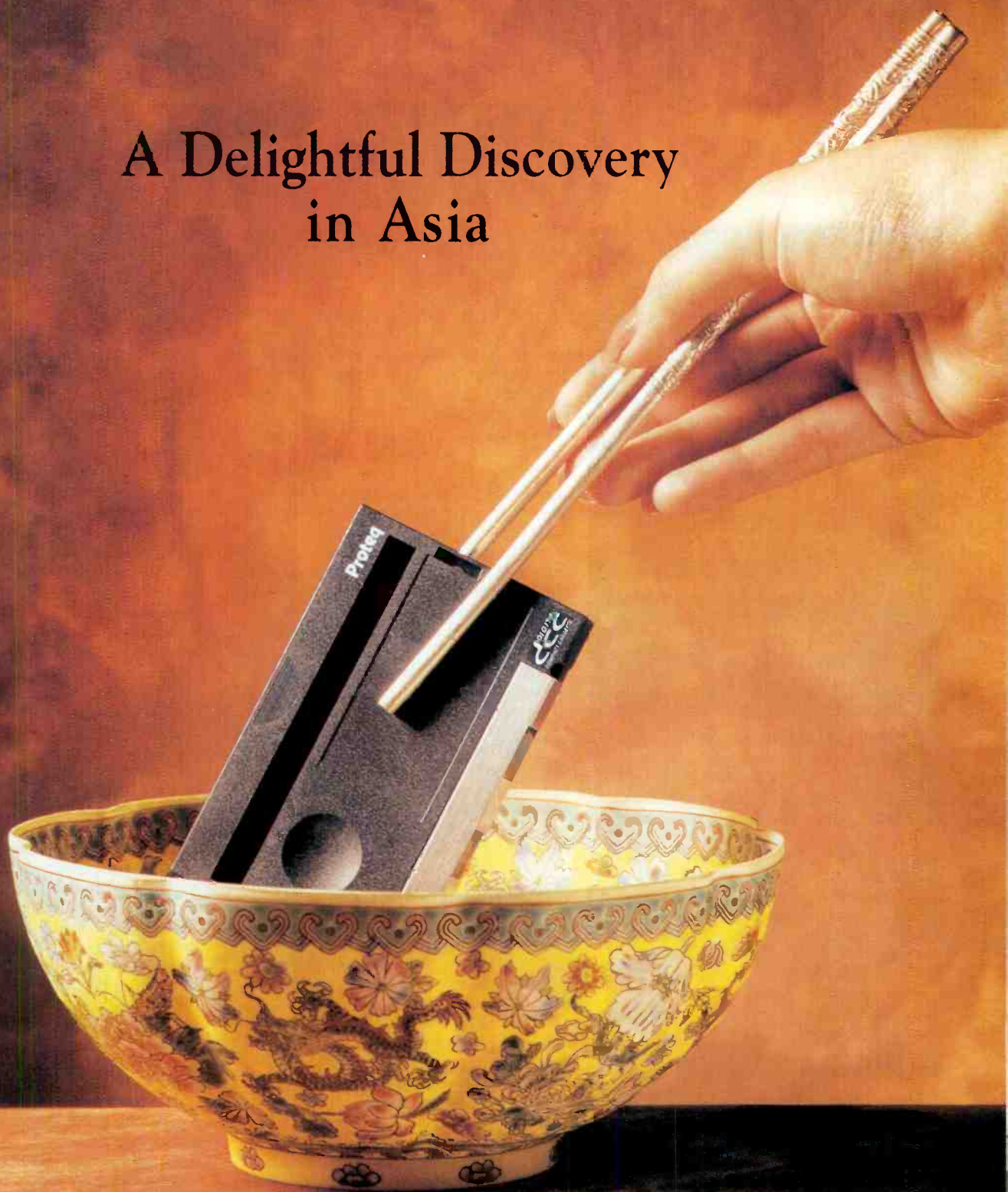
Being something of a perfectionist, Walter admits that he's never entirely satisfied with the finished result and is continually striving for improvement.

'I think one can always envisage improvements, and it's important that we keep trying to get things better and better. If I listen to things I did three years ago, for example, I know I could do better now because the software's improved and I suppose so too have my skills. That's why it's absolutely crucial that we hang on to all our archive material and look after it as best we can. Who knows what developments the future may hold! ■

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CEDAR Audio, 5 Glisson Road, Cambridge CB1 2HA, UK. Tel: +44 223 464117.
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GOING OUTBOARD

The choice of outboard equipment can readily give one mastering facility an edge over another. Bill Foster takes a look at what there is on offer

Every CD premastering facility requires a certain basic inventory of equipment—with probably the most important item still being a Sony *PCM-1630/1610* and its attendant U-matic machine. Add to this a desk, a pair of monitors, a DAT recorder, an analogue 2-track machine, and maybe a digital workstation, and you are in business—up to a point, anyway.

Of course, what makes a particular premastering room special is the choice of additional equipment—the outboard gear. But, while there are literally hundreds of choices for a recording studio, for the premastering facility the selection is decidedly limited.

Outboard gear for premastering falls into two fairly broad categories.

Add-ons

First, there are the necessary add-ons such as format convertors and interfaces—the 'fudge boxes' which always seem to be necessary in order to make everything work properly.

In this category are included digital sample-rate convertors, AES-EBU to SPDIF interfaces and the 'flag' switches which allow equipment with nonstandard digital interfaces to talk to machines with better implementations. Meanwhile, in the analogue domain are found such necessities as the phono-to-XLR convertors for matching the level and impedance of 'domestic' devices to the professional environment.

Early entrants into the digital interface market were Audio Design, who found a solution to the problem of connecting a *PCM-F701* to the Sony *PCM-1630*. Audio Design have since produced a

myriad of different outboard gear for the digital studio; among their current products are an 18-bit sigma delta D-A convertor and a 20-bit sample-rate convertor.

In fact, it seems that there are currently almost as many sample rate convertors on the market as there are samples to convert (far too many to list here), and thanks to recent advances in chip technology it is now possible to buy a high quality unit for around £1,000–£1,500.

Specifications do vary, however, and anyone seeking to add an SFC to their inventory should look for the following in the specification: the capability to handle all the recognised sample frequencies as well as tracking a varying (varispeed) input; the clock reference can be derived from either the studio master, signal input or internal crystal; at least 20-bit word length capability; the option to output 20, 18 or 16-bits with correctly implemented dithering.

If it anticipated that transfers are going to be made from DAT to CD-R, then the ability to pass the DAT IDs through the system is a useful additional feature.

Squeezing 20-bit recordings onto the 16 bits required by the CD is another area which has seen a high level of activity in recent months. The major players in this noise shaping market are currently Sony with their Super Bit Mapping system, Prism with the *AD-1 Dream* noise-shaping convertor, and Apogee, who have recently launched the *UV1000* processor.

Signal processing

While digital format, word length and sample frequency conversion appear to be well catered for by the hardware manufacturers, in the area of signal processing there is a distinct lack of choice for the premastering facility.

A great deal of this second category of outboard equipment has been principally designed for use by recording studios rather than premastering facilities—although this is not actually very surprising when the relative size of the two markets is considered.

In the USA, mastering houses have for years relied on equalisers and compressors built by Sontec. These units, which first appeared in the 1970s, were specifically designed to meet the needs of disc-cutting engineers and featured stepped

controls which provide very accurate, and quickly recallable, level and other parameter adjustments. Rather surprisingly, Sontecs never penetrated the UK market—in fact, the first units only appeared in Britain last year at London's Metropolitan Mastering Studio.

Seeing this potential gap in the market, UK console manufacturer Focusrite—who have been enjoying considerable success with the *Red* series of outboard gear—have now turned their attention to the mastering industry with the introduction of the *Blue 315* Isomorphic Mastering Equaliser. This features Sontec-style stepped controls giving $\pm 10\text{dB}$ in 23 steps over four independent ranges of 11 frequencies and Q, plus high-pass and low-pass filters, phase reverse and EQ bypass.

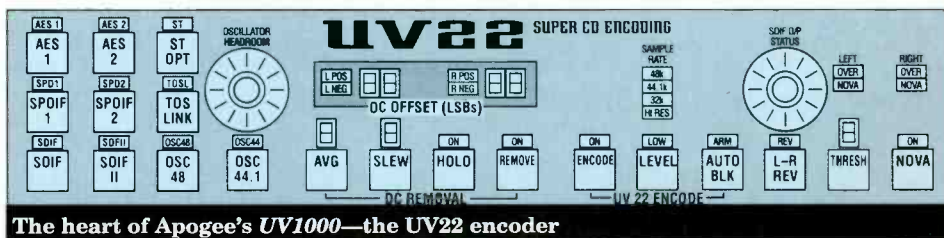
While there is no doubt that the Sontec's physical design has had a significant influence on the layout of the Focusrite front panel, from an electronics standpoint the EQ is 100% Focusrite, with the circuit design being taken from their highly praised *ISA 315* studio equaliser.

GML are another company whose EQs are used extensively by recording studios, but despite the company's principal, George Massenburg having been in the design team at ITI (Sontec's predecessor), there is no mastering version available. A great many of the premastering facilities have therefore resisted buying GMLs, relying instead on hire companies to provide units in response to specific client requests.

A high percentage of today's recordings are still mastered onto analogue media, and valve equipment still reigns supreme with a great many engineers and producers. The Summit Audio range is one of the favourites at present, while Tube-Tech's Pultec-style EQs are also to be found in some mastering rooms.

For the all-digital facility the choice of outboard gear becomes even smaller. Apart from the EQs and compressor-limiters found in digital consoles such as the Yamaha *DMC1000* and Neve's *DTC-1*, there is virtually nothing on the market which meets the need of a digital premastering engineer.

The limited selection that is available includes a Yamaha 19-inch rackmount EQ, the *DEQ5*, while both Symetrix and Valley People make compressor limiters that operate in the digital domain. Valley People's new *730* dynamics unit includes a de-esser and they are believed to be targeting this device at the mastering market.



The heart of Apogee's *UV1000*—the *UV22* encoder

Most other units rely on some type of external control surface, or are really screen-based mini workstations. Included in this category fall Sony's SDP-1000 Digital Effector, the BW102 series and the Penguin (the latter both now marketed by Switzerland's Weiss Engineering).

Some of the digital reverbs also offer EQ; Lexicon's 480L and 300 series being two examples. The 480L not only has 4-band parametric EQ, it can also be used as a mini desk as it provides a digital domain mixing page in the software.

A-D and D-A converters—and the unenviable task of deciding which ones to buy—is an area that makes choosing monitor loudspeakers seem comparatively easy!

In the United States most mastering rooms offer their clients a choice of converters; the decision on which ones to use for a project often being made only after lengthy evaluation using the material to be mastered. But in the UK this is rarely the case. Either through lack of patience, or possibly finance, some—although to be fair, by no means all—mastering rooms have one outboard converter of each type, and these are used on all jobs, irrespective of the programme material.

A-D and D-A converters vary enormously, both in price and specification. Most outboard A-Ds will

now convert to word lengths in excess of 16 bits, and a number also have noise-shaping circuitry built in. Engineers seeking to add one or more outboard converters to their inventory should definitely try a selection of units before making a decision. This is because, as with monitors, listening in one's own room is really the only way to make a proper evaluation.

A fairly new entrant into the outboard market is CEDAR Audio. Over the past two years they have launched three stand-alone products which bring the real-time audio processing functions of their computer-based audio restoration system into 19-inch rackmount boxes.

The DC-1 and CR-1 enable declicking and deackling of old 78 or vinyl albums, film and TV soundtracks, and modern recordings with digital clicks or other problems. The third and most recent addition to the range is the AZ-1, which corrects phase, time and azimuth errors on stereo recordings (see review in MDR issue 2). All three units feature both analogue and digital I-Os (which are capable of handling word lengths up to 24 bits).

One category of outboard equipment really has no place in a mastering facility, but they always seem to get in there anyway—'tone benders', devices that deliberately re-shape the audio. These

are normally only used under the direction of a producer or artist. Or at least one hopes they are.

Finally, a couple of recent additions to the range of mastering hardware. Although these cannot strictly be termed 'outboard', they are probably worthy of a mention.

The need to store word lengths in excess of 16 bits has led to the search for alternatives to the PCM-1630 and DAT. One of the strong contenders is a format known as the Disc Description Protocol (DDP), which uses the 8mm Exabyte cassette. DDP is being widely used in conjunction with workstations such as the Sonic Solutions, but because it is effectively a data streamer the system can accommodate virtually any type of digital format.

DDP is therefore not only being used extensively for the delivery of CD-Audio masters to the manufacturing plants—where it allows CDs to be mastered at double speed—it is also proving invaluable to mastering facilities as they begin to turn away from audio for the far more lucrative markets of CD-ROM and other CD-based interactive media.


It hardly seems necessary to point out that making a CD-ROM requires another set of outboard gear entirely. ■


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THE CUTTING EDGE

Successful duplication of compact discs relies upon accurate stampers, and these can only be as good as the glass master. John Watkinson looks at the readout principle of CD and shows how it determines the factors affecting the cutting process

half the of light energy should be incident on the top of the bump and half on the surrounding mirror surface. The height of the bump is ideally one quarter the wavelength of the light in a reflective system and, as a result, light which has reflected from the mirror surface has travelled one half a wavelength further than light which has reflected from the mirror surface. Consequently, along the normal, there are two components of light of almost equal energy, but they are in phase opposition, and destructive interference occurs, such that no wavefront can form in that direction. As light

energy cannot disappear, wavefronts will leave the phase structure at any oblique angle at which constructive interference between the components can be achieved, creating a diffraction pattern in a plane which is normal to the disc surface and which intersects a disc radius.

When the light spot is focused on a plain part of the mirror surface, or land, clearly most of the energy is simply reflected back. Thus when a bump is present, light is diffracted away from the normal, whereas in the absence of a bump, it returns along the normal. The effect of diffraction is that the ►

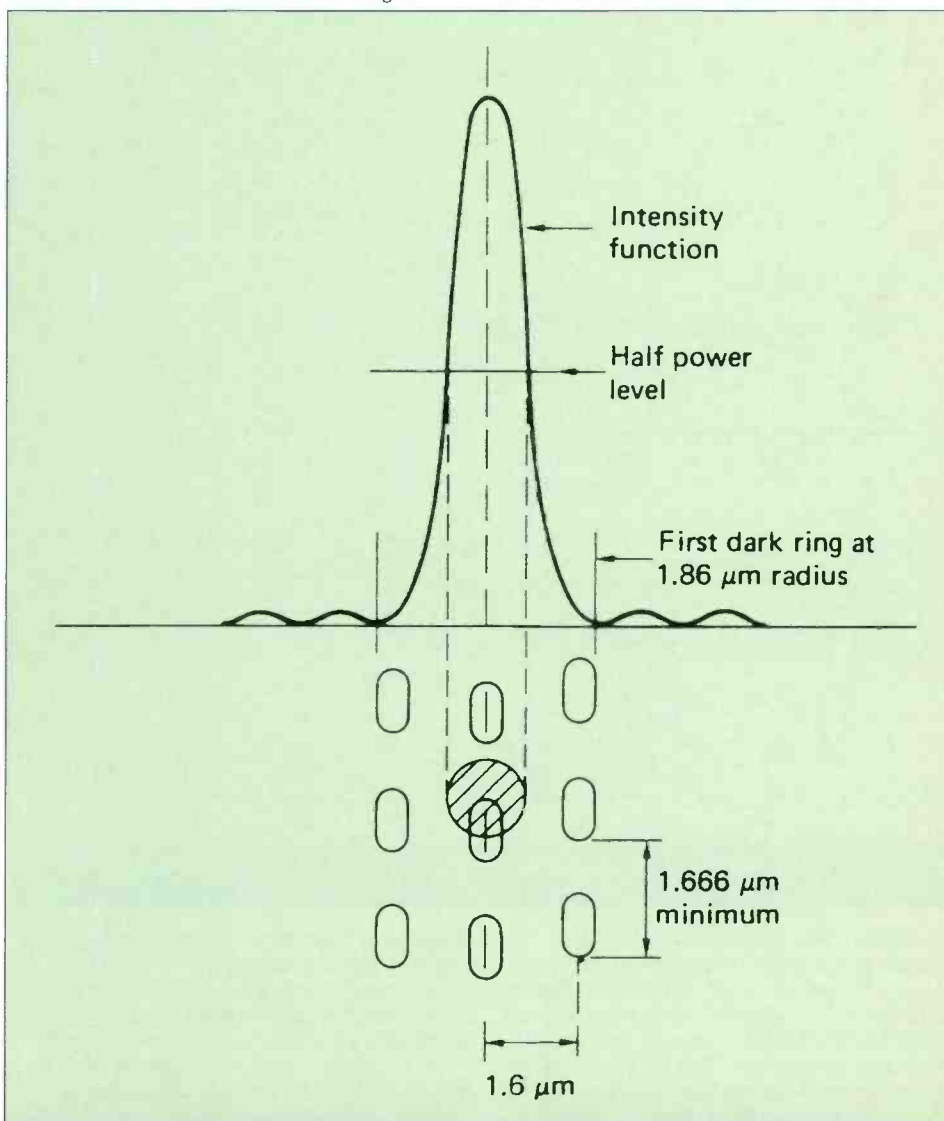


Fig.1: The structure of a maximum frequency recording is shown here, related to the intensity function of an objective of 0.45NA with 780nm light. Note that track spacing puts adjacent tracks in the dark rings, reducing crosstalk. Note also that as the spot has an intensity function it is meaningless to specify the spot diameter without some reference such as an intensity level

The term 'cutting' is a leftover from the days when vinyl discs were actually cut. In CD production the process is actually photolithography but this is such a mouthful that the earlier term is preferred.

The compact disc, the prerecorded MiniDisc and the LaserVision discs have in common the use of the same basic structure and readout principle. While earlier optical discs attempted to obtain contrast photographically or by perforations in an opaque layer, the Philips patent taught a disc with no conventional contrast at all. The disc surface simply contained areas of relief—now called pits or bumps—which could simply be replicated by moulding. As a practical matter, the bumps must have slightly sloping sides so that it is possible to release the CD from the mould. The moulded disc is rendered almost completely reflective by metallising.

The player focuses a spot of light on to the relief structure such that it straddles a bump. Ideally

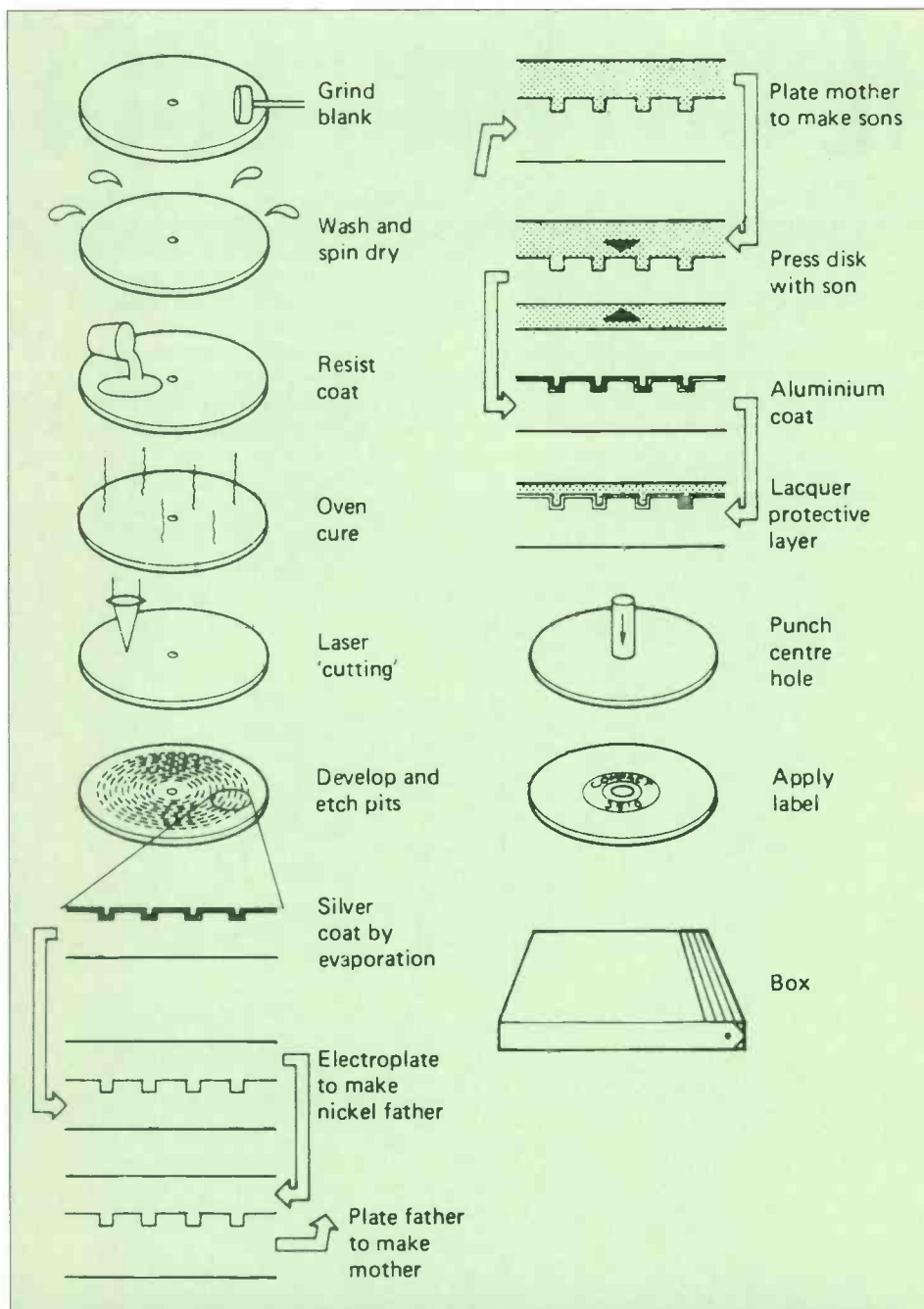


Fig.2: The many stages of CD manufacture, most of which require the utmost cleanliness

direction in which wavefronts leave the phase structure is changed by the presence of the bump. In a conventional CD player the light diffracted by a long bump will be sufficiently oblique that it passes outside the aperture of the objective and does not return to the photosensor. Thus the bumps appear dark to the photosensor and the lands appear bright; a phenomenon called Phase Contrast.

Diffraction prevents light being focussed to a point. Instead the result is a pattern of light called the Airy distribution after Lord Airy (1835) the then astronomer royal. The resulting intensity function is shown in Fig.1 and contains a central

sloping peak surrounded by alternating dark rings and light rings of diminishing intensity. The phenomenon is due to diffraction effects across the finite aperture of the objective. For a given wavelength, as the aperture of the objective is increased, so the diameter of the Airy pattern reduces. An intensity function does not have a diameter, so the effective diameter typically quoted is that at which the intensity has fallen to half that of the peak.

Clearly, the smaller the spot size, the higher the recording density of the disc can be. In CD and MiniDisc the spot size was obtained by selecting

the shortest wavelength (780 nanometres) which could be produced by an economic laser and the largest Numerical Aperture (0.45) which still allowed a reasonable depth of focus. The spot size then determines the bump width which can be straddled and the wavelength sets the bump height. Work is going on in many places to reduce the spot size in optical discs in order to increase storage density. This requires the development of economic shorter wavelength lasers. Clearly, discs with reduced wavelength and spot size would need lower bump heights. These are not compact discs as we recognise them, and a regular CD player could not play them.

The intensity function which produces the deformities in the photoresist on the glass master must be smaller in diameter than that in the reader. This is conveniently achieved by using a shorter wavelength of 400-500nm from a helium-cadmium or argon-ion laser combined with a larger lens aperture of 0.9. These are expensive, but only needed for the mastering process.

On the make

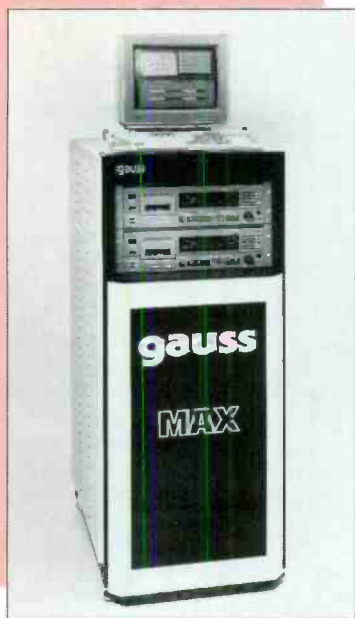
The major steps in CD manufacture are shown in Fig.2 and begin with an optically flat glass disc about 220mm in diameter and 6mm thick. An adhesive layer is applied followed by a coating of positive photoresist. This is a chemical substance which softens when exposed to an appropriate intensity of ultraviolet light. The thickness of the resist layer must be accurately controlled, since it affects the height of the bumps on the finished disc, and an optical scanner is used to check that there are no resist defects which would cause data errors or tracking problems in the end product. Blanks which pass this test are oven-cured, and are ready for cutting.

The cutting process is shown in simplified form in Fig.3. A continuously operating helium-cadmium or argon-ion laser is focused on the resist coating as the blank revolves. Focus is achieved by a separate helium-neon laser sharing the same optics. The resist is insensitive to the wavelength of the He-Ne laser. The laser intensity is controlled by a modulator which is driven by the encoder. As a result, the deformities in the resist produced as the disc turns when the modulator allows light to pass are separated by areas unaffected by light when the modulator is shut off. Information is carried solely in the variations of the lengths of these two areas.

Owing to the minute dimensions of the track structure, the cutter has to be constructed to extremely high accuracy. Air bearings are used in the spindle and the laser head, and the whole machine is resiliently supported to prevent vibrations from the building from affecting the track pattern.

It is a characteristic of photo resist that its development rate is not linearly proportional to the intensity of light. This nonlinearity is known as 'gamma'. As a result there are two intensities of importance when scanning photo resist; the lower sensitivity, or threshold, below which no development takes place, and the upper threshold above which there is full development. As the ►

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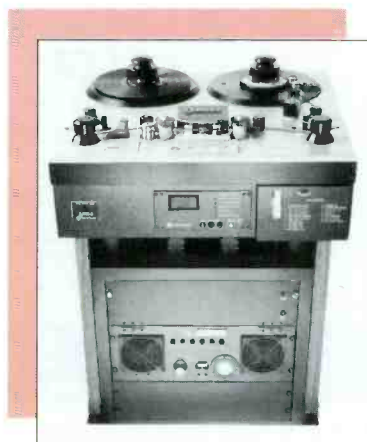
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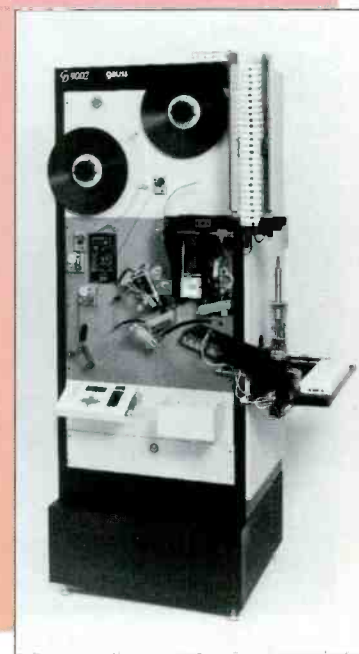
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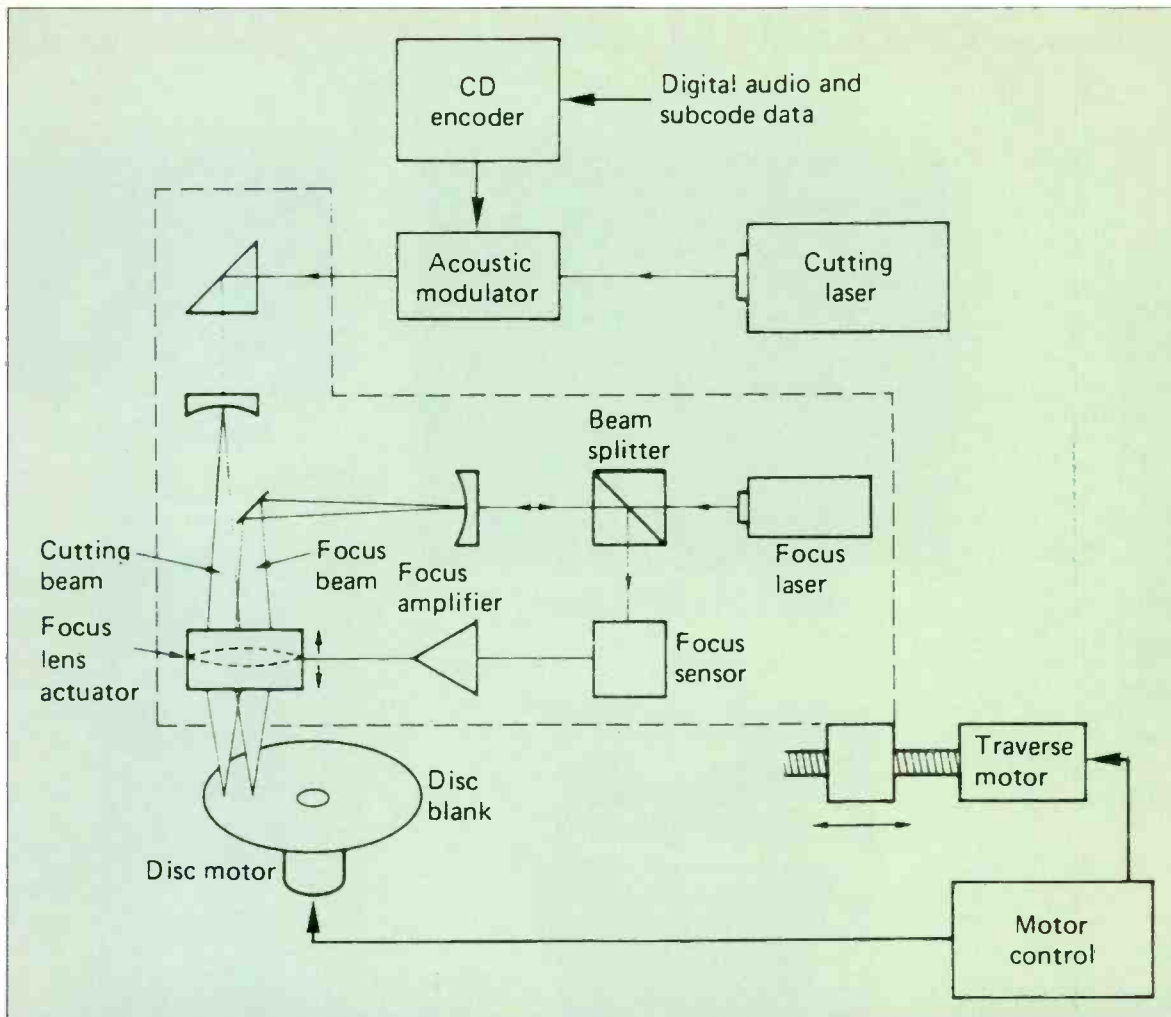


Fig.3: CD cutter. The focus subsystem controls the spot size of the main cutting laser on the photosensitive blank. Disk and traverse motors are coordinated to give constant track pitch and velocity. Note that the power of the focus laser is insufficient to expose the photoresist

laser light falling on the resist is an intensity function, it follows that the two thresholds will be reached at different diameters of the function. It can be seen in Fig.4 that advantage is taken of this effect to produce tapering sides to the pits formed in the resist. In the centre, the light is intense enough to fully develop the resist right down to the glass. This gives the deformity a flat

bottom. At the edge, the intensity falls and as some light is absorbed by the resist, the diameter of the resist which can be developed falls with depth in the resist. By controlling the intensity of the laser, and the development time, the slope of the sides of the pits can be controlled.

The softened resist will be etched away down to the glass to form flat-bottomed pits whose depth is

dispersing the incident white light into a spectrum. The resultant spectrum is not at all like that produced by a conventional prism or rainbow. In these spectra the green in the centre appears brightest, the red at one end is less bright and the blue at the other end is fainter still due to the unequal response of the eye to various colours. In the diffracted spectrum from a CD, however, the blue component appears as strong or stronger than the other colours. This is because the relief structure of CD is designed not to reflect infrared light of 780nm wavelength. This relief structure will, however, reflect perfectly ultraviolet light of half that wavelength as the zeroth order light reflected from the top of the bumps will be in phase with light reflected from the land. Thus a CD reflects visible blue light much more strongly than longer wavelength colours. ■

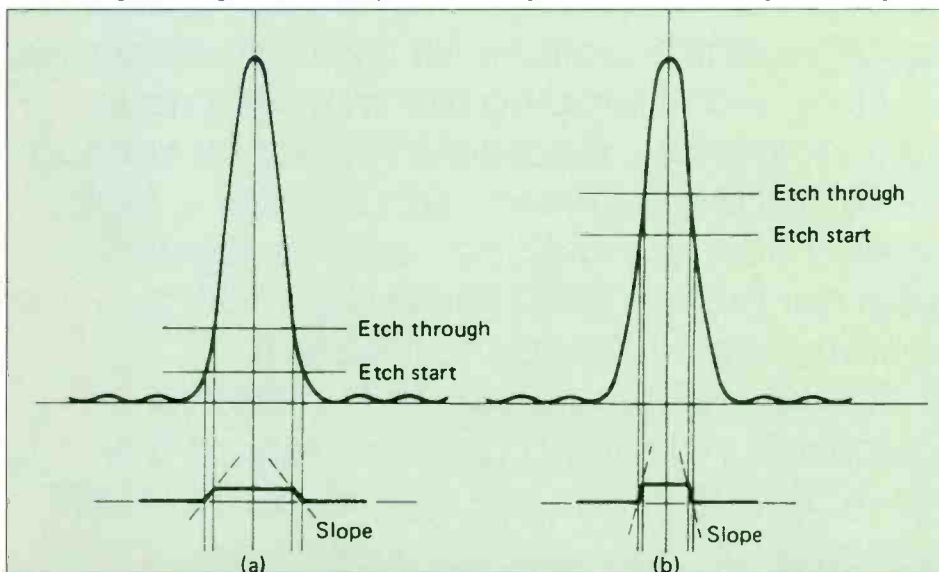


Fig.4: The two levels of exposure sensitivity of the resist determine the size and edge slope of the bumps in the CD. (a) Large exposure results in a large bump with a gentle slope; (b) less exposure results in a smaller bump with steeper sloped sides

John Watkinson is an independent consultant in digital audio, video and data technology and is the author of seven books on the subject, including *The Art of Digital Audio*, acclaimed as the definitive work on the subject. He is a Fellow of the Audio Engineering Society and is listed in *Who's Who in the World*. He regularly presents papers at conventions of learned societies and has presented training courses for studios, broadcasters and facilities around the world. He is currently writing a book on data reduction for video and audio

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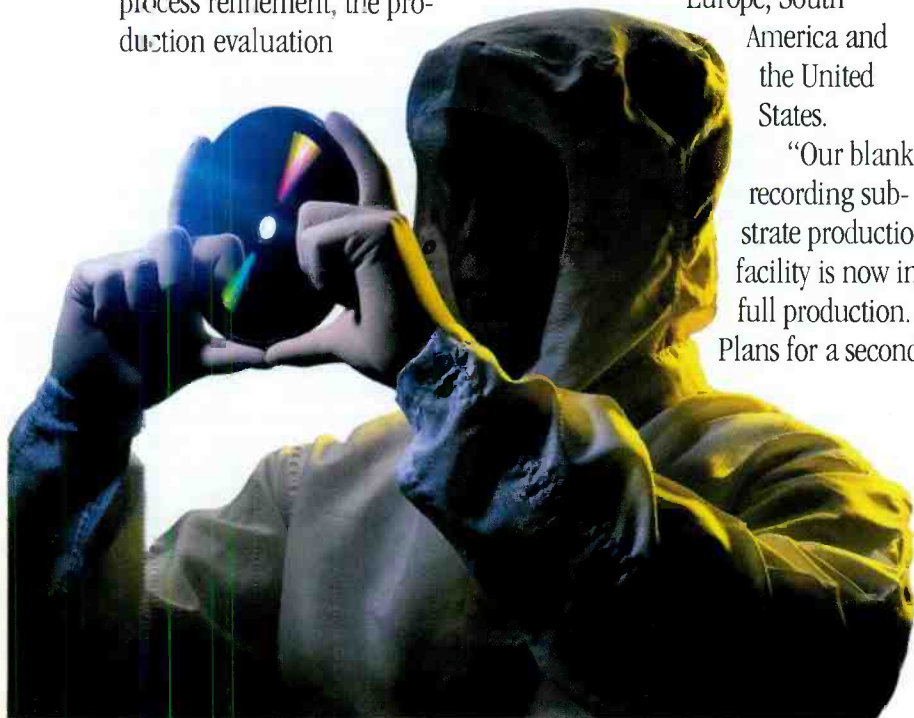
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For Your Money.*



The CD-ROM has had to live down the perception of being the less attractive cousin of the glamorous CD. The reality of CD-ROM is that it is the fastest growing member of the CD family with pressing industry 'numbers' that some forecasters predict will surpass audio CD by the end of 1996. Many CD pressing facilities have seen their fears of under capacity and loss of profitability eliminated as CD-ROM has taken off.

It is estimated that, by the end of 1994, 20% of all computer owners will own or have access to CD-ROM drives. By 1996, CD-ROM drives could have 40% penetration of the installed computer-user base, including a substantial number of the so-called 100 million television homes in the US and the 20+ million television homes in the UK. By the year 2000, industry analysts predict that 80% of all computers in the home and office will have CD-ROM drives.

The format and compatibility issues remain a problem. Essentially, CD-ROMs destined for computer use have to be compatible with operating system architecture of the computer programming on the disc. There are CD systems for DOS, compliant for *Windows* (MPC), video enhanced for *Windows* (MPC2), for *Macintosh* (High Sierra, ISO 9660) and *Macintosh* video (*Quicktime*, *Quicktime 2*), potentially compatible on several platforms with as many as 50% of all CD-ROM 'readers' by 1996.

(XA, XA2), for Commodore (CDTV), for Atari (*Jaguar*) and CD-ROMs with Unix source code and applications for Unix platforms. There are games on CD-ROM for all of the platforms above and for Nintendo, Sega, NEC (Duo-Soft), Philips CD-i and the much heralded '3D0' system supported by such industry giants as Matsushita.

There are dedicated systems for portable data retrieval, literary appreciation, education, self-improvement from Sony with the Bookman and Data Discman, and from Philips with CD-i. In fact, there are currently nearly 30 CD-ROM formats in use, most of which are incompatible with any other format.

Then there is the Kodak Photo-CD system that can be played by CD-i, *Macintosh* and by *Windows* systems. Kodak *Photo-Edge* and *Shoebox* software is available for both *Windows* and *Macintosh* platforms to display and edit the stored images. Photo-CD formats are also being used to replace large printed catalogues.

It frequently is simple to release software written for *Windows* and for *Macintosh* on the same disc—within the 660Mb capacity of the disc.

CD-ROM drives themselves, generally, have full stereo audio, both to reproduce audio on the CD-ROM and to play 'conventional' audio CDs both for listening and for editing or manipulation. There



CD-Rom drives into the future: the way it will be

has been controversy in the audio and computer press as to whether the CD-ROM 'transports' would be desirable to play audio CDs. The heavy construction of CD-ROM transports is seductive to the audiophile currently experiencing the consumer electronic industries' constant cutting of corners to achieve ever lower prices. But, listening tests do not favour the analogue outputs of CD-ROM players which are after all primarily designed to transfer digital data in the digital domain.

The issue of CD-ROM 'caddies' is not a simple one and again works against universal adoption and consumer ease. It is also not a major issue, but it is worth remembering that virtually every drive sold between 1986 and Christmas of 1993 required the use of a 'caddy'. Drives introduced in 1994 are without such a caddy.

'Jukebox' CD-ROM drives have emerged and remind the sceptic of the way carousel and jukebox CD audio players became popular. With audio CD 'jukes' selling at the same price in 1994 as single-play decks, it is not too far a reach to assume that CD-ROM jukeboxes will be available at price comparable to single drives within 18 months.

The first drives were so-called single-speed drives, sold in the late 1980s for \$500 or more. Today such drives are being closed out for as little as \$80.00. So-called double-speed drives are the most prevalent in use today, with significantly more than 80% of the user base operating at double speed.

Double-speed drives can be purchased in the US for as little as \$200. External drives have achieved some popularity for adding CD-ROM capability to computers not previously equipped but the preinstalled 'caddyless' drives sold in computers manufactured in 1994 and beyond will cement the utility of CD-ROM usage.

During the last half of 1993, the emergence of triple-speed drives and quadruple-speed drives raised the 'odds' for everyone in the CD-ROM community. Currently priced at two to four times

the going 'street' prices of a double-speed drive, the faster drives confront the fact that the majority of current computer programs are written for double-speed transfer and the vast majority of the users are equipped with double speed drives. In an industry already somewhat 'hamstrung' by lack of compatibility among disc systems and content, adding disc speed to the incompatibility list would be suicide for the industry.

The most prolific usage of CD-ROM is as a storage medium for data and other business information, contrary to popular conception. In fact, of nearly 10,000 titles extant on CD-ROM, well under a thousand are of computer programs and games. The rest hold data and statistics. *Jane's All The World's Aircraft* is available on CD-ROM. So are all of the back issues

of most if not all computer magazines.

The rather prosaic business of providing systems software and applications software for computers is also migrating to CD-ROM. All of the new generation Apple *Macintosh* computers provide the system software on CD-ROM. Makers of programs such as the Microsoft *Office* suite do the same in lieu of providing the user with 26 diskettes. The reasoning can follow several logical directions but the bottom line is that the software remains forever indestructible and unerasable on a compact disc. If 3½-inch diskettes were used, the cost could run to ten times the expense of the CD or better for the software manufacturer!

The most successful entertainment CD-ROM programs for the consumer are interactive games which represent phenomenal amounts of programming time to give the consumer a truly enjoyable and/or educational experience. The success of edu-games such as *Oregon Trail* and sci-fi mysteries such as *Myst* reflects the kinds of CD-ROMs that will eventually 'go platinum.'

There have also evolved CD-ROM magazines. The foremost example of this is *Nautilus*. Such magazines require subscriptions in the \$100 range but offer hundreds of gigabytes of software, literature, pictures and games. In addition, there is a whole developing category of 'books' offered by conventional book publishers on CD-ROM in full multimedia format.

There is no problem with consumer acceptance, as the CD format is already familiar to the consumer. There is no other data store available that can move programs and/or data into the hands of the computer user at unit prices as low as 67 cents per disc in the United States. And for the mastering, duplicating and replicating business the CD-ROM is the closest medium to a sure thing. This is one format that will be around into the next century and then some. Isn't that a comforting thought? ■

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