

CEDAR System showing EQ curve

How fortunate we are to have today's audio recording media: analogue tape with Dolby SR noise reduction or DAT, PCM-1630 and the various other digital formats currently available. We can capture sound with an almost incredible accuracy and, with due care and attention, be sure that no intrusive background noises, other than an almost non-existent hiss, will mar our listening pleasure. And with CD this degree of perfection extends right down the audio chain to the domestic and even to in-car and personal stereo users. Things haven't always been so good.

Over the last couple of years we have been hearing about a process known as CEDAR, which claims to remove clicks and other non-musical events from old recordings and there has been some interesting discussion in *Studio Sound* recently (May and July 1990). This article will describe what CEDAR is and what it does, and give a personal impression on how well it performs. The precise details of how the process works involve high flying mathematics, which must wait for another day.

Applications

It will not have escaped anyone's attention that there is a sizable market for 'antique' recordings transcribed onto CD. It's a pity no-one thought of this when the CD specification was drawn up otherwise Philips and Sony might have included a mono standard to allow the discs to play for twice as long. These antique recordings date as far back as the acoustic gramophone and even back to cylinders, although mainly for their curiosity rather than musical value. There is a vast archive of material on acoustically and electrically produced 78 rpm records, which covers a very important period in the development of

CEDAR

David Mellor investigates the method and operation of this digital noise processing system



Screen display of noise reduction menu

performance styles. Many of the artists involved in making these 78s had a very close musical connection either with the composers of 19th century repertoire, or people who followed closely in their musical tradition. As we move further and further away in time we inevitably lose perspective and old recordings provide a valuable educational resource.

Also on 78 rpm discs is an equally vast repertoire of jazz recordings. Jazz, more than any other type of music, is ephemeral in its nature unless captured in a recording. Once again, the catalogue of 78s holds important information, this time on the development of a musical style. These old recordings need to be available. Modern recordings may be technically perfect but can somehow never capture the excitement and vigour of the originals.

The application of some type of restoration process to scratched and noisy 78 rpm records is self evident. Slightly less so is the need to improve the quality of 33 $\frac{1}{3}$ rpm long playing records. After all, if you want to release '60s or '70s material on CD, it's best to go back to the original master tape if you can find it, and if it is still in a playable condition. It seems more and more horror stories concerning the longevity—or rather lack of it—of $\frac{1}{4}$ inch tapes are coming to light. If you have an old tape which sheds oxide, sticks to the heads or is otherwise difficult to play, the first course of action is to consult the tape's manufacturer who may have a fix. If the master tape cannot provide usable results, then the only thing to do is to find a good copy of the LP to transcribe onto CD.

Another source of noise-ridden dialogue and music is the optical film soundtrack. Once again, this is a very 'clicky' medium, any scratch on the film is interpreted as a noise impulse, and these scratches are bound to occur through repeated spooling of the film print.



Screen showing noise reduction curve

Ethics

The restoration and enhancement of audio is as tricky an ethical problem as the colourisation of old black and white films. A modern film in full colour with Dolby Stereo is very much an interpretation of real life, and when the director has chosen to shoot in black and white that is part of his artistic interpretation. But there is a world of difference between restoration, which means making something as good as it once was, and enhancement, which means making it 'better'. CEDAR can do both and it is very important to make a distinction between the two processes.

If one is going to put the ethical position under a microscope, however, then it would be possible to say that it's not right to transcribe an original 78 rpm recording onto another medium such as CD anyway. Maybe it should be played on the type of equipment it was made for. I had the opportunity of listening to several types of wind-up gramophone recently, and although by no stretch of the imagination was the sound high quality, it was very exciting sound and in some ways preferable to how it would be hearing the same recordings played over speakers.

Another point to be considered is whether or not there was ever any 'approved' version of a recording. Gradually in the history of recording techniques there has been a shift of emphasis from 'let's get the best recording we can', to a position where a producer, in conjunction with his engineer, put together a sound which is thought to be artistically good. In the former case, there is no 'correct' sound a restoration should aim to copy and a full effort can be applied to making the recording sound as good as possible to modern ears. In the second case the recording passed through a stage where its creator said 'it's right', and subsequent copies and restorations must aim to imitate that.

Preparation

The CEDAR process works from a digital copy of the recording to be restored or enhanced. This means that there is some work to be done before sending the material to Cambridge Sound

Restoration, CEDAR Audio Ltd's subsidiary company, or running it through your own CEDAR processor.

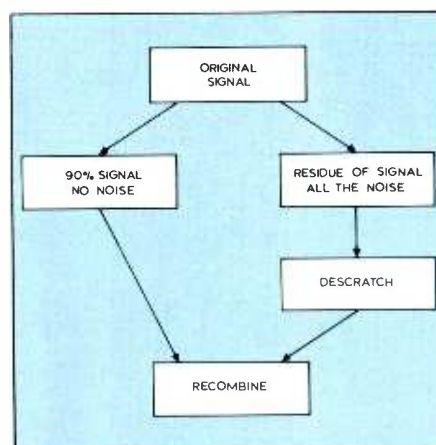
In the case of 78 rpm records, the first thing to do is get hold of the best possible copy of the recording. Obviously, it makes sense to start with as few problems as you can but even simply playing a 78 is not as straightforward as it might seem, not if you want to get the best results. Once you have a clean copy, the next problem is almost bound to be that the hole isn't central, causing wow. CEDAR can do nothing about this, so the disc has to be correctly centred on the turntable. Next question: At what speed should the turntable run? Unfortunately, 78 rpm is not always the correct answer and the label is not likely to be very informative on the subject. The speed could easily be 10% out and you'll have to judge it for yourself. If these problems are not enough, there's plenty of work left in finding the correct stylus to get the most music out of the disc with the least noise.

Once the optimum playing conditions have been found, the disc can be transcribed to a digital medium such as DAT. After this stage, things become more straightforward.

The system

The hardware part of the CEDAR system doesn't take up much desk space. In fact just enough for a Compaq Deskpro personal computer, monitor and keyboard, fitted with a large hard disk drive and the all-important CEDAR digital signal processing boards; the rest is in the software. The software currently has four modules, a one-pass scratch remover, a two-pass scratch remover, a 512 band equaliser (yes, 512 bands) and a noise reducer with equalisation of the noise-free signal.

The first step in restoring a recording is to load it in from a DAT master over the SPDIF digital interface (there is also AES/EBU). CEDAR includes a hard disk recorder, which stores audio segments as files on the disk. The presentation is very straightforward and I was able to operate it immediately. Once the file is on the disk, it can be Descratched to remove the major clicks. This is not a realtime process: the software looks at the material and builds up a model of what the music should be like, and then takes away anything it regards as not being music. The gaps where the



The screen displays shown are from the prototype version and following feedback from beta test sites have been changed in content. For example all four screens now appear on single screen but can be selected for whole screen display as required.



Screen display of logo

clicks had been are filled by interpolation, resynthesis or adaptive splicing. The two adjustable parameters are 'Order', which roughly speaking is the 'power' of the system, and 'Threshold', which represents the degree to which a noise must deviate from the 'model' of the music to be considered a candidate for removal. There are two ways to set these parameters: trial-and-error and experience. Setting the Order is fairly simple because if you make it too high, all you lose is time—the process takes longer. If the Threshold is set too high, however, then the process may develop an appetite for music as well as scratches. After processing with the Descratcher, which might typically take twice as long as realtime, there should be no major clicks, although 'ticks', surface noise and hiss will remain.

The second level of operation is the two-pass process, which can be done after Descratching. This will remove all the remaining impulsive noises. How it actually works, it seems, is too mathematical to be fully comprehended by anyone with less than an infinite IQ, but Fig 1 describes the process. First the signal is split into two parts—one containing 90% of the signal and no noise, the other the remaining 10% of the signal and all the noise. This Splitter level is set by the operator while listening to the signal in realtime. It is not a critical operation as long as all the noise goes into the portion to be processed. In this portion, the noise is very much more prevalent than the signal so a Descratch process, similar to the original Descratch, can be applied to root out nearly all the noise. This final Descratching is incorporated into the Recombine procedure, which puts the two parts of the signal back together, hopefully resulting in all the signal that there ever was but with none of the noise. Like Descratch, there are two adjustable parameters: Order and Threshold.

After the one-pass and two-pass scratch removal procedures there should remain only the signal and non-impulsive noise. It's probably fair to say that up to this point CEDAR is purely attempting to restore the signal to its original state.

The next step along the road to enhancement is Dehiss, where the operator's judgement is critical to the results from the process. Fortunately, Dehiss works in realtime, so given a keen ear and

a good acoustic environment it should be possible to find an optimum point where all the bath water has been thrown away but the baby has been wholly left behind.

Firstly, a 'fingerprint' is taken of the noise spectrum, from a section of the recording without signal. Then, during processing, the software decides on a moment-to-moment basis whether or not noise is present, and if it is, it is removed. Note that this is not done by equalising with the inverse of the noise curve. EQ in CEDAR is a separate process. There are two main parameters the operator must adjust correctly: the Multiplier, which sets the decision level, at which CEDAR will detect signal to noise, and the Attenuation, which defines the residual noise level after processing. Roughly speaking, Multiplier adjusts the effect between 'hissy' and 'dry', and Attenuation adjusts between 'Warbly' and 'sounds OK'. The range of defects it is possible for the process to produce is some way removed from the conventional boundaries of audio malaise so description is difficult but for any recording there should hopefully be a combination of parameters that has a solely beneficial effect.

Once Dehissed, the recording can be Equalised with CEDAR's 512-band EQ. Referring back to Fig 1, an interesting feature is the ability to split the signal into 90% signal/noise and 10% signal/100% noise components. If the portion that contains only the signal is equalised, then it is apparently possible to get 30 dB to 50 dB of noise-free equalisation!

Bureau service

Until recently CEDAR has been operated purely as a bureau service, and this facility is still available from Cambridge Sound Restoration. A potential user of this service may either send up a DAT cassette, which Cambridge Sound Restoration will Descratch using either the one-pass or two-pass process. If the DAT is accompanied by an engineer, the Dehiss and EQ, which need subjective decisions, can also be done.

The environment in Cambridge Sound Restoration's headquarters is far removed from what a studio engineer might expect, appearing more like a cross between computer dealer and hi-fi demonstration room. For the standard unassisted bureau service the operator works with headphone monitoring which, although good for hearing clicks, is perhaps not entirely adequate for evaluation of audio quality. In the more normal audio domain it is well known that some

things, such as pitch-related phenomena, while clearly audible on speakers are difficult to hear on headphones. Both the one-pass and two-pass scratch removal processes can have a damaging effect on the music if taken too far and correct judgement is essential.

Dehissing and EQ can be done using Cambridge Sound Restoration's monitoring system, which offers a choice of small Rogers loudspeakers or (original) Quad electrostatics in an, as yet, acoustically untreated space. I was disturbed that the left and right channels of one of my test pieces were treated with casually set different parameters, even though I was 'assured' that this would only result in a slight imbalance in the distortion in the two channels.

But despite these points, the proof of the pudding is in the eating and I was able to take home the CEDAR demo DAT and another DAT of some tracks that were processed during my visit. One of the most remarkable examples on the demo is a jazz 78, which had been broken and glued together—glued together amazingly well but still with some horrendous scratches. On this example, processing has wholly beneficial effects. Another example is a recording that had scratches, so I am told, occurring at a rate of around 2500/sec. There is no doubt that CEDAR can produce very listenable results from previously unlistenable discs.

When the scratches on a disc are less major, some possible doubts about CEDARisation might set in, such as that there might seem to be less top end, and there might appear to be some slight compression. This is very difficult to judge, one has to be very aware that the ear is so easily fooled into thinking that artifacts such as scratches and crackles are part of the music that taking them away inevitably results in a sense of loss. On balance, I think that for declipping 78 rpm records the system works well.

When it comes to Dehissing I was less happy. There are two very illuminating examples on the demo DAT. One is a fairly noisy recording of Schumann's *Piano Concerto*, probably 1950s, which after Dehissing is as silent as a modern digital recording, apart from a little modulation noise. Perhaps it's a matter of aural education but there is such a contradiction between the restricted frequency range of the recording combined with high distortion levels and the almost digital silence, that it somehow just doesn't sound right. Maybe it has been overprocessed and with a little noise left in it would have been OK. The other example is a stereo recording of Prokofiev's *Classical*

Symphony, which in its original form is very present and vivid but loses sparkle along with the noise in the processing. A very successful example, however, is a live recording that was rendered unusable by dimmer noise. CEDAR was able to eliminate this problem completely.

The last track on the demo DAT is a recording of Noel Coward which has been Descratched, Dehissed and EQ'ed. This presents a good opportunity to hear the effects of overprocessing. On the CEDAR version there is an effect very similar to the phasing of a poorly aligned NAB cartridge, which is definitely not on the original. If you get a chance to hear the demo it's very clear just after the words 'What avails the sceptred race'. (No blame is attached to Cambridge Sound Restoration's judgement on the degree of processing applied as the customer's engineer was present during the restoration.)

My tests on tracks I had taken along to Cambridge Sound Restoration confirmed that the demonstration tracks were typical examples of CEDAR at work and not tracks that had happened by chance to work particularly well. My personal conclusions are that Descratching is excellent and has a lot of potential. Dehissing definitely works but it is not without side effects and needs to be carried out with extreme care.

CEDAR for sale

Perhaps a better idea than using a bureau service for such a critical application as the restoration of artistically and commercially valuable archive material is the possibility of buying a CEDAR system. Installed in a studio with good acoustics and operated by an experienced sound engineer there is every possibility of excellent results. At present, CEDAR seems to be in a transitional phase between the theoreticians who devised the process, the computer experts who implemented the system and the sound engineers and other musically aware people who ought to be in charge of its use.

If CEDAR's past has not exactly been ideal in terms of a product launch, this is no reason to suppose that its future may not be very bright. Arguments about restoration and enhancement will no doubt continue but if CEDAR is placed in the hands of audio professionals and seen as a tool to be used rather than a total solution, then it has every chance of success. □

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Cambridge CB1 2HA, UK. Tel: 0223 464117.**

For your reference below is a list of some commercially available CEDAR processed recordings (some older releases are not up to CEDAR's current standard)

Albert Lee Hiding (A&M 394750-2)

The Best of the Big Bands

Benny Goodman (CBS CK 45338)

Glen Gray (CBS CK 45345)

Woody Herman (CBS CK 45340Z)

Les Brown (CBS CK 45344)

Cab Calloway (CBS CK 45336)

Kay Kyser (CBS CK 45343)

Hal Kemp (CBS CK 45346)

Columbia Jazz Masterpieces

Gene Krupa (CBS CK 45448)

Billie Holiday Vol 6 (CBS CK 45449)

Bix Beiderbecke (CBS CK 45450)

Noel Coward Noel 1928-1938 (Conifer CDHD 168)

Jack Buchanan This'll Make You Whistle (Conifer CMSCD 010)

Elizabeth Schwarzkopf Recital (EMI CDH 7 63201 2)

Rudolf Serkin Bach/Beethoven (EMI CDH 7 63494 2)

Dinu Lipatti Chopin/Grieg concerti (EMI CDH 7 63497 2)

Pablo Casals Dvorak/Elgar/Bruch (EMI CDH 7 63498 2)

Roger Whittaker Live at the Tivoli (Polygram Music Video 081 1843)

Holst The Planets (NIXA CD6013)

Various

The Bing Crosby Years (Reader's Digest Records RDCD 121-6)

The George Formby Years (Grosvenor Records CDGRS 1224)

Unfortunately, while CEDAR Audio Ltd require the CEDAR logo to be included in the CD booklet, it is not always present on the cover, which is the only place it would be seen in the shop if the product were shrink-wrapped. Just as many people would be unhappy about buying a mono recording, which had been artificially processed into stereo, there is a distinct need for restoration and enhancement processes, CEDAR and others, to be identified so the customer has the opportunity of judging which process they think is best. Obviously, people who like what they hear will want to buy more, those who don't will vote with their wallets.