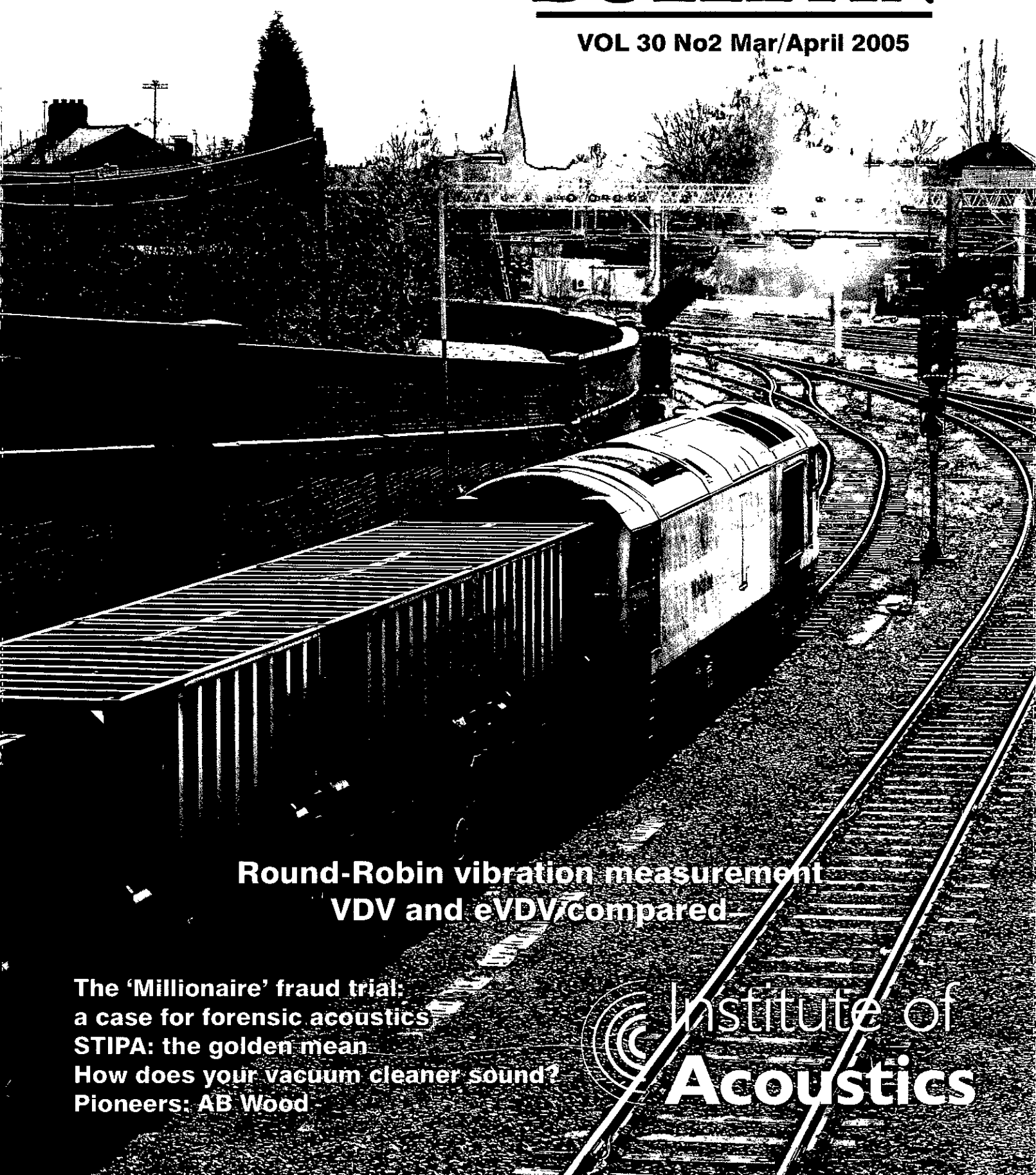


Acoustics

BULLETIN

VOL 30 No2 Mar/April 2005



**Round-Robin vibration measurement
VDV and eVDV compared**

**The 'Millionaire' fraud trial:
a case for forensic acoustics
STIPA: the golden mean
How does your vacuum cleaner sound?
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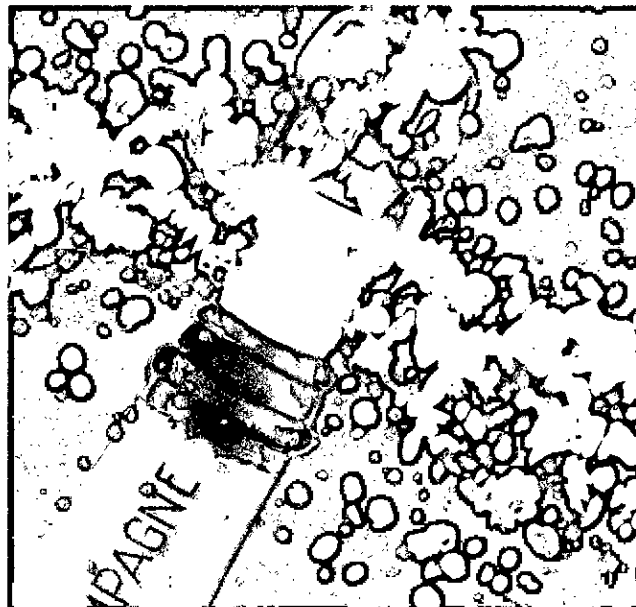
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CONTACTS**Editor:**

I F Bennett BSc CEng MIOA

Associate Editor

J W Tyler FIOA

Contributions, letters and information on new products to:

Ian Bennett, Editor, 99 Wellington Road
North, Stockport SK4 2LP
Tel 0161 476 0919 Fax 0161 476 0929
e-mail ian@acia-acoustics.co.uk

Books for review to:

S R Peliza MIOA, Institute of Acoustics,
77A St Peter's Street, St Albans, Herts
AL1 3BN

Advertising:

Advertising enquiries to
Dennis Baylis MIOA, Peypouquet, 32320
Montesquiou, France
Tel/Fax 00 33 (0)5 62 70 99 25
e-mail dbioa@hotmail.com

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The Institute of Acoustics, 77A St Peter's
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Acoustics

BULLETIN

[Vol.130.No.2,Mar/Apr 2005]

Contents

INSTITUTE NEWS

4

Spring Conference Preview
From DAT to Disk
NW Branch meeting report
Editor's Notes

TECHNICAL CONTRIBUTIONS

8

Does the sound of your vacuum cleaner suck?
Assessing sound quality
Trevor Cox, Claire Churchill and Sophie Maluski
A case study in forensic acoustics -
The 'Who Wants to be a Millionaire?' fraud trial
Peter French and Philip Harrison
ANC round robin VDV measurement exercise -
Analysis of eVDV data
Richard Greer, Rupert Thornely-Taylor, David Malam,
Patrick Williams, John Pollard, Tom Brodowski and Phil Evans
STIPA - the golden mean between full STI and RASTI
Ole-Herman Bjor

TECHNICAL NOTES

27

Crisp Acoustics
Vibration White Bottom
Janet Metcalfe

PIONEERS OF ACOUSTICS

30

Albert Beaumont Wood
John W Tyler FIOA

HANSARD

36

LETTERS

39

INDUSTRY NEWS

41

PRODUCT NEWS

45

OBITUARY

47

IOA DIARY

48

LIST OF ADVERTISERS

48

IOA SPONSORS

48



Institute of
Acoustics

The Institute of Acoustics was formed in 1974 through the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is the premier organisation in the United Kingdom concerned with acoustics. The present membership is in excess of two thousand and since 1977 it has been a fully professional Institute. The Institute has representation in many major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental, industrial and architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration. The Institute is a Registered Charity no 267026.

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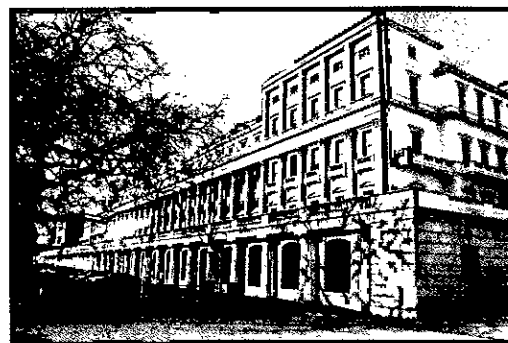
Dear Members

Our Spring Conference 'The heart of building acoustics – what makes it tick' will be held at The Oxford Hotel on 19 and 20 April. The programme of submitted papers focuses on topical issues, and is complemented by three invited medal lectures by distinguished acousticians: Professor Heinrich Kuttruff (Rayleigh Medal 2005), Professor Michael Vorlander (R W B Stephens Medal 2005) and Rob Harris (IOA Engineering Medal 2004). I hope that as many of you as possible will be able to attend the conference, for which thanks are due to the Building Acoustics Group's organising committee. Also, our thriving Underwater Acoustics Group held the latest of their successful conferences on 21-22 March at NPL. 'Sonar transducers and numerical modelling in underwater acoustics' provided an update of developments in this field and was the opportunity for Dr Eric Pouliquen to receive his A B Wood Medal 2004 and present his medal lecture.

Having mentioned the medals soon to be presented, I would remind you about two new awards that were announced recently. The closing date for nominations for the Award for Promoting Acoustics to the Public is 31 May 2005, and that for the Young Persons Award for Innovation in Acoustical Engineering is 15 July 2005. Please put on your thinking caps and ensure that the judging panels have a range of worthy nominations to consider. Details of these and all our other prestigious medals and awards are available on the Institute's web site or from the office.

Council is conscious of the need to encourage young people to take up acoustics as a career and to ensure that they can benefit from appropriate training. In this regard the participation of some employers in modern apprenticeships is very encouraging, but much more needs to be done in this area. Please don't hesitate to contact me if you can contribute suggestions or would be prepared to volunteer to progress these important issues; ideas from our younger members would be particularly welcomed. In this vein, during 2005 the Institute of Physics will be operating a community outreach programme 'Lab in a Lorry' and their mobile laboratories will be visiting schools, youth centres and science festivals to expose young people to experimental physics. The IOP would be happy for our members to participate in the programme, partly to help out with the demonstrations but also to represent acoustics as a career option. Please contact Roy Bratby or Judy Edrich at head office if you would like to become involved in this interesting programme.

Tony Jones
President



The west façade of the Royal Society overlooking St James's Park

Left; Simon Bull of Castle Group, the meeting organiser, begins the proceedings

From DAT to Disk

Simon Bull reports from the Measurement and Instrumentation Group meeting held at the Royal Society

Over 50 delegates attended the one-day meeting held by the Measurement and Instrumentation Group at the Royal Society on 15 February 2005. The subject was sound recording for measurements, with a focus on recording equipment and media. The presentations ranged from an historical overview of recording devices to a detailed look at the process of taking good quality recordings where there is a high cost of failure. The afternoon sessions took a different course in the form of two seminars demonstrating both the making and the re-analysing of a recording

An historical overview

The first presentation was by **Geoff Kerry** (Immediate Past President), entitled *Where did the 10dB go?* Geoff took us right back to a picture of a steel wire recorder from 1897 as one of the first recording methods. We then saw the progression of technology in the late 1930s with the introduction of tape by BASF, followed by rapid improvements in quality when it was adopted from the Germans by the Allies at the end of World War II. Geoff highlighted the impact of recording on the acoustics world, and weighed the benefits of capturing a sound for later analysis against the pitfalls in making field recordings. Early hi-fi technology caused many problems for acousticians, and when the Dolby system appeared the difficulties were multiplied, although professional developments such as frequency modulation, improvements in tape manufacture, and better recording mechanisms were undoubted benefits. The best of these analogue systems are still in use today.

To round off his presentation, Geoff talked about the introduction of digital technology using compact disc and video recorder techniques to create the ubiquitous DAT recorder. Was this perhaps just a way of finding a use for Sony's Betamax standard? He also looked at linear digital tape recorders and concluded with solid-state recording, pointing out that Bruel & Kjaer's first system became available in 1972!

Choosing the right medium

John Shelton (AcSoft) gave the second paper, *Horses for courses*, in which he compared the various methods of digital



Geoff Kerry presents his talk on the history of sound recording

recording and looked at their pros and cons. After establishing the basic differences between tape-based and file-based systems, we were shown a number of pitfalls in using DAT, such as compatibility between systems and the slow speeds at which information can be found.

For file-based systems, the basic parameters were defined, and this gave an insight into the link between quality and file size. An interesting point was raised about the use of file-based audio for evidence in court: how could a recording be verified as original in this case? John continued by discussing various file and media formats, and dealt with compression and the reproduction of so-called 'CD quality'.

The last part of the presentation was an

investigation into the merits and demerits of re-analysing a compressed audio file. Recordings of a calibration tone, a diesel engine and general environmental noise had been made and then compressed into MP3 format. The re-analysis surprisingly showed that the results were very close below about 8kHz, which was not quite what John had expected ... answers on a postcard please! [or e-mail john@acsoft.co.uk – Ed.]

Hand-held recording

The presentation from **Brian McMillan** (Bruel & Kjaer), based on a paper by **Julian Simpson**, looked at the possibilities of multi-channel recording in the palm of your hand. To achieve this, Brian took each of the technologically limiting factors for hand-held devices and looked at the limits of the performance envelope.

The areas discussed were mechanical requirements, processor speed, batteries, pre-amplification, storage media, and bit-rate budgets. Interesting highlights were the observations that Moore's Law (that processor speed doubles every 18 months) only applied to processors (just about) whereas storage media size was increasing much more quickly. Ergonomics statistics were given for the variation in hand size for men and women, as the comfortable grip size (and thus overall size of a hand-held unit) followed from it. Otherwise, weight and battery consumption were major limiting factors (no surprises there).

The conclusions were that two-channel intensity meters were already available with recording capabilities although two was probably the current limit. From the insight

into the rapid change of technology, though, it would not be long before multi-channel hand-held instruments with huge recording capacity became a reality.

UKAS calibration

UKAS accreditation for Calibrating Noise Recording Instrumentation was the title of the presentation from **Richard Tyler** (AVI Calibration Ltd). Richard started by asking what 'calibration' is, telling us that the UKAS position is to take a system 'as is' and measure its performance. Moreover, 'calibration' in the case of a recording system should include all the elements that make up that system. One stumbling block pointed out by Richard was that the set-up procedure defining all the variables and normal settings must be written down. Without this, calibration was not possible. He then discussed what was checked, and what information was needed, such as the calibrator coupling correction. The importance of correctly setting-up the system, watching for overload levels on the recorder and correct range selection were also pointed out.

Richard went on to highlight the benefits of UKAS calibration in terms of the rigour of the auditing process and the protection it could give a user when faced with a court appearance. He also pointed out that full calibration was a good and thorough check of the entire system, including cables and accessories.

The age-old question of 'how often should I calibrate?' came next - there is no definitive guidance. Richard suggested that calibrators should certainly be checked annually, and sound meters biannually (annually for analogue meters). Apart from this, any suspected damage should be checked immediately.



Mike Swanwick of Rolls-Royce discusses the pleasures and pitfalls of recording aircraft engine noise

Data integrity

It was clear from **Mike Swanwick's** (Rolls Royce) presentation that mistakes were easy to make, but in certain cases could be very expensive. The paper, called *Recording methods to ensure data integrity* looked at sound recording from an engineering perspective. After another look at the various media available, and the disclosure that AIT (Advanced Intelligent Tape) was Mike's current preferred format, the measurement

chain and its set-up were discussed. This included pistonphone calibration and electrical audits using white and pink noise. The next main point was the importance of a recording log sheet on which all information was noted, to ensure repeatability and integrity of the final results. Mike pointed out that to hold an aircraft for one day can cost Rolls Royce up to £10,000, so making a mistake was not an option!



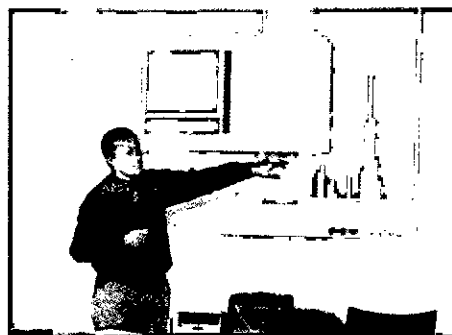
"What is the sampling rate of a Sony D10 DAT recorder?"

"Does anyone here know the sampling rate of a Sony D10 DAT recorder?"

Further recommendations and advice were given, including which spare parts should be carried, the practice of using only new recording media, how to conduct a comprehensive system check in the laboratory, the need for careful labelling of everything, and the care of equipment including storage, calibration and maintenance.

Hard disk and solid-state recording

The morning's final presentation was *Hard disk recording systems*, given by **Ian Campbell** (Campbell Associates). Ian looked at a few more historical systems before describing the digitising process in some detail, in terms of quantisation (bit-depth) and sampling frequency. This discussion led to a demonstration of audio recorded at various quality levels, and compression as well as recording levels in respect to full



John Shelton of AcSoft demonstrates the adjustment of a pre-recorded calibration tone during the afternoon workshop

scale deflection. The demonstration made it clear that with care, good audio quality was obtainable even with compression, as long as certain rules were followed.

The point was made that the application is very important and if only a subjective impression was required, lower quality was enough, and therefore more information could be stored. For detailed analysis, full precision audio should be used (48kHz and 24-bit).



Seminar Sessions

Mike Swanwick (Rolls Royce) and **John Shelton** (AcSoft) ran the afternoon seminar sessions which covered techniques for the recording and analysis of signals.

Mike started with a brief presentation on the process of setting out to make a good quality recording, including equipment lists, the suitability of equipment, and forward planning. He showed a system set-up with a Sony D10 DAT recorder (with preamplifier modification) and a Bruel & Kjaer microphone. Several sounds were recorded onto the tape including white noise and pink noise, the noise-floor of the set-up (using a dummy microphone), the ambient noise in the room, and a signal from a pistonphone calibrator through the measurement system.

Mike then made further comments on the procedure in the real world, showing free-field corrections, and spoke about the importance of ensuring that all the data required was actually recorded.

John Shelton then had the onerous task of taking the recordings from the previous session and playing them back into a hard-disk recording system in an attempt to validate the results. After some discussion as to the correct way to set up the system (showing the care needed), the expected results were obtained. John then played a number of recordings he had made earlier, to show what was possible with PC based recording systems, thus concluding a successful day that had passed with barely a technical hitch!

Editor's Notes



Ian F Bennett BSc CEng MIOA
Editor

One of the benefits of sitting in this chair is that I get to learn what is happening on the opposite side of the globe. I am grateful to the Australian Acoustical Society and the New Zealand Acoustical Society for continuing to send me free copies of their respective publications. Judging by *From the Editor* (Acoustics Australia) and *The Editor's Whim* (New Zealand Acoustics) my Antipodean colleagues get headaches just like mine when publication date approaches. However, the point of this is not to have a moan, but to observe that the problems faced by legislators, enforcers and consultants on both ends of the planet are remarkably similar. A quick glance over the past couple of years reveals that domestic sound insulation, noise nuisance from entertainment, wind energy, and road traffic noise are the most popular topics in terms of their appearances in print. I suspect that a straw poll of acoustical consultancies in terms of the importance of each area of business would produce similar results. No wonder we are all so busy!

Since I am no sort of academic, and my University days are well behind me, I am not qualified to comment on why there is such a shortage of engineering and scientific undergraduates. Nevertheless, the recently proposed changes to secondary education prompt me to wonder why so few young people seem to be excited by finding out how things work. Is it because physics teaching no longer has much of the optics, thermodynamics and acoustics I found so fascinating, or is it simply that nobody gets the chance to tinker with a car engine any more in these days of ECUs and engine management?

Copy date for the May/June issue is 15 April, and offers of technical contributions are, as always, very welcome. If your particular Group or Branch does not seem to have been represented in the Institute Affairs pages recently, feel free to ask your secretary or chairman why!

Dan Bennett

Ian Bennett
Editor

Spring Conference Preview

The heart of building acoustics - what makes it tick?

The Institute's Spring Conference will take place at the now-familiar venue of the Oxford Hotel, which is not actually in Oxford but at Wolvercote, about three miles north of the city centre. If you have ever tried to drive into central Oxford, you will immediately see the benefit!

The conference will be held on Tuesday 19 and Wednesday 20 April 2005, and an interesting and varied programme of papers and panel discussions has been arranged for both days.

The themes of the sessions will be:

- * **room acoustics;**
- * **studios;**
- * **sustainability;**
- * **schools;** and
- * **sound insulation.**

There will also be a sound transmission testing workshop, during which delegates will be invited to measure the sound transmission of a wall.

The testing workshop will take place during the first day of the conference, with each individual or group of individuals being allocated a one-hour slot to conduct their tests, using their own equipment. However, there are expected to be opportunities to conduct tests using shared equipment, thus investigating operator variation as well as instrument uncertainty.

Anyone interested in taking part in the tests is asked to visit the Institute web site, www.ioa.org.uk to complete a form.

The intention is to provide confidence to those undertaking the tests as regards their methods and results, and to give an indication of the likely variation that might be expected between different tests of the same wall. Results will be presented in terms of D_{nT} and D_{nTw} for comparison purposes (see below).

The main business of the conference begins with the room acoustics session, which will feature the Rayleigh Medal lecture by **Heinrich Kuttruff** (Aachen University) on the subject of *Retrospective room acoustics*. Rob Harris of Arup Acoustics will also be presenting the Institute Engineering Medal lecture on the acoustic design of the new Copenhagen Opera House.

The 'studios' session will include the intriguingly-titled *Phase and confused* by **Andy Munro**, as well as two other studio design presentations. Sustainability in buildings and sustainable design in acoustics will be followed by a panel discussion, chaired by Richard Cowell. The evening's events will also be interesting and relevant: the AGM of the Institute will be followed by the Building Acoustics Group's own AGM, and after a drinks reception the Conference Dinner will bring the first day to a close. The standard of catering at the Oxford Hotel is usually high!

Wednesday's presentations will begin with five papers on various aspects of acoustic in schools, which now that BB93 is in effect promise to be particularly useful to



The Oxford Hotel - our conference venue

the acoustical consultancy community. After a panel discussion with three of the morning's speakers, **Michael Vorlander** (Aachen University) will present his RWB Stephens Medal lecture on *Buildings: how they sound*.

Lunch will be followed by the final and potentially most controversial session, on sound insulation. This will focus on the workings of Robust Details in the house-building industry, (as reported in *Acoustics Bulletins* passim.) then **Bob Craik** will present the results of the sound transmission testing workshop. These will doubtless form the basis of the final panel discussion before the conference closes. In line with the usual policy that the Spring Conference should be accessible in academic circles as well as industry and the public sector, students can attend for a greatly reduced fee. All members should by now have received a booking form, but the Head Office team is quite willing to provide additional forms on request (01727 848195).

SPECIAL DISCOUNT FOR IOA MEMBERS

Elsevier, the publisher of *Applied Acoustics* and *Journal of Sound and Vibration* (JSV), advises us that members of the Institute of Acoustics are entitled to a substantially reduced personal subscription rate to both of these publications. The IOA members' rate for *Applied Acoustics* is €343, and for JSV it is €1317. Please visit the journal home pages (www.elsevier.com/locate/apacoust) and (www.elsevier.com/locate/jsv) to download an application form, or contact Dan Lovegrove (d.lovegrove@elsevier.com) for more information.

NW Branch meeting

Why the changes to Approved Document E2003?

The North-West branch's final meeting of 2004 was a presentation by **Dr Les Fothergill** from the Office of the Deputy Prime Minister. Les made his way northwards enduring not just the journey, but also the AGM, where, since the floor was silent, none of the Committee could stand down. This was a well-attended meeting which gave our hosts BDP the problem of finding sufficient chairs. It is amazing how many people want to come to an AGM!

Les provided an overview of the new requirements of *Approved Document E 2003* and the background to why the changes were made. The primary objectives were:

- ☐ to improve standards of sound insulation particularly now that there are significantly greater numbers of adjoining residences;
- ☐ to improve compliance with the standards by introducing pre-completion testing or Robust Details; and
- ☐ to extend the scope to rooms for residential purposes and schools.

The reasoning behind Robust Details was explained together with amendments to the guidance and legislation necessary to allow Robust Details to be used. Les confirmed that Robust Details are only an alternative to testing for new houses and flats, and gave a brief explanation of the responsibilities of Robust Details Ltd and

how the company monitors the performance of the details.

Several frequently asked questions were identified by Les before a lengthy discussion took place. These together with the main heads of discussion are listed below.

Robust Standard Details

How robust is robust? This was an interesting topic and one which challenged the notion of robustness. Surely if the details were robust, there should be no concern over them ever failing.

Testing organisations

Organisations identified in *Approved Document E* as being able to perform pre-completion testing are either those who are UKAS-accredited or those who are members of the ANC Registration Scheme. In the absence of any alternative ways of determining appropriate testing organisations, Les confirmed that these requirements were the preferred options. Obviously there were many organisations represented at the meeting who felt that to comply with either option would be unnecessarily onerous. In some instances organisations considered that they were not necessarily consultants, and therefore affiliation to the ANC was inappropriate. Since the scale of potential testing was so high would there be enough testing

organisations either UKAS-accredited or part of the ANC Registration Scheme?

Rooms in care homes

These would be covered by the requirements for rooms for residential purposes, unless they were occupied by patients who could lead independent lives.

Students halls of residence

Each study/bedroom should be treated as a room for residential purposes.

Domestic extensions and loft conversions

The requirement E2 would apply, ie the internal construction should achieve 40dB R_w.

Schools

The definition of a school was confirmed: it was unlikely to include sixth form colleges. Nurseries and/or crèches would be included if attached to a school.

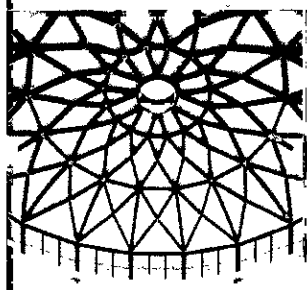
The meeting wound up at the local hostelry where any differences were put aside over a small beverage.

Thanks are due to Nick Antonio for organising the meeting and to BDP for being such good hosts.

Peter Sacre

Chairman, North-West Branch

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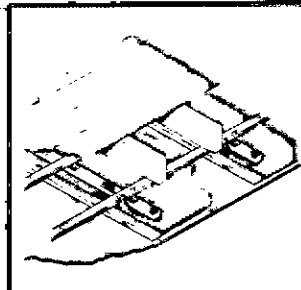
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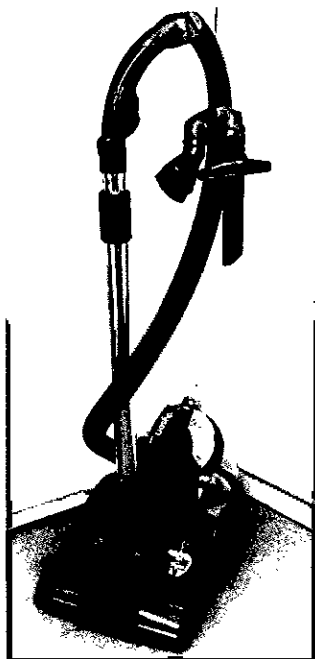
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Does the sound of your vacuum cleaner suck?

assessing sound quality

Trevor Cox, Claire Churchill and Sophie Maluski

How much consideration does a customer give to sound when buying a product such as a domestic appliance? If they are buying a vacuum cleaner, one might expect the look, functionality and cost to be considered; but what about the sound? Customers only get to hear most products when they get them home, so provided there are no returns or customer complaints, should a manufacturer assume there is no need to improve the acoustic design? Even if a manufacturer decides to improve the sound of a vacuum cleaner, how do they know what the perfect machine should sound like? Should it be silent? What can sound quality research offer the manufacturers of domestic appliances?

Sound quality design is the process of making a product sound suitable for its function or improving the sound to create the right image for a product. In the past, most sound design has been concerned with minimising the noise generated by a product; the assumption being the lower the noise level the better. However, this design principle does not always work. In some cases, it may be impossible to lower the noise level below a certain value because the end product would be too expensive.

Maybe the only way to lower the noise level is to make an ineffective product; outdoor manufacturers claim that new EU noise regulation for outdoor products may result in lawn mowers being sold that do not cut the grass very well, because the only way to meet noise requirements is to use less powerful motors. In other cases, lowering the level of the sound may actually result in customers being less satisfied, even if the product still functions.

To take an example, we spoke to a manufacturer of outdoor products who designed a low-noise leaf blower. However, when the leaf blower was sold, there were a number of returns from customers who assumed that low noise meant low power. In these kinds of cases, there is a need to not only look at the total sound energy being emitted, but also to look at the detailed quality of the sound. Maybe the solution to the quiet leaf blower would be to design one that not only has a low noise level but one that still sounds powerful.

Usually, the process of sculpting a sound is the domain of sound quality research, although the term 'product sound' is also used in this context. The industry that has carried out the most research in this area is car manufacturing, which also has access to the biggest product development budgets. A commonly cited example from the automobile industry is the work to optimise the sound of car door closing.

Manufacturers realised that the door-closure sound is an important first impression of a car. After all, when you enter the show room, one of the first things you will do is open the door, sit in the car and close the door. Consequently, some manufacturers have gone to great lengths to make the door-closure sound give the impression of a robust and well designed car. This work has even featured on car adverts, where the engineer is

seen going around listening for the right sound for a door closing. The next time you see a car advert on television, you might notice how the door sound is used to create the right atmosphere and feeling of quality, alongside the usual imagery of (mysteriously) empty roads.

Although sound quality is often defined as simply whether the quality of the sound befits the function of the product, this definition does not seem to encompass the automobile manufacturer's use of sound quality design. There can be more to sound quality than simply making a vacuum cleaner sound like a vacuum cleaner. It can be about what image the product sound portrays: does the manufacturer want the sound to give the impression of the product being powerful, robust, well made etc.?

So sound quality isn't always just about making the product acceptable (although that is an important part), it can also be about changing the impression of customers in a favourable way. Sound engineering shouldn't always be about avoiding annoyance and bad impressions. In crowded and mature markets, such as cars and domestic appliances, sound quality testing is one way to differentiate a product from those manufactured by competitors.

Industry attitudes

Our work on sound quality began by looking at the attitudes of UK industry to the subject. 100 questionnaires were sent to companies to find out some brief details about how sound quality is tested across the UK; 50 of the questionnaires were then completed and returned.

A large majority of respondents thought that the loudness or quietness of their products was always or often important to customer satisfaction, and all considered loudness somewhere in product development. But sound quality is not just about whether a product is noisy, it is also about the quality of the noise that is made. A product that produces a tonal noise can still cause customer dissatisfaction, even if the tone is relatively quiet. When asked if the quality rather than the loudness of the sound was important to customer satisfaction, 70% answered 'always' or 'often'. Only three companies selected the options 'sound quality never considered' and one manufacturer selected 'sound quality not important'.

The questionnaire's main purpose was to identify

subjects for further, more detailed discussions, and so a dozen companies were selected for phone interviews. These followed a semi-structured format. The companies selected were manufacturers of outdoor products, domestic appliances, air conditioning and heating systems, electric showers and audio-visual equipment. We only interviewed people who felt that sound was important to their products, because we didn't feel we would gain much by talking to people uninterested in sound. However, this selection process does bias the sampling of the interview subjects. In addition, we interviewed other stakeholders such as the Consumer's Association and representatives of the elderly, hearing and visually impaired.

Sound quality assessment

We interviewed the manufacturers about the two main methods for sound quality assessment: namely objective and subjective methods.

The objective method makes measurements of the product sound which are then analysed using sophisticated sound analysis software; various commercial systems are available for this. These systems sample the sound produced by the product, maybe using binaural recordings via an artificial head, before carrying out the analysis. The software produces a set of sound quality metrics that are designed to relate to how humans respond to sound. The only objective index which is widely known to manufacturers is the decibel, and they are unaware of the more sophisticated sound quality metrics such as loudness, roughness and sharpness.

These more sophisticated sound quality metrics have been used in product development. For instance, the metric loudness (unsurprisingly) relates to a person's perception of the loudness of a product. The loudness metric is more effective at modelling the human response than the better known sound pressure level measured in decibels, as it is based on a more complex model of human hearing. However, the vast majority of manufacturers we have spoken to have not even heard of the more detailed metrics, let alone used them. Given that some manufacturers already seem confused about the difference between sound pressure and sound power level and even the humble dB scale is often misunderstood by manufacturers and consumers (also confirmed by the I-NCE questionnaire), there seems to be little appetite for additional indices.

Added to this, the sound quality community is split as to the usefulness of many sound quality metrics. Apart from possibly loudness, the metrics can not be universally used for all products. Indeed they may need to be tuned or altered for each product to ensure a significant correlation between the metrics and responses from juries; sometimes new metrics need to be developed for each product.

Commercial sound quality assessment software deals with this problem by having a large array of metrics available (say thirty) and then the software identifies which metric is useful for which product. This is done by carrying out large-scale jury tests, where the metrics are correlated with the responses of the juries, and the appropriate metrics thereby identified. This is not a quick process, and there is a risk that at the end, no appropriate metrics are found. However, if successful and appropriate metrics have been identified, this test method then negates the need for further lengthy testing using customer juries. The products can be designed, and the success of the designs from an acoustic standpoint tested by calculating and analysing the sounds using the identified metrics. Also, by understanding

the definitions of the metrics, it is possible to get further insight into what is desirable or undesirable about the product sound.

A further problem is that many of the metrics are not standardised, indeed the definitions of many metrics are not in the public domain for reasons of commercial confidentiality. So the use of metrics is not straightforward, and the sound quality testing community is split on the usefulness of metrics - some use the metrics widely in product design, while others claim that they are useless and rely solely on jury testing.



'Sound quality testing is one way to differentiate a product from those manufactured by competitors'

Subjective testing, on the other hand, is less problematic. In the context of sound quality assessment, this is often referred to as jury testing. All those involved in sound quality assessment agree that getting the response of actual humans to the sound is important, either to discover the appropriate objective metrics or as a stand alone procedure in sound quality assessment. We found that many of the manufacturers interviewed carry out sound quality tests using subjects, mainly using juries of customers, but they don't call this sound quality testing. This testing might be part of more general functionality tests. Such tests are only carried out for significantly new products, or when there have been a significant number of complaints from customers.

Companies say that there are specific sounds which are bad selling points which they know about and therefore

continued on page 10

Does the sound of your vacuum cleaner suck?

assessing sound quality

continued from page 9

these need to be avoided. They generally think the jury test methods used are reliable, because they have a low number of complaints about product sounds. However, 40% of those surveyed didn't think the customers knew what they wanted from a product! A large majority said customers would like their products to sound as quiet as possible. But, in the case of many products, it is impossible to produce zero noise, and so it might be asked in those cases, what is the most appropriate noise to make?

In contrast, about a fifth of respondents thought that quietness is not always the best design goal, because the sound of the product is a source of information. For instance, the sound of the product tells the user that the product is on, something that is useful to operators of dangerous equipment such as hedge trimmers. For the visually impaired, the sound of a product is very important because it tells them what state the product is in, and the charities are keen for inclusive designs which work for everyone, say by including additional sounds to inform users about the operating state of products. (A common example of an operation sound is the noises that are made in cars when the indicators are turned on).

So overall, UK companies seem to take a reactive rather than proactive approach to acoustic design. In contrast, the automobile industry uses sound quality design to differentiate products in a mature market, rather than as a method only needed when there are complaints. So it could be that other manufacturers are missing an opportunity to view sound design in a positive way, and improve products to boost sales and customer satisfaction.

Overall, the jury testing methods implemented by manufacturers seem to lack the rigour that formal subjective testing should have. There is a risk that, without proper experimental design and statistical analysis, incorrect conclusions might be drawn from these tests. An example given to us was a company that used the engineers to listen and test the quality of the product sound, only to find that the sound preferences of the engineers were rather different to their average customers.



The EU energy label ignores any structureborne sound paths, which can be very important for some products in certain places, for instance a washing machine mounted on a suspended floor

Sound labelling

Labelling is considered to be a powerful tool by industry and consumer organisations. Labels help consumers to identify the right product for them. For instance, the introduction of the Energy EU label on white goods has led to an improvement in the energy efficiency of white goods, to the point now that the label is no longer very useful in differentiating between products. To take an acoustic example, customers are often dissatisfied with the excessive noise of vacuum cleaners. Yet, the sound power level of vacuum cleaners currently available has a relatively limited range of between 72 and 77 dB(A). There is a risk that all labelling achieves is to unify the noise level of vacuum cleaners, rather than encourage the manufacture of quiet vacuum cleaners.

The most popular sound labels accessible to manufacturers and consumers are the Energy EU label (see Figure 1) and the L_{WA} label (Figure 2).

The EU Energy label prioritises water and energy consumption. It also contains one section towards the bottom for noise levels, almost buried in the small print. This considers only airborne sound and reports an A-weighted sound power level referenced to 1pW. It ignores any structureborne sound paths, which can be very important for some products in certain places, for instance a washing machine mounted on a suspended floor.

The sound label can be explained to the customer by saying the lower the number, the quieter the appliance. But this does not help people understand what the numbers mean. While the decibel scale is taught to schoolchildren as part of the national curriculum, it is difficult to see how a customer can interpret the sound power level (which is different from the sound pressure level taught in schools) without further guidance. Try going to your local white-goods retailer and asking for a product which does not exceed a certain sound power level. A colleague tried this when buying something recently, and you can imagine the blank expressions he got.

We found that some white goods manufacturers were dissatisfied with the EU Energy label. The fact that the

Energy

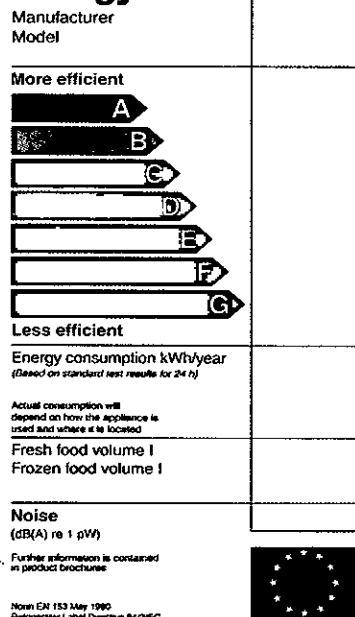
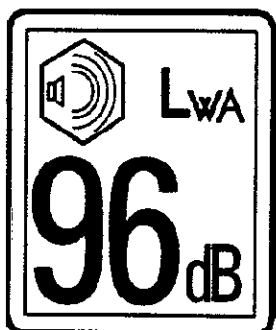


Figure 1:
(Left) EU Energy
label

Figure 2: (Below) Label
for outdoor products and
machines



sound label is voluntary means that some companies will carry out sound testing while others do not. Some manufacturers would prefer the sound label to be either compulsory or non-existent. Sometimes information on noise levels is only accessible to the consumer after purchase, because the noise level is mentioned in internal documents such as instruction manuals.

The second sound label is the L_{WA} (Figure 2) implemented by the noise directive passed in July 2000. The purpose of this directive was to harmonise national laws of the member states, regarding noise emission limits and labelling requirements at the manufacturing stage. The label is compulsory for 57 specified types of equipment for use outdoors such as construction machinery, lawnmowers, edge trimmers and leaf blowers.

This labelling is causing some disquiet among outdoor product manufacturers, because reducing the noise level to the required (and possible future) value is a very difficult task given the nature of the products. Manufacturers feel that there is a large amount of work required for what is a small decrease in decibels, and that this noise reduction is unlikely to be aurally significant. All the outdoor equipment manufacturers interviewed felt that sound quality labelling should be the future direction, rather than just sound power level, although this may be influenced by the difficulties companies are currently experiencing. Certainly, this experience has shown that regulation is a sure-fire way of getting companies to take more notice of acoustics!

The problem with using a sound quality label is how to translate the human response to some form of label that can be interpreted by customers. If customers struggle to understand sound power level, bringing in further complications of additional parameters is unlikely to be useful. Maybe simple classifications A,B,C etc. similar to those used for efficiency could be appropriate. However, as mentioned before, the defining of sound quality metrics is product-specific and, to many, problematic. If a manufacturer produces a new product that operates in a different way from previous products and so produces a very different sound, then the metrics used to assess the previous products might be rendered useless. This sort of labelling could stifle innovation. Furthermore, some manufacturers will only accept the new label if it was Europe-wide, and others have expressed a worry about increasing paperwork and costs of regulation. Given all these problems, it seems unlikely that standard sound quality labelling could be agreed.

To summarise, current sound labelling does not inform the consumer about the nature of the sound. Two machines could display the same noise level, but sound different. One sound could be perceived as louder than the other because of its spectral balance. The noise level could comply with the sound labelling but the nature of the sound could be very unpleasant. For example, a frost-free freezer can produce tonal noise which can be very unpleasant to hear. The current voluntary scheme does not serve customers very well.

Other sound labels across Europe

Unlike the UK, which only supports the EU Energy label, there are many countries with their own national eco-labels or eco-mark schemes. They are all voluntary, which means there are no regulations to oblige manufacturers to apply for the label. One well-known label is the 'Blue Angel' in Germany, which has been established since 1977.

continued on page 12



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Does the sound of your vacuum cleaner suck? *assessing sound quality*

continued from page 11

Owned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, about 700 companies and 4,000 products use this environmental label. About 40% of consumers in Germany take it into account when they go shopping. This makes the Blue Angel a signpost for the environmental awareness of consumers. Other eco-labels exist in Europe such as the Nordic 'Swan', and the French and Austrian Ecolabel.

There is also the 'TCO' label in Sweden, which is part of scheme design to make the working environment better for offices; you may have seen the label on some IT equipment. Like the Ecolabel, noise level is one criterion with which the manufacturer must comply in order to obtain the label from TCO development. There are noise criteria for printers, computers and fans, among others.

The European Union Ecolabel, known as the 'Flower' (Figure 3) was established in 1992, but had to be relaunched in September 2000. The label is based on the Blue Angel criteria and is used by goods and services on a voluntary basis. The scheme places an emphasis on consumer demand to transform products and markets, and actively encourages manufacturers to design products with reduced environmental impacts. The Flower today represents several hundred products with sales in 2001 of approximately 54 million eco-labelled items. The Ecolabel licences are mainly given to textile products, indoor paints, cleaners, detergent, footwear, but also for furniture and domestic appliances. The highest flowering rates so far are achieved in Italy, Denmark and France.



Figure 3: Ecolabel logo

The Ecolabel includes noise criteria for some domestic appliances as shown in the table. The noise criteria are below 56dB(A) for all the domestic products, except washing machines when spinning, and vacuum cleaners. The criteria defined for the Ecolabel are only valid over a period of time, often between three and five years, after which they are reviewed and the company must reapply for a licence.

None of the manufacturers interviewed, or the Consumers Association, mentioned the Ecolabel or indeed

any other European label. However, when prompted, companies' major concern is the cost of these types of labelling schemes. With the EU Energy Label being so dominant, some do not consider that addition ecological labels will make significant differences to their sales. Furthermore, manufacturers of domestic appliances frequently change their product lines, so testing to meet labelling criteria is expensive.

Concluding remarks

There is relatively little formal sound quality testing being carried out in the UK, with the exception of the car industry (and those who make sound reproduction equipment). This is probably due to the limited acoustic know-how of many manufacturers, the lack of guidelines, standards and sound labelling, and the lack of customer demand for a better sound. Maybe customers need to be made more aware of what modern acoustic engineering can achieve.

The manufacturers interviewed might be prepared to include noise standards and sound labelling, but their concern is the interpretation and cost of these labels. At present, only few products must comply with sound labelling and the difficulties caused by the lack of understanding of the labelling and the lack of information on the character of the sound, as well as the costs, discourage manufacturers from joining the labelling scheme.

The car industry has shown what can be achieved through better sound design by considering the quality of sound as well as the sound power level. This has allowed manufacturers to differentiate their cars from their competitors in a crowded and mature market place. Most domestic products are very mature, and certainly there is strong competition in the sector. Maybe it is time for the manufacturers of these products to consider what sound quality testing can do for them.

Acknowledgements

The work reported here is part of the findings from a DTI-funded project based at University of Salford. Best practice guides for objective and jury testing were developed, and these can be found at www.acoustics.salford.ac.uk/sqa, alongside suggestions for further reading, information on sound quality metrics and example of sound quality assessments.

Noise level	Dishwashers	Washing machines	Vacuum cleaners	Refrigerators	Portable and personal computers
dB(A)	free standing: < 53	washing: < 56	76	42	idle operating mode: < 48
	built-in models < 50	spinning < 76			when assessing a disk drive: < 55
Standards	EN50242 EN60704-2-317	ISO 3743 EN6045619	ISO 3743 EN60704-2-120	EN 28960	ISO 7779 ISO 9296

Ecolabel noise criteria for domestic appliances and their respective noise measurement standards



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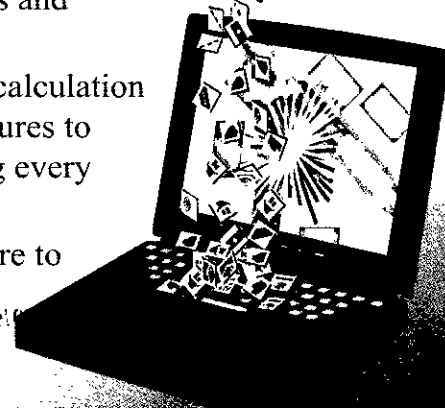
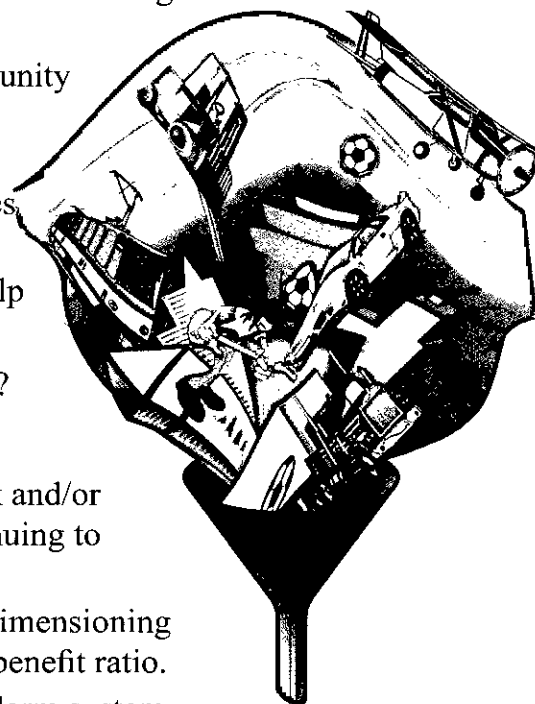
- ☐ How can I efficiently map the transportation and industrial noise from an agglomeration?
Can the software calculate in the background while I continue working?
Can I use a PC network to distribute the calculations?
- ☐ What is the most cost effective method to minimize community noise?
- ☐ How loud is it inside a building? Which sounds dominate?
Can the noise breakout be minimized with new doors, gates or window applications?
- ☐ Can I document my data sufficiently? Will the software help me comply with ISO 9000 quality control?
- ☐ Will I get the hotline support I might need in my language?

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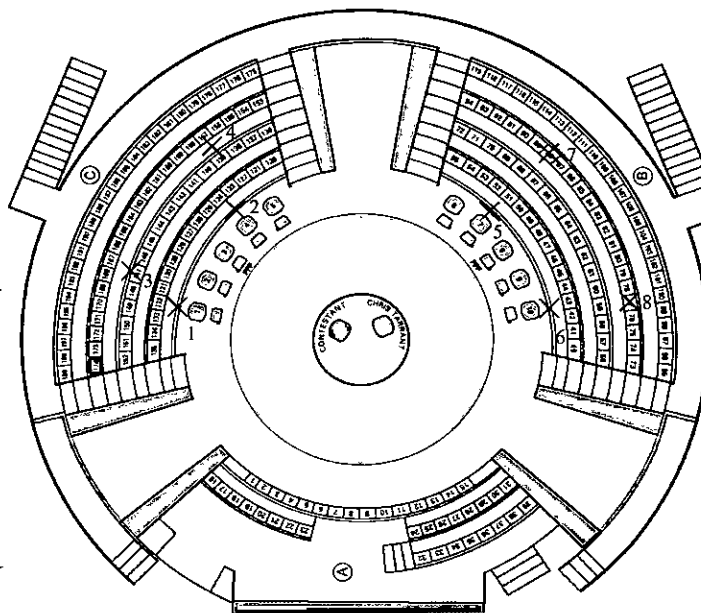


Figure 1: Plan of studio showing position of 8 audience microphones

A case study in forensic acoustics

R -v- Ingram C, Whittock T, and Ingram D

The 'Who Wants to be a Millionaire'? fraud trial

Peter French and Philip Harrison

The television show, 'Who Wants to be a Millionaire?' (WWTBM), was created in 1998 by the independent UK production company, Celador. It is a general knowledge quiz show in which contestants have the chance to win a top prize of one million pounds. The programme has reached its fifteenth series in the UK and it runs several nights a week on the independent television network. It has been exported to over 100 countries worldwide.

In March and April 2003 two contestants and an accomplice were tried and convicted of attempting to defraud the programme of the million pound prize (1). Their strategy involved the contestant, after having been asked the questions, 'thinking aloud' about possible answers whilst an accomplice in the studio guided him towards the correct one by a system of coughing. This article describes the methods used by the authors to determine from the recordings of the programme where in the studio the coughing was coming from (2).

The game

The quiz is divided into two rounds, known as the 'fastest finger first' (FFF) and the 'hot-seat'.

The FFF round involves ten contestants attempting to place given answers to a question in the correct order in the shortest possible time by pressing buttons. The winner of this then moves forward to the 'hot-seat' round and becomes the main contestant who has a chance of winning the one million pounds top prize. The remaining FFF contestants stay in their seats, as they may have a further opportunity to reach the hot-seat later in the programme.

Once in the hot-seat, the contestant has to answer a series of multiple-choice general knowledge questions that increase in difficulty and in value up to the final question, number 15, which carries the million pound prize. The

contestant is allowed to see each question and its four possible answers before deciding whether to answer, or retire from the game with the prize money won so far.

There are three aids, or 'life-lines', available to players if they are unsure about an answer. One of these (called 'phone a friend') involves making a telephone call requesting assistance from a nominated person. Another ('fifty-fifty') entails narrowing the odds in the contestant's favour by having two of the three wrong answers removed. The third ('ask the audience') puts the question to the studio audience (260 people) who provide their answers via keypads.

If a hot-seat contestant is still playing at the end of a programme, the seat is resumed at the next show. Contestants are normally accompanied by a partner, friend or relative who sits in the audience.

The rogue episode

On 9 September 2001 a British army major, Charles Ingram, became the hot-seat contestant in the quiz. His wife, Diana, was in the audience as his official companion. By the end of that day's filming, although he had used up two of his life-lines, he had nevertheless answered the first seven questions correctly and won £4000. He returned the next day to continue his attempt for the top prize and after correctly answering the remaining eight questions he won the million pounds.

During his play on this second day, however, various people in the studio - including FFF contestants and production staff - became suspicious about his playing style and also about the amount of coughing that was occurring. As a result of these suspicions, the tapes of the day's filming were reviewed, the police were contacted and the million pound prize cheque was withheld.

The analytic task

We were contacted by the Special Investigations Branch of the Metropolitan Police at New Scotland Yard to assist in their investigations and provide expert opinion. The police had already arrived at the view that someone had been coughing in the studio to prompt the major into giving the correct answers.

They suggested to us that the major had used a highly unusual answering technique that involved 'thinking aloud' and systematically talking through each of the possible answers. When he reached the correct answer, the prompter would cough to signal that it was correct. An illustrative example from a transcript prepared later follows.

Question 12

Host: 'The Ambassadors' in the National Gallery is a painting by which artist? Van Eyck, Holbein, Michaelangelo, Rembrandt? 'The Ambassadors' in the National Gallery is a painting by which artist? Van Eyck, Holbein, Michaelangelo, Rembrandt? It's worth one hundred and twenty five thousand pounds.

Cl: I th- Just look at the cheque. [Laughs]

Host: Have a good look.

Cl: Erm.

Host: You can walk away with that cheque, but have a good look at this question. Have you got erm-

Cl: Well I- I th- I-

Host: Have you got a clue?

Cl: I think it was either Holbein or Rembrandt, I have seen it. Erm, I think it - I think it was Holbein.

[PROMPTING COUGH]

Cl: I'm sure it was Holbein, I'm sure it was Holbein. God damn it. Sorry, I'll just rethink this for a second.

[PROMPTING COUGH]

Cl: Yeah, I'm su- I'm sure it was Holbein, sure of it. I don't think it was Michael- Michaelangelo, I don't think it was Van Eyck. In fact I - I'm not sure that I've actually ever heard of Van Eyck, erm. I don't think it-

Host: Just remind you hadn't heard of Craig David.

Cl: I know. [Laughs]

Host: And somehow that's how you got it.

Cl: [Coughs] I know. I don't think it was Rembrandt. I'm pretty sure it was Holbein.

Host: Are you sure enough to risk thirty-two thousand pounds on it?

Cl: Yeah. I think so.

Host: It's your call.

Cl: It's a lot of money.

Host: You've got sixty-four thousand, you've got no lifelines, you can walk away with that sum of money.

Cl: Yeah. Down-payment on a house. Erm, yeah, I think I'm going to go for Holbein.

[PROMPTING COUGH]

Cl: Yeah, erm, Holbein.

Host: Final answer?

Cl: Can't see any clues in your face. [Laughs] S - Holbein, yeah, yeah Holbein.

The police had set out in a schedule a total of nineteen coughs they considered to be prompting coughs (3). Although we were eventually given further tasks (see below), our initial instructions were to determine from where in the studio of 260 people these coughs were coming.

The analysis

In order to understand the method of analysis adopted, one needs first to know about the configuration of the studio recording equipment. The police had, in fact, been in touch with studio staff before we were consulted and the investigating officer had gained a quite comprehensive understanding of how the programme was recorded. He was able to explain to us that there were 21 microphones in the studio, where each was positioned and how the signal from it was routed, via a mixing desk, to a particular tape track. The information given to us by the investigating officer was confirmed and supplemented by a site visit to the WWTMB studio.

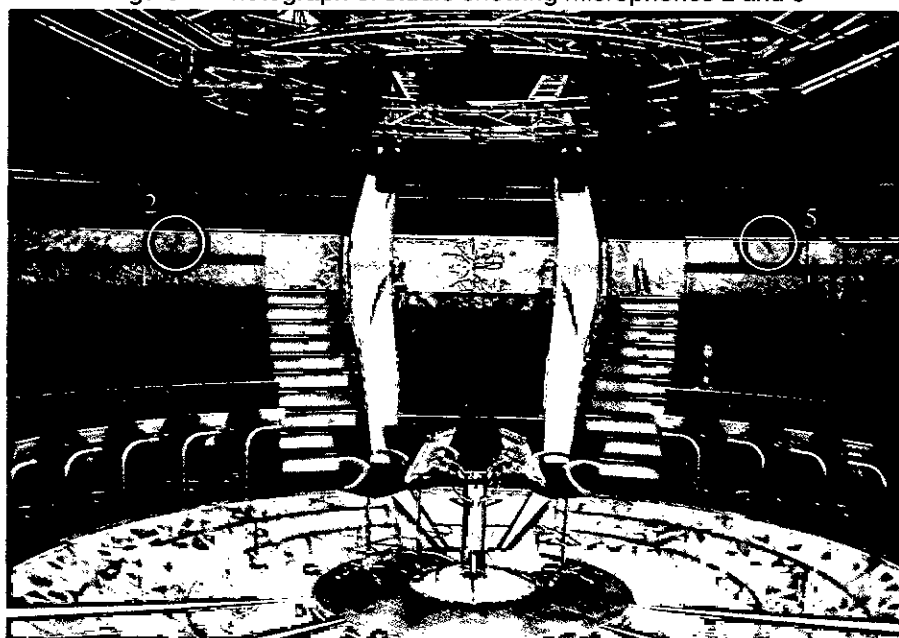
Positions of microphones

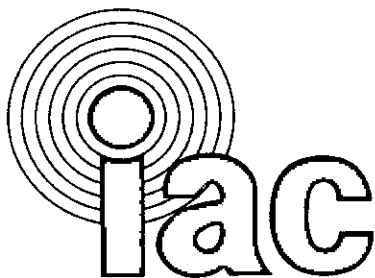
Fixed microphones: Figure 1 is a floor plan of the studio indicating the positions of eight fixed microphones suspended above the audience. A three-dimensional impression is afforded by the Figure 2 photograph in which microphones 2 and 5 are visible.

Radio microphones: In addition to the fixed microphones, 13 individually-worn radio microphones are

continued on page 16

Figure 2: Photograph of studio showing microphones 2 and 5





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A case study in forensic acoustics

The 'Who Wants to be a Millionaire'? fraud trial

continued from page 15

in operation during the filming of the show. These are worn by the host, the hot-seat contestant, the accompanying partner or friend and by each of the 10 FFF contestants.

Routing of microphone feeds

The mixing desk allows a 'sound supervisor' who is present behind the scenes to combine the various microphone signals and produce a stereo mix as the show is going on. This is what normally will be heard by people watching and listening at home when the programme is broadcast.

In addition and at the same time, the desk routes the individual microphone signals and combinations of signals to separate tape tracks. This is to allow an alternative mix to be created at the post-production stage, if the contemporaneous mix proves unsatisfactory. Each of the signals, along with the different video images, is recorded onto six Digibeta tapes, this being Celador's chosen professional digital video format.

The routing of the microphone signals through the mixing desk to the Digibeta tape tracks is illustrated in Figure 3.

The radio microphones attached to the host, the hot-seat contestant and the hot-seat contestant's companion are each routed to a single Digibeta track (A, B and C in Figure 3).

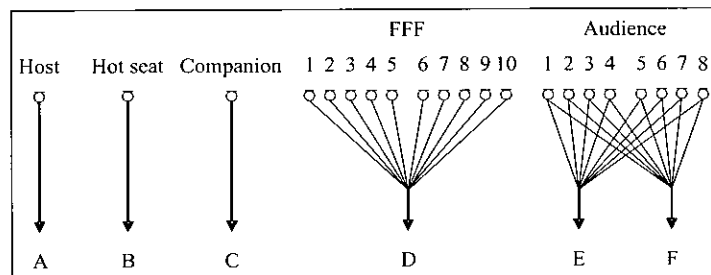


Figure 3: Routing of the microphone signals through the mixing desk to the Digibeta tape tracks

The signals from the ten FFF contestants' radio-microphones are mixed together and routed to a single track (D).

The signals from the eight suspended audience microphones are mixed in a rather complex way and routed to two separate tracks (E and F), in order to provide a stereo playback effect. The mixing technique involves routing all eight signals to both tracks, but panning the first four feeds incrementally from the centre-most (4) to the left-most (1) towards to left track, whilst panning feeds 5 to 8 to the right track on the same principle, as shown in Figure 4.

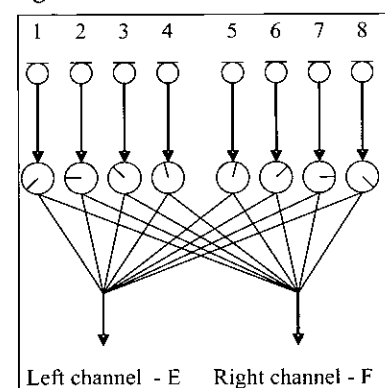


Figure 4: Panning of eight audience microphones to left and right channels

Thus, sound from the left hand side of the audience is louder in playback in the left channel and sound from the right hand side is louder in the right.

Finding the cougher

Stage I

Audio material originating from the various Digibeta tape tracks was re-recorded to the hard drive of a computer (44.1kHz sampling rate; 16 bit resolution) and examined within two sound playback and analysis systems (Praat 4.0.5 and SoundForge).

The questioned coughs were identified and compared across the recordings from the different microphone feeds. From a preliminary auditory examination it emerged quite strongly that they had been produced by one of the ten FFF contestants. This impression was based on the fact that the prompting coughs were significantly louder on this track than were other, background, coughs. Also, the tonal quality indicated close proximity to one of the FFF radio microphones (4). In short, the overwhelming impression was that they were what those working in the sound recording industry would call 'on-mic' coughs.

This auditory impression was borne out by subsequent acoustic analysis. Table 1 shows the dB levels measured both in terms of peak and rms values of prompting coughs and other coughs - which are perceived as background coughs - from three question sequences.

For Question 12 the highest amplitude cough perceived as a background cough is number 1 with an RMS value of -57.42dB, and the lowest amplitude prompting cough is number 9 with an RMS value of -35.86dB. The difference in amplitude here is around 1200%. For Questions 14 and 15 the difference between the highest level background cough (number 7 in each) and the lowest level prompting cough (respectively numbers 9 and 4) is around 1650% (5). These differences were of a magnitude that left us in no doubt that the prompting coughs were 'on-mic', having been produced by an FFF contestant. We discounted the possibility of their having been produced by a nearby member of the audience (6).

Stage II

Having established to our satisfaction that the prompting coughs had originated from the FFF contestants, we then attempted to narrow further the potential population of coughers. An immediate difficulty appeared to arise from the fact that signals from the FFF radio-microphones had all been inextricably combined before being routed to a single tape track.

However, the coughs were also audible on the audience tracks. Remembering that there are two audience tracks, the contents of the left track having sounds from audience microphones 1 - 4 more strongly represented, and the right track having stronger representation of sounds from microphones 5 - 8. Returning to Figure 1, it can be seen that the ten FFF contestants were arranged in terms of two curved rows of five, one row nearest audience microphones 1 - 4 and the other row nearest 5 - 8. In order to determine which of the rows harboured the cougher, the coughs could therefore be compared for relative level across the audio originating from two audience tracks.

Before any measurements, however, there were two potential impediments to be addressed. The first concerned the almost continuous presence of background musical accompaniment. Because this was being played in stereo through speakers situated at different points

Question 12			Question 14			Question 15		
cough no	rms dB	peak dB	cough no	rms dB	peak dB	cough no	rms dB	peak dB
1	-57.42	-37.63	1*	-31.50	-14.17	1	-67.65	-48.51
2	-58.39	-41.33	2	-60.92	-36.73	2	-60.01	-42.41
3	-59.93	-40.09	3	-68.45	-56.15	3	-71.76	-52.24
4	-66.16	-47.89	4*	-34.45	-11.90	4*	-35.14	-13.13
5*	-32.40	-13.02	5	-61.50	-41.03	5	-65.48	-50.93
6*	-34.71	-12.47	6*	-33.66	-10.58	6*	-31.42	-10.44
7	-61.21	-43.98	7	-59.79	-41.12	7	-59.66	-42.99
8	-65.61	-50.05	8	-64.92	-49.80	8*	-34.09	-15.20
9*	-35.86	-19.86	9*	-35.49	-13.29	9	-61.27	-44.37
						10*	-30.55	-12.08

* asterisk denotes 'prompting' cough

Table 1: Peak and rms levels of coughs from FFF recording

in the auditorium, there was the possibility that any measurements of relative left-right sound levels for prompting coughs could be influenced by differential left-right stereo fluctuations in the level of the background music. In order to minimise the potential effect, the spectrum of the music was measured and found to dominate at frequencies below 1.1kHz. The comparative measurements of the prompting coughs across the left and right audience tracks were therefore made within the frequency band 1.2 to 22.05 kHz.

The second potential problem for the comparisons concerned a function of the mixing desk not so far described. In addition to routing signals from the microphones, the desk also allows the signals to be modified, either by boosting or reducing their sound energy levels overall or within selected frequency bands. This facility is represented in Figure 5.

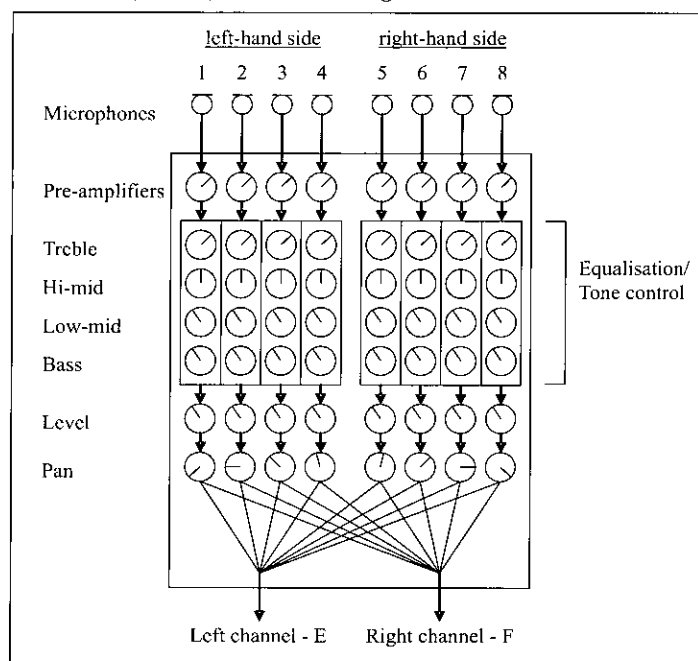


Figure 5: Routing of audience microphone signals through equalisation to tape tracks

The possibility of selective attenuation could thus mean that the relative left-right sound levels had been influenced by the settings adopted by the sound supervisor, rather than giving a true reflection of those reaching the audience microphones. However, the sound supervisor informed us that it was his practice, both generally and during the recording in question, to use 'mirror image' attenuation. That is, whatever attenuation settings were used for the left audience channels, corresponding ones were selected for the right. So, even though it could not be claimed that the signals on the two tracks were unmodified, it appeared

continued on page 18

A case study in forensic acoustics

The 'Who Wants to be a Millionaire'? fraud trial
continued from page 17

that they had at least been modified in comparable ways and to a comparable degree. It was made clear that the reliability of our comparisons was dependent upon the veracity of the sound supervisor's claim, eventually given in evidence at the trial, that left-right parity of attenuation had been maintained.

The difference in amplitude level between the left and right audience channels was small. It was therefore decided

prompting cough no	L channel energy Pa ² s	R channel energy Pa ² s	delta Pa ² s	% difference
1	4.93E-06	3.10E-06	1.83E-06	59.0
2	5.52E-06	3.43E-06	2.09E-06	60.9
3	7.98E-06	6.05E-06	1.93E-06	31.8
4	1.28E-06	9.25E-07	3.51E-07	37.9
5	8.07E-06	4.67E-06	3.40E-06	72.9
6	3.22E-06	1.47E-06	1.76E-06	119.6
7	6.54E-06	4.46E-06	2.08E-06	46.5
8	1.87E-06	1.71E-06	1.53E-07	9.0
9	4.58E-05	3.68E-05	9.07E-06	24.7
10	1.06E-05	9.28E-06	1.31E-06	14.1
11	7.81E-06	7.23E-06	5.79E-07	8.0
12	3.68E-06	2.21E-06	1.47E-06	66.2
13	1.06E-05	6.21E-06	4.42E-06	71.2
14	1.03E-05	9.06E-06	1.22E-06	13.4
15	5.33E-06	4.62E-06	7.14E-07	15.5
16	1.00E-05	6.46E-06	3.55E-06	54.9
17	1.73E-05	1.32E-05	4.09E-06	31.1
18	6.06E-06	5.34E-06	7.15E-07	13.4
19	1.05E-05	8.30E-06	2.22E-06	26.8

Table 2: Energy values for prompting coughs from left and right audience microphones

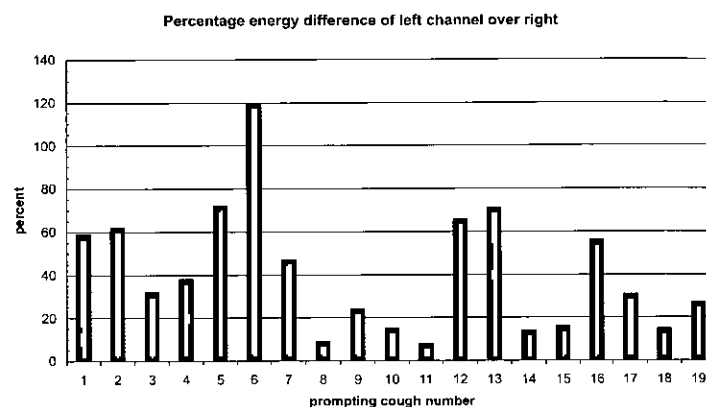


Figure 6: Percentage energy difference of left over right audience channel

that decibels, as logarithmic units, could not effectively be used to demonstrate the disparities. Instead, we opted to measure the energy of the signal in pascal-squared seconds Pa²s (not absolute). For each of the prompting coughs, the energy was greater in the left channel. In percentage terms, the difference ranged from just over 8% (cough number 11) to almost 120% (cough number 6). The values are presented in Table 2 and graphically in Figure 6.

This led us to conclude that the cougher was one of the FFF contestants sitting nearest to audience microphones 1-4 on the left-hand side of the studio. As one of the four was a woman and the coughs were quite decidedly male, we formed the view that the cougher was one of four male FFF contestants.

On the basis of other information, the police had already interviewed one of these four, Tecwen Whittock, about the offence. Mr Whittock was sitting in the centre seat of the left-hand FFF row some two metres behind the hot-seat. During his tape recorded interview he provided some specimen coughs which we were asked to analyse and compare with the 19 prompting coughs from the programme.

The forensic comparison of coughs is uncharted territory and we made no claim that the prompting cougher could be identified as Tecwen Whittock. The most that it was felt safe to say was that the prompting coughs showed some auditory, and to a lesser extent acoustic, similarities to those of Mr Whittock (7). It was, however, pointed out that all the prompting coughs bore quite strong similarities to another, such that they could very well have a common origin, and an edited recording in which they appeared one after the other without potentially distracting intervening material was prepared and played to the jury in demonstration of this.

It was agreed from the outset that the prompting coughs were not the only ones with a similar sound quality emanating from the left-hand FFF group. Indeed, a further nine such coughs were identified. None of these, however, occurred within a question sequence.

Further areas of examination

We were also asked to address a number of other issues, two of which are dealt with here.

Transcription

Taken together, the FFF group constitutes a considerable pool of knowledge, in that its members are mainly quiz aficionados. A certain amount of quiet conversation is apparently tolerated among them during the hot-seat round of the show. At selected points we were asked to examine audio from the FFF track and to transcribe any

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words exchanged within the FFF group. Around certain questions at least, it appeared that the group was engaging in discussion and thereby unwittingly making available the correct answer for Whittock to act on, if he did not already know it himself as the following transcript highlights.

Question 13

	Host & Hot-seat		FFF Discussion
Host	What type of garment is an Anthony Eden?		
Host	Overcoat.	C	Oh god, what's up with you?
Host	Hat.	?	What's that?
		C	It's a hat.
Host	Shoe.	?	... (question).
Host	Tie.		
		C	Jesus, I wished I was up there.
Host	It's worth two hundred and fifty thousand pounds.	?	You ever worn one of them?
		C	Hm?
		?	Have you ever worn one?
CI	I think it's a hat.	C	I haven't but Anthony Eden wore them.
		C	Very popular (around about that point in time and) ...
CI	I mean again, you know, I'm- I'm not sure. But I- I think it's a hat. I think it's one of those really sort of tall hats, that sort of came into fashion, presumably when he was Prime Minister.	?	[Cough]
		?	[Cough]

'C' = male FFF contestant with Cockney accent

'?' = male FFF contestant, accent unidentified

'No!'

During the fourteenth question, the police had identified a one syllable utterance after a prompting cough which they believed was the word 'no'. We were asked to provide an opinion on this. The utterance in question occurred during the question worth £500,000 and immediately followed the 12th cough on their schedule. The question was 'Baron Hausmann is best known for his planning of which city: Rome, Paris, Berlin, Athens?'. In answering this question, Ingram seemed to be going for the answer Berlin without going through his usual method of talking through the possible answers. At that point the cough occurred followed by the syllable in question, whereupon Ingram changed tack saying 'there's a chance it's Paris' and proceeded to answer the question with 'Paris' after the occurrence of two further coughs.

On examining the questioned syllable, we interpreted it as being 'no', called out on a tense whisper some 0.7 seconds after the cough. It bore certain similarities to tokens of 'no' identified in Whittock's police interview recording and we concluded that it could well have been uttered by the cougher. Interestingly, then, the general pattern was for the coughs to occur after Ingram mentioned a right answer: in the single instance of a cough being produced as he appeared to be going for a wrong answer, it is immediately followed by 'no'.

Outcomes

The trial began on 3 March 2003 and it was agreed that one of us (French) would represent the work carried out

from the witness box. At the beginning of the first of the two days over which our evidence was heard, but before it began, we were informed that it was now conceded by the defence that Mr Whittock had produced 'many if not all' the coughs the police had identified as prompting coughs. After our evidence, the defence called no counter-evidence from sound or speech experts. Their position was that Whittock was suffering from an allergic condition that caused the coughing and that the timing of the coughs in relation to the questions and answers was purely coincidental.

After three days of deliberations, the jury returned majority verdicts of guilty in respect of all three defendants. Charles and Diana Ingram were given prison sentences of 18 months and Tecwen Whittock received a sentence of 12 months, all of which were suspended for two years. Additionally, the Ingrams were fined £15,000 each with £10,000 costs and Whittock received a fine of £10,000 with costs of \$7,500.

Notes

- 1 Southwark Crown Court, London. Before HH Geoffrey Rivlin QC, 3 March - 7 April 2003. Prosecuting: Mr Nicholas Hilliard leading Mr Jonathan Rees. Defending: Miss Sonia Woodley QC leading Mr Sean Enright (Charles Ingram); Mr Adrian Redgrave QC leading Mr Paul Wakerley (Diana Ingram); Mr David Aubrey QC leading Mr David Webster (Tecwen Whittock).
- 2 A wide-ranging account of the trial and the background to the fraud can be found at http://www.ukgameshows.com/index.php/good_game_guide_7_ingrams_millionaire_trial
- 3 In the police documentation the coughs in question were, in fact, referred to as 'significant' coughs. However, as they were considered significant because they were believed to be prompts, for clarity of explanation we simply refer to them here as 'prompting' coughs.
- 4 The 'proximity' effect - increase in low frequency energy when a source is close to a directional microphone - does not apply in this instance, as omni-directional microphones were used for the FFF contestants.
- 5 If the calculations are made in terms of peak values, rather than RMS, the differences are: Question 12: 774%; Question 13: 1343%; Question 14: 2241%.
- 6 If this point had been subject to serious doubt or questioning, it would, of course, have been possible to carry out a statistical test of the significance of the differences between the levels.
- 7 Recordings of specimen coughs from other FFF contestants were not available for comparison.

Acknowledgements

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Peter French and Philip Harrison are with JP French Associates, Forensic Speech and Acoustics Laboratory, York, UK

About the authors

Peter French is an independent forensic consultant specialising in the analysis of magnetic and digital recordings, speech and language samples. He is Chairman of the International Association for Forensic Phonetics and Acoustics and has acted in some 3000 cases from countries across the world.

Philip Harrison works for J P French Associates as a forensic consultant, undertaking case work and research and development. He was educated in acoustical engineering at the Institute of Sound and Vibration Research (ISVR) at Southampton University and in phonetics and phonology at the University of York.

ANC round robin VDV measurement exercise analysis of eVDV data

Richard Greer, Rupert Thornely-Taylor, David Malam, Patrick Williams, John Pollard, Tom Brodowski and Phil Evans.

In October 2002, the Association of Noise Consultants (ANC) organised a round-robin VDV measurement exercise at the ISVR in Southampton. The main purpose of this exercise was to determine whether, under controlled conditions, a range of measurement systems and signal processing methods would provide consistent results. The exercise and its findings were reported in *Acoustics Bulletin* (Nov/Dec 2003).

A consistent set of results was recorded across 12 measurement systems that were predominantly bespoke systems put together by the participants (rather than off-the-shelf proprietary systems). The consistency identified is broadly equivalent to that of type 1 sound level meters used for noise measurements.

The report focused entirely on VDV measurements. This paper, which draws on the same exercise but considers the estimated Vibration Dose Values (eVDV) collected at the same time, considers the following:

- ☐ The eVDV results from a number of the measurement systems;
- ☐ A review of the consistency in the eVDV data from the different systems;
- ☐ A comparison of the eVDV data and the VDV presented previously;
- ☐ A review of the different methods for calculating eVDV from the Round Robin test signals and the effect the different methods have on the consistency between the eVDV and VDV; and
- ☐ Suggested guidelines for the most accurate method for calculating eVDV from a measured signal.

A high speed passenger train was one of 20 separate test signals used in the round robin



The round-robin exercise

For ease of reference, the 20 separate test signals used in the round-robin were each of 30 seconds duration consisting of:

- ☐ Sine waves at frequencies 1, 2, 4, 8, 16, 32, 64 and 80 Hz for 30 second durations (8 signals);
- ☐ Sine waves at 40 Hz frequency for 1, 2, 4, 8 and 16 seconds duration (5 signals);
- ☐ Band limited pseudo random noise between 1 and 80 Hz of 30 seconds duration (3 signals);
- ☐ Impulsive signal of 30 seconds duration (1 signal);
- ☐ Train sample 1 (high speed passenger train) (1 signal);
- ☐ Train sample 2 (medium speed domestic passenger train) (1 signal); and
- ☐ Train sample 3 (low speed freight train) (1 signal).

Signals 1 to 8 and 14 to 16 had a full 30 second duration, signals 9 to 13 and 18 to 20 contained 'bursts' of signal energy centred within the 30 second period while signal 17 featured 18 evenly spaced impulses during the 30 s duration. A 10 second countdown was given before the start of each signal to enable the monitoring equipment to be manually triggered.

Each participant was required to record the full 30 seconds of each signal to ensure consistency. As discussed later, this approach was appropriate for the assessment of VDV but it is not necessarily appropriate when calculating eVDV.

VDV and eVDV

From a continuous weighted acceleration time history the VDV is calculated using equation 1 taken from Appendix B of BS 6472: 1992 (1).

$$VDV = \left(\int_0^T a_w^4(t) dt \right)^{0.25} \quad \text{equation (1)}$$

Where 'aw' is weighted acceleration.

BS 6472:1992 Appendix B defines an estimated VDV termed the eVDV. This is calculated as:

$$eVDV = 1.4 \times a_{wrms} \times t^{0.25} \quad \text{equation (2)}$$

In this equation t is the period over which the rms weighted acceleration a_{wrms} [ms^{-2}] has been evaluated.

Further details on the calculation of VDV and eVDV are presented in the BS 6472: 1992 or in the ANC Guidelines (2).

Analysis of the eVDV reported by participants

The analysis considers firstly the consistency of eVDV results between measurement systems and secondly the consistency between eVDV and VDV (as reported in the earlier article). This second analysis focuses on identifying any consistent difference between eVDV and VDV for the same input signals, or any trends in the differences between the two indicators.

For the 20 different test signals used in the round-robin, Table 1 summarises the eVDV from the seven current measurement systems and the VDV for the 11 measurement systems presented previously (four systems are common to both datasets).

Taken at face value, *Table 1* suggests that the variability in eVDV between measurement systems is significantly greater than for VDV (comparing the standard errors for the eVDV and VDV datasets). This is considered further below. However, overall the small difference (3%) between the average eVDV and average VDV results suggests that the eVDV indicator is a good general estimate of the true VDV.

However, on closer analysis it is apparent that the overall consistency between eVDV and VDV is actually a balance between a consistent over-estimate of the VDV for continuous sinusoids (ignoring the results for 1 and 2 Hz which appear to be affected by the poor low frequency response of several measurement systems) and a consistent under-estimate of the VDV for transient signals (including 'real-world' train data).

The fundamental reasons for these two observations are worthy of examination.

Different methods for calculating eVDV

The previous section raised two important points: the effect of signal type and duration on the calculation of eVDV.

The calculation of eVDV may be better expressed as:

$$\text{eVDV} = k \times a_{\text{rms}} \times t^{0.25} \text{ equation (3)}$$

Where, in BS 6472:1992, $k = 1.4$.

Sinusoids

The standard value of $k = 1.4$ was derived empirically by the authors of the BS 6472: 1992 from typical vibration environments having low crest factors.

However, this does not mean that $k = 1.4$ is the correct value for all signals.

Signals 1 to 8 from the round-robin exercise were sinusoids. For a continuous sinusoid it is possible to evaluate an exact value of k , thus:

$$\text{RMS} = \left(\frac{1}{t} \int_{t=0}^{t=2\pi} A \sin^2(\omega t) dt \right)^{1/2} = \left(\left[\frac{At}{2} - \frac{A \sin 2\omega t}{4\omega} \right]_0^{2\pi} \right)^{1/2}; \text{ and}$$

$$\text{RMQ} = \left(\frac{1}{t} \int_{t=0}^{t=2\pi} A \sin^4(\omega t) dt \right)^{1/4} = \left(\left[\frac{3At}{8} - \frac{A \sin 2\omega t}{4\omega} + \frac{A \sin 4\omega t}{32\omega} \right]_0^{2\pi} \right)^{1/4}$$

therefore

$$\left[\frac{\text{RMQ}}{\text{RMS}} \right]_0^{2\pi} = \frac{(3/8)^{1/4}}{(1/2)^{1/2}} = 1.11 \text{ (to 2 D.P.)}$$

Thus for a continuous sinusoid of frequency f [Hz], the VDV can be calculated exactly as:

$$\text{VDV} = 1.11 \times a_{\text{rms}} \times t^{0.25} \text{ equation (4)}$$

TABLE 1: STATISTICAL ANALYSIS OF ROUND ROBIN VDV AND eVDV RESULTS

		VDV (From 11 systems with outlier removed)				eVDV (from 7 systems)				Average eVDV / Average VDV
		Average VDV [m/s ^{1.75}]	Std Error	Range around Average		Average eVDV [m/s ^{1.75}]	Std Error	Range around Average		
				Min	Max			Min	Max	
Signal No.	Description of Stimulus									
1	30-s Sine 1 Hz	0.0210	17%	-24%	24%	0.0176	39%	-72%	33%	-16%
2	30-s Sine 2 Hz	0.1815	15%	-26%	22%	0.1776	39%	-66%	43%	-2%
3	30-s Sine 4 Hz	0.2704	11%	-18%	18%	0.3201	22%	-29%	28%	18%
4	30-s Sine 8 Hz	0.2419	13%	-24%	19%	0.2810	21%	-28%	19%	16%
5	30-s Sine 16 Hz	0.1244	11%	-19%	21%	0.1531	20%	-33%	33%	23%
6	30-s Sine 32 Hz	0.0633	11%	-18%	22%	0.0779	20%	-31%	32%	23%
7	30-s Sine 64 Hz	0.0309	14%	-26%	26%	0.0405	21%	-41%	28%	31%
8	30-s Sine 80 Hz	0.0242	12%	-22%	20%	0.0330	21%	-39%	24%	36%
9	1-s Sine 40 Hz	0.0196	10%	-18%	17%	0.0136	19%	-23%	25%	-31%
10	2-s Sine 40 Hz	0.0249	10%	-20%	20%	0.0196	18%	-24%	27%	-21%
11	4-s Sine 40 Hz	0.0316	10%	-18%	20%	0.0274	16%	-18%	28%	-13%
12	8-s Sine 40 Hz	0.0373	9%	-17%	18%	0.0374	17%	-16%	26%	0%
13	16-s Sine 40 Hz	0.0428	9%	-16%	19%	0.0479	16%	-23%	27%	12%
14	Random 1-80 Hz	0.0132	10%	-16%	16%	0.0165	37%	-27%	82%	25%
15	Random 1-80 Hz	0.0346	10%	-16%	16%	0.0365	11%	-18%	12%	6%
16	Random 1-80 Hz	0.1136	11%	-17%	18%	0.1137	13%	-16%	18%	0%
17	Impulsive	0.0842	10%	-16%	20%	0.0574	16%	-20%	25%	-32%
18	Train 1 High-speed TGV	0.1022	9%	-16%	19%	0.0650	28%	-46%	37%	-36%
19	Train 2 low speed DMU	Signal dominated by high background level and poor signal to noise ratio. Refer to original IoA Bulletin paper								
20	Train 3 low speed freight train	0.0255	11%	-22%	22%	0.0197	46%	-90%	42%	-23%
Overall		N/A	12%	-26%	27%	N/A	24%	-90%	82%	3%

Again, in this equation t is the period over which the *rms* weighted acceleration a_{rms} [m.s⁻²] has been evaluated.

Table 2, which is described in more detail later, shows the eVDV calculated from the output from one measurement system using $k = 1.11$ for the sinusoid signals: this significantly improves the consistency of the eVDV and VDV results.

Transients

The accuracy of eVDV for transients has arguably greater importance for 'real world' applications than the consideration of sinusoids.

As discussed in the ANC Guidelines, the accuracy of the eVDV compared with the 'true' VDV for an event is dependant on the 'duration' of the signal chosen to calculate the *rms* vibration amplitude and hence the eVDV.

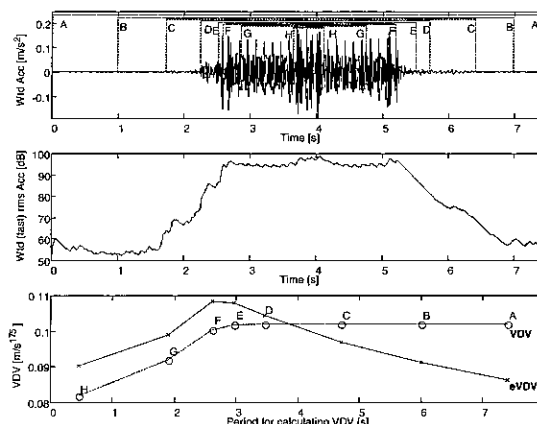


Figure 1: Evaluation of VDV and eVDV from a transient signal

Figure 1, which is an analysis of signal 18, demonstrates the point. Provided that the ambient level in the signal (before and after the transient signal of interest) is small, then the calculation of VDV remains stable regardless of the analysis period chosen around the transient, so long

continued on page 22

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0296

analysis of eVDV data

as the analysis period includes the greater proportion of the event itself.

The reason why the 'event' approach provides a more accurate reflection of the VDV is clear. The eVDV depends on the *rms* weighted acceleration of the signal. For an event where the ambient level before and after the event is low, the *rms* will reduce in magnitude the longer the period over which the *rms* is calculated compared with the duration of the event. First impressions might suggest that when calculating the eVDV a 'suppressed' *rms* acceleration (as a result of calculating the *rms* over a longer period than the event period) may be balanced by the longer time period used to convert the *rms* acceleration into an eVDV using equation 3. However, the fourth power weighting of amplitude but fourth root weighting of time dependency in the calculation of true VDV mean that eVDV actually falls further and further below the true VDV as the analysis period (compared with the event period) is allowed to become longer.

Applying this event-oriented approach to signals 9, 10, 11, 12, 17, 18, 19 and 20 from the round-robin generates the results presented in *Table 2*. The ‘event’ eVDVs are very much closer to the VDV values than the eVDVs calculated over the full 30 seconds of each signal. It should be noted that in *Table 2* the second set of eVDV values for the sinusoid signals are calculated using the method described under ‘sinusoids’ above.

Table 2 shows that evaluating the eVDV on an event basis does not materially change the overall average difference between eVDV and VDV across all 20 signals (-1% compared with +1%). However, with the event approach there is a significantly more consistent relationship between eVDV and VDV on a signal-by-signal basis, for all types of signal. The improvement in accuracy for the real world signals (signals 17 to 20) is particularly important.

Table 2 also presents the crest factors for the signals. Ignoring the continuous sinusoids, it is apparent that, when analysing each 30-second signal in total, the lowest consistency between eVDV and VDV is where crest factor is around 6 or above. This would appear to be consistent with the advice in BS.6472: 1992 that eVDV becomes unreliable when the crest factor exceeds a value of 6.

However, it is also clear that using event duration reduces the crest factor for each signal. This means that care must be exercised in quantifying the crest factor for many 'real world' signals before considering the signal in the context of the crest factor threshold of 6 in BS 6472. Calculated, as it should be, over the event duration the crest factor for most real transient vibration events is not as high as may be first anticipated. Hence, as this analysis shows, the eVDV is a good estimate of the true VDV for the majority of signals.

in real-world analysis it is unlikely any practitioner would evaluate the eVDV for, say, a 4s event based on a 30s window around the event. Nevertheless, the assessment serves to demonstrate how important the detailed form of the analysis is to the results.

It can therefore be concluded that analysis of eVDV and crest factors for transient signals should be focused on the transient event, ideally between the 20dB down points or more practically between the 10dB down points.

It is also relevant to return

to the value of k in equation 3. Whilst it is beyond the scope of this article it is possible to derive appropriate values of k for different classifications of signal, including transient signals. The parameter k can be defined analytically where the signal has a predetermined mathematical definition: eg sinusoids, white noise, pink noise etc. Values of k for other classes of signal have to be evaluated empirically.

It is of value to note that as part of the CTRL project, the value of k was empirically derived for railway vibration based on a range of measured data. The analysis derived a value of $k = 1.4$ with a standard error of 0.1. This provides

Signal No.	Description of Stimulus	VDV [m/s ^{1.75}]	eVDV CALCULATED FROM 30s SIGNALS					CF	Error eVDV/VDV	eVDV FROM EVENTS AND 'K' VALUES					CF	Error eVDV/VDV
			Awrms [m/s ²]	Awnmax [m/s ²]	duration [s]	eVDV [m/s ^{1.75}]	Awrms [m/s ²]			duration [s]	No. events	K' value	eVDV [m/s ^{1.75}]			
1	30-s Sine 1 Hz	0.0169	0.0063	0.0145	28.8	0.0204	2.3	21%	0.0063	28.8	1	1.11	0.0162	2.3	-4%	
2	30-s Sine 2 Hz	0.2055	0.0780	0.1392	29.3	0.2541	1.8	24%	0.0780	29.3	1	1.11	0.2014	1.8	-2%	
3	30-s Sine 4 Hz	0.2965	0.1145	0.1717	29.6	0.3739	1.5	26%	0.1145	29.6	1	1.11	0.2964	1.5	0%	
4	30-s Sine 8 Hz	0.2645	0.1040	0.1529	27.7	0.3340	1.5	26%	0.1040	27.7	1	1.11	0.2648	1.5	0%	
5	30-s Sine 16 Hz	0.1350	0.0522	0.0793	29.4	0.1702	1.5	26%	0.0522	29.4	1	1.11	0.1349	1.5	0%	
6	30-s Sine 32 Hz	0.0696	0.0267	0.0441	29.7	0.0873	1.7	26%	0.0267	29.7	1	1.11	0.0692	1.7	-1%	
7	30-s Sine 64 Hz	0.0349	0.0133	0.0247	29.6	0.0434	1.9	24%	0.0133	29.6	1	1.11	0.0344	1.9	-1%	
8	30-s Sine 80 Hz	0.0257	0.0097	0.0191	29.6	0.0317	2.0	23%	0.0097	29.6	1	1.11	0.0251	2.0	-2%	
9	1-s Sine 40 Hz	0.0214	0.0038	0.0306	29.7	0.0124	8.1	-42%	0.0190	1.0	1	1.11	0.0209	1.6	-2%	
10	2-s Sine 40 Hz	0.0274	0.0056	0.0328	29.8	0.0183	5.9	-33%	0.0202	2.0	1	1.11	0.0267	1.6	-3%	
11	4-s Sine 40 Hz	0.0349	0.0083	0.0359	29.7	0.0271	4.3	-22%	0.0218	4.1	1	1.11	0.0345	1.6	-1%	
12	8-s Sine 40 Hz	0.0412	0.0115	0.0362	30.0	0.0377	3.1	-9%	0.0220	8.0	1	1.11	0.0410	1.6	0%	
13	16-s Sine 40 Hz	0.0474	0.0157	0.0353	29.7	0.0513	2.2	8%	0.0213	16.0	1	1.11	0.0473	1.7	0%	
14	Random 1-80 Hz	0.0138	0.0045	0.0163	29.6	0.0147	3.6	6%	0.0045	29.6	1	1.40	0.0147	3.6	6%	
15	Random 1-80 Hz	0.0380	0.0124	0.0421	29.7	0.0405	3.4	7%	0.0124	29.7	1	1.40	0.0405	3.4	7%	
16	Random 1-80 Hz	0.1261	0.0412	0.1436	29.7	0.1347	3.5	7%	0.0412	29.7	1	1.40	0.1347	3.5	7%	
17	Impulsive	0.0926	0.0175	0.1198	31.3	0.0579	6.8	-37%	0.0361	0.4	18	1.40	0.0828	3.3	-11%	
18	Train 1 High-speed TGV	0.1110	0.0204	0.2034	29.8	0.0667	10.0	-40%	0.0588	3.6	1	1.40	0.1130	3.5	-2%	
19	Train 2 low speed DMU	Signal dominated by high background level and poor signal to noise ratio. Refer to original IoA Bulletin paper.														
20	Train 3 low speed freight train	0.0282	0.0072	0.0578	29.6	0.0235	8.0	-17%	0.0085	20.9	1	1.40	0.0254	6.8	-10%	
										Avg	1%					
										Max	26%					
										Min	-42%					
										Avg	-1%					
										Max	7%					

22



Vibrating tools are often used in rail infrastructure maintenance

additional support for the use of the standard value of $k = 1.4$ for railway vibration.

Conclusions

The analysis has demonstrated that eVDV is generally a reliable and accurate estimate of the 'true' VDV provided that:

- ☐ eVDV and crest factors for transient signals are calculated over the period ideally between the 20dB down points (from the event maximum level with slow time response) or, for practical reasons, over the period between the 10dB down points; and
- ☐ where data are available a more appropriate value of k should be used (rather than $k = 1.4$) in the equation

$$eVDV = k \times a_{w rms} \times t^{0.25}$$

For sinusoids $k = 1.11$. For rail vibration, empirical analysis has shown that $k = 1.4$ with a standard error of 0.1. Values of k can also be derived for other classes of signal although this is beyond the scope of this article.

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STIPA in practice

STIPA - the golden mean between full STI and RASTI

Ole-Herman Bjor

Speech intelligibility is a key quality rating of most indoor spaces and many outdoor venues require that people can converse and clearly hear performances both with the natural and amplified voice. In a typical situation the effects of the various acoustic features of the space combine to have positive and negative effects on the comprehension of the spoken word and it is obviously necessary to be able to quantify these effects. Reverberation, background noise and other factors need to be considered in developing a meaningful method of quantifying speech intelligibility, from 'good' to 'poor'. The results of such an assessment are shown in *Figure 1*, which clearly shows the locations in the auditorium where comprehension would be at its best.

Speech transmission index, STI, has proved to be a valuable tool for the objective rating of speech intelligibility. The principles were first published in *Acustica* in 1971 (1) and the method has been refined and developed since to cover a wider range of applications, to such an extent that it has formed the basis of National and International Standards. Recently, the International Electrotechnical Commission (IEC) published the third revision of the International Standard specifying the method for calculating the index, as IEC 60268-16 (2). Central in the development of this new Standard was the work at TNO Human Factors Laboratory in the Netherlands, and of the pioneers Tammo Houtgast and Herman Steeneken.

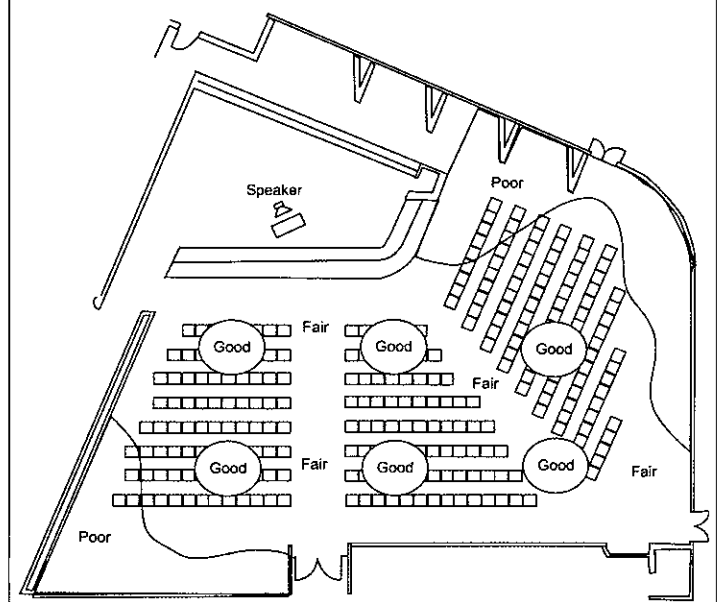
Speech transmission index

The basis for the index is centred on the observation that the speech band covers the range from around 125 to 8k Hz and that this waveform envelope is amplitude modulated over the range 0.63 to 12.5 Hz. It follows that speech intelligibility is to a large extent based on this slow modulation of a sound pressure signal that is acting as a carrier. In the Standard this speech waveform envelope is synthesised by a stationary gaussian noise signal centred on seven bands in octave steps ranging from 125 Hz to 8 kHz with each having a band-width of one-half octave.

Each of the bands is then amplitude modulated with 14 frequencies that are selected in one-third octave steps from 0.63 Hz to 12.5 Hz. This gives a total of 96 combinations of carrier and modulation frequency. This signal is expressed in terms of the square of the sound pressure and in this context is called 'intensity'; this is the quantity being modulated. An artificial voice, or small loudspeaker, acts as the source voice and generates the modulated sound field from this signal.

A microphone placed at the listener position receives this signal and from this the degree of modulation in each band is determined with the speech transmission index based on the weighted average of the response to the different modulation frequencies. Noise and reverberation in the room will reduce the observed degree of modulation and the method also considers the effect of the most common

Fig 1 Speech intelligibility map of an auditorium



types of distortion such as harmonic and intermodulation. The last revision of the STI Standard also considers masking effects and the absolute threshold of hearing. Some other less frequent forms of non-linearity, such as frequency shifts and multiplications are not, however, treated so effectively.

In order fully to take care of the effects of non-linearity, it is important that the basic signal being modulated has a high crest-factor and a spectral distribution similar to the long-term speech spectrum, and that the main modulation frequencies are selected one by one. The measurement of the full STI therefore has to be performed as a sequence of measurements. If each of the 96 combinations is measured for 10 seconds, the total measurement time will be about a quarter of an hour. With such a long measurement time required in order to obtain the STI value - and this is just for one position of a room - it limits the applicability of the full STI method in many practical situations.

The STI method may be modified in different ways to reduce the measurement time. If the system to be measured is regarded as linear, there are several solutions. The excitation signal may be modulated with all modulation frequencies simultaneously and the components may be separated after reception by the use of digital filters or by Fourier analysis. A more common method is to calculate the complex modulation transfer function from the impulse response of the space. Schroeder has shown (3) how the modulation transfer function may be calculated from the band filtered impulse response and Rife has shown how maximum-length sequences may be used for measuring the modulation transfer function (4). The STI value may, therefore, be calculated from a noise free impulse response together with information on the level of the received signal and background noise.

The modulation transfer function, at frequency F , may also be calculated from the reverberation time, T , and the effective signal-to-noise ratio, S/N , (exponential decay is assumed) (5) by the relationship

$$m(F) = \frac{1}{\sqrt{1 + (2p F \frac{T}{13.8})^2}} \times \frac{1}{1 + 10^{(-S/N)/10}} \quad (1)$$

A long reverberation time reduces the modulation for the highest modulation frequencies.

RASTI and STIPA

In order to simplify the direct measurement the RASTI method (Room Acoustic Speech Transmission Index) was developed at TNO in 1979 and a number of different instruments was introduced for its measurement according to this method. As the RASTI procedure only considers two octave bands, namely 500Hz and 2kHz, a typical measurement time was only 10 to 15 seconds.

Owing to their simplicity in use, RASTI instruments were used also for applications beyond their original main design goal of room acoustics. The RASTI value has been used for assessing the quality of public address systems, but comparisons with subjective measurements have shown that the deterioration of speech intelligibility is not handled correctly if the PA system is strongly non-linear or suffers from limited bandwidth.

In order to improve the accuracy in the intelligibility assessment the STIPA method (Speech Transmission Index Public Address) was developed. It is a development of the basic RASTI method using a more complex matrix of carrier and modulation frequencies, as can be seen in Figure 2. Its algorithm has been developed to handle effects due to reverberation in the room as well as distortions commonly

Fig 2 Carrier and modulation frequencies for RASTI and STIPA

		Carrier frequency [Hz]						
		125	250	500	1k	2k	4k	8k
Modulation frequency [Hz]	0,63							
	0,8							
	1							
	1,25							
	1,6							
	2							
	2,5							
	3,15							
	4							
	5							
	6,3							
	8							
	10							
	12,5							

RASTI

		Carrier frequency [Hz]						
		125	250	500	1k	2k	4k	8k
Modulation frequency [Hz]	0,63							
	0,8							
	1							
	1,25							
	1,6							
	2							
	2,5							
	3,15							
	4							
	5							
	6,3							
	8							
	10							
	12,5							

STIPA

found in public address systems. It preserves the benefits of RASTI so it also performs well for room acoustics and can therefore in nearly all cases be used to assess both the natural and amplified voice and deliver results more closely to the values obtained by the full STI method. The measurement time for a STIPA measurement is no longer than the older RASTI method of 10-15 seconds.

Implementation in a sound level meter

The flexibility inherent in modern sound level meters that employ digital signal processing means that the STIPA method may be implemented in the new generation of hand held instruments. In the *Norsonic Nor118* sound level meter the STIPA method is a program option in the instrument's software. A CD delivered with the instrument option contains the excitation signal. This is the sum of six bands of noise, each modulated with two frequencies as specified for the STIPA method with the shape of the spectrum being specified in the standard. The sound level meter in the normal mode of operation may be used for verifying the spectral weighting. The excitation signal runs continuously and no synchronisation between the excitation and the instrument is needed.

After the STIPA mode of operation is selected, pressing the START button initiates a measurement which runs for about 13 seconds. At the end the quantitative STI value, calculated according to the standardised method, is presented on the screen together with a qualitative statement of the assessment: 'Excellent', 'Good', 'Fair',

continued on page 26

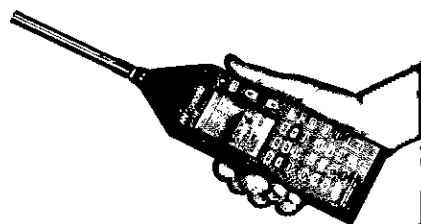
STIPA - the golden mean between full STI and RASTI

continued from page 25

'Poor' or 'Bad'. More information is available by selecting a tabular display that gives the mean level in each band.

During the measurement the short time equivalent-level in each octave band is measured with a time resolution of 5 milliseconds. Figure 3 shows a typical level versus time diagram for the 500 Hz octave. The level is converted to squared sound pressure, Pa², or 'intensity' in this context and the result of this is shown in Figure 4.

The degree of modulation for each frequency is found



Hand held
analyser for STIPA
measurements

by Fourier transformation. By comparing the measured degree of modulation in the received signal with the degree of modulation known to be in the excitation signal (55%) the value for the modulation transfer function is obtained. In total twelve combinations of carrier modulation frequencies are measured. The measured modulation transfer function is corrected in order to compensate for the standardised threshold of hearing and for the masking effect in the human auditory organ.

Although not a part of the International Standard, this implementation allows the addition of a specified background noise level for each band. The correction is made according to relationship

$$mc_{k,f} = m_{k,f} \frac{I_k}{I_k + Irs_k + Ino_k + Iam_k} \quad (2)$$

Fig 3 Typical sound pressure level in the 500 Hz band as function of time (seconds)

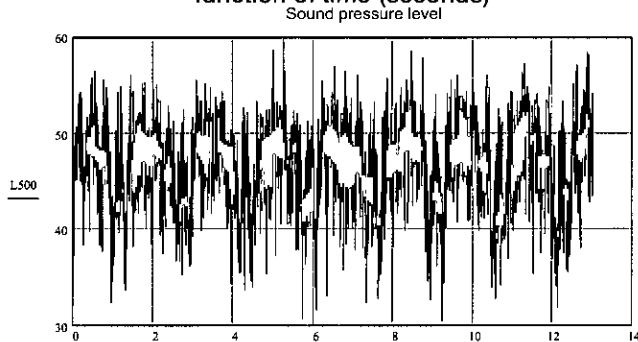
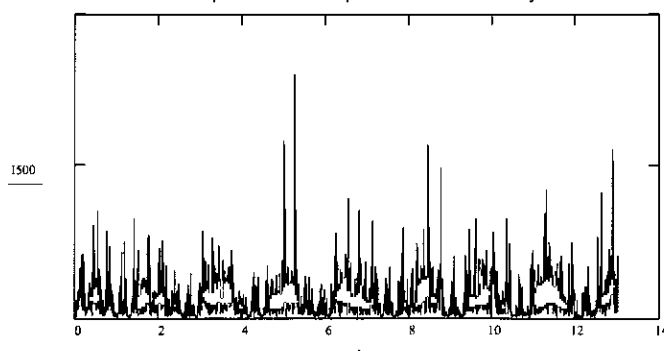


Fig 4 Sound 'intensity' in the 500 Hz band, computed from the sound pressure level. The modulation is at 0.63 and 3.15 Hz



where:

$mc_{k,f}$ is the corrected modulation transfer function for octave band number k and modulation frequency f .

$m_{k,f}$ is the measured modulation transfer function.

I_k is the measured 'intensity' in octave band number k

Irs_k is the 'intensity' in octave band number k related to the hearing threshold

Ino_k is an optional 'intensity' in octave band number k corresponding to a specified background noise level. If not used this value is zero.

Iam_k is an 'intensity' in octave band number k used to mimic the masking effect in the auditory organ. The value is a function of the level in the adjacent lower octave band.

Note that the noise correction is an extension from the method specified in IEC 60268-16. It allows a measurement to be made in a situation without the normal background noise and then the result post-processed to re-calculate the STI value when there are different background noise conditions.

Implementation of the STIPA measurement mode in

Fig 5 Typical results of a STIPA analysis

S 031106-0019S		S 031106-0019S	
STI = 0.68 "Good"		1/1 oct	Leq
		125Hz	59.3
		250Hz	56.9
		500Hz	52.4
		1.0kHz	37.2
Noise corr: On STI = 0.39 "Poor"		2.0kHz	42.1
		4.0kHz	38.6
		8.0kHz	38.0
		16.0kHz	34.1
		A-netw	53.0

an ordinary sound level meter allows an easy and fast measurement of speech intelligibility. Normally, the STI value is measured with the normal background noise and the value indicates the speech intelligibility with this level of background noise (figure 5). For a situation where the measurement is performed in an atypical quiet situation, a synthetic background noise may be added and the modified STI value is indicated. This feature is especially useful when assessing speech intelligibility in auditoria with no audience present.

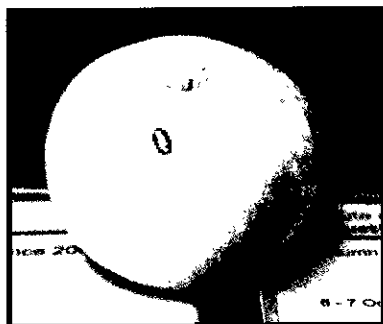
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Ole-Herman Bjor is with Norsonic AS, Norway

Crisp acoustics

**Sounding
out a bite
from the
apple**



How far can you go with sound quality research?

It appears even apples are not immune to acoustic engineering. This is a genuine scientific paper, and the cited references include papers following research where subjects had to eat fresh and stale crisps!

Crispness judgement of Royal Gala apples based on chewing sounds

De Belie N, Harker FR, De Baerdemaeker J
(*Biosystems Engineering* 81 (3): 297-303 Mar 2002)

Abstract

Chewing sounds were analysed to detect small differences in crispness between Royal Gala apples. Different parameters calculated from the sound waves for bite and chews included amplitude, energy, and frequency content after fast Fourier transformation (FFT) combined with data reduction to 100Hz segments and fractal dimension. These parameters were

compared with crispness scores given by a trained analytical sensory panel. Recordings of apples were compared with recordings of teeth clacking and chewing sounds of rice crackers.

In the frequency domain, the high values in the teeth signal between 700 and 900 Hz, and to a lesser extent between 1200 and 1400 Hz, affected the rice cracker and apple signals. After FFT and data segmentation per 100Hz, the amplitude-frequency data of the first bite in apples and the first chew for both apples and rice crackers contained a typical 'hump' at around 4kHz. The minimum in the spectra at around 3kHz could be caused by the damping properties of the soft tissues in the mouth.

For both apples and rice crackers, the bite contained on average a lower amount of frequency components between 300 and 700 Hz than the consecutive chew. The energy of the first bite gave, depending on the panellist, mostly a better indication of crispness than the penetrometer firmness. The best correlation with sensory crispness could be found by combining the information from different frequency bands after data segmentation (correlation coefficients r up to 0.83).

However, the significant frequency bands differed between panellists. Fractal analysis on the normalised amplitude-time data showed that chew sound waves have a higher degree of jaggedness than bite sound waves. The fractal dimension could not be correlated with sensory crispness.

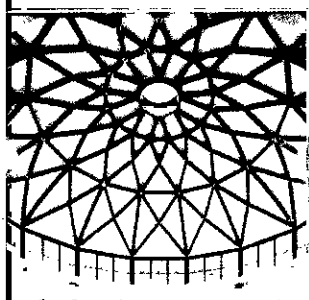
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KeyWords Plus: *food crushing sounds, mastication, crunchiness, perception, products*

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(Thanks to Trevor Cox for unearthing this gem – Ed.)

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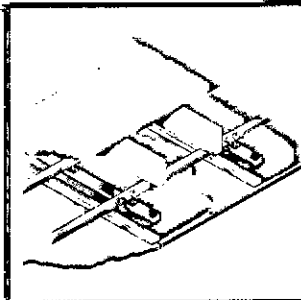
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Vibration White Bottom

Janet Metcalfe MIOA

For decades, Vibration White Finger has been recognised as an unacceptable and preventable occupational hazard, primarily among power tool users. However, the incidence of a parallel condition, known as Vibration White Bottom, has received far less attention. It was found to occur in infants up to two years old, most recently in the 1970s.

Historical

As long ago as 1888, Esra B. Muntog, a Czech doctor working in London, made observations on the behaviour of young children as their nannies pushed them in their prams in Hyde Park. He noticed that the construction of the prams offered little comfort to the occupants as their nannies struggled along the uneven gravel paths. Younger babies seemed to be far more affected by the rough ride than did their older siblings. On one occasion he observed: "Nanny was much astonished when little Albert, after some long while in gently bouncing up and down, began to rebound higher and yet higher. The distressed woman was obliged to halt the perambulator lest the infant bounce onto the pathway."

He concluded from this that the gravel surface imparted excess vibration to the infant, and that some form of damping should be incorporated into pram design.

It took a further 20-25 years - in parallel with the development of the motor vehicle - for more robust, coach-sprung prams to become generally available.

During the following fifty years or so, little is found in the literature, reporting the short-comings of pram suspension, and no cases of White Bottom have been found in medical journals. Coach-sprung prams seemed to have solved the vibration problem.

However, in the 1960s, a new design of baby transport was evolving to fulfil the needs of the changing lifestyles of modern mothers. These mothers were now mobile, car drivers, who did not need the large, comfortable prams of the kind that their own mothers pushed along the streets. They needed portable, collapsible prams. Initially, pushchairs were developed from these sturdier, springier prams, but they were still too heavy to lift comfortably into cars. The next phase saw the carrycot becoming popular, with its detachable sprung chassis, and light-weight cot which could be laid on the back seat of the car.

Next, the early 1970s saw development of the ultra-light, folding 'babybuggy' that really caught the imagination of the modern mum. Holding baby with one hand, she could fold up and stow the buggy with the other. A real advantage!

It was about this time that reports began to appear of a mystery skin condition among babies. The cheeks of babies' bottoms began to turn white. As they grew older and able to talk, they complained of discomfort and tingling

when they sat down. Mothers' groups discussed this at length. Some even bared their own children's bottoms to show their friends. Some were mystified, as their older children might complain of 'having a numb bum' although, as babies, their bottoms seemed not to turn white. (It is thought that nappy rash could have masked the condition in the earlier stages).

As the reports increased, doctors grew more baffled, and called for research into what many regarded as a new syndrome, popularly known as white numb bum. It was also reported to be linked with babies who had a history of stomach upsets.

However, by the late 1970s, fewer cases were being reported in babies of first-time mothers, although second and third children in a family were still being affected.

Happily, over the last twenty-five years fewer and fewer cases have been reported.

Research findings

The 1970s outbreak caused some consternation, firstly among Health Visitors, and then among paediatricians. There seemed no obvious connection between the cases, apart from age and location.

Then, in 1975, Doctor Andrew Payne, working in the field of Acoustical Resonance in Sports Events, stumbled on a

likely cause. He had been investigating go-kart designs following complaints of abdominal and buttock discomfort from karters of many years' experience.

He had recently bought a baby buggy for his newly-arrived son, and his wife had commented, jokingly, about putting an engine on it, as it was hard work pushing it over the gravel paths in their village. Dr Payne's week-end push-chair walks with his son turned into trips of experiment and observation. What made the ride harsh or comfortable? What determined how easy it was to push? How quickly and why did the child become discontented?

Through his work with go-karts, he recognised that a design flaw might be involved - excessive vibration from the buggy. By 1978, Dr Payne had extended his research to other babies in other sorts of pushchairs and had published his most famous research paper: *A Treatise on the Factors Affecting the Incidence of Vibration White Bottom in Young Children*, the findings of which are summarised below.

Dr Payne identified four factors which affected the condition:

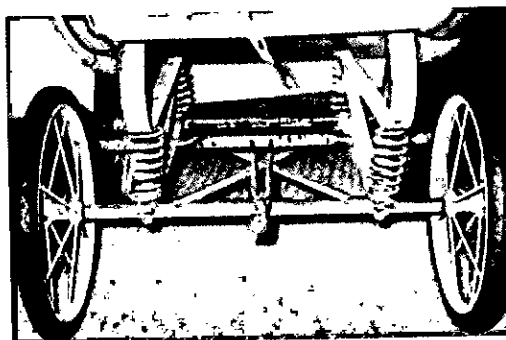
- a) type of pushchair;
- b) path surface;
- c) weight or age of infant; and
- d) nature of infant's clothing.

a) The type of pushchair was the overriding factor. Common to all the cases was the babybuggy - the little



Above: uneven gravel paths meant a rough ride for babies in the late 19C

Below: in tandem with the motor car, coach sprung prams became generally available



deck-chair on wheels, where the wheels had hard, solid, rubber rims, and there was no suspension on the rigid frame.

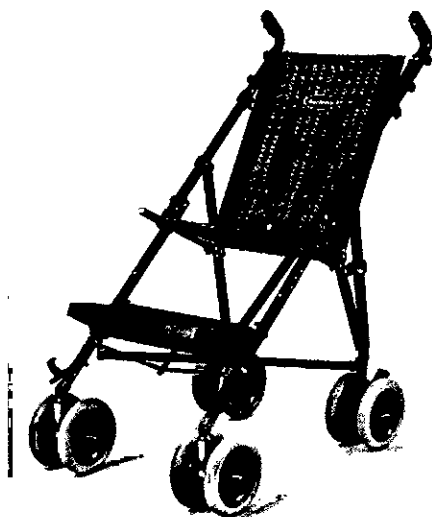
Meanwhile, manufacturers had begun to receive complaints of sprained wrists from mothers, like Mrs. Payne, who found it hard to push the buggy. In response to this, the newer buggies, from the later 1970s onwards, had wheels with softer rims, which created an easier, smoother ride.

b) Gravel paths produced the biggest outbreak of vibration white bottom. The uneven surfaces of rural pathways shook all the children to some degree, whatever their age. Paved or concrete paths on urban housing estates produced fewer cases.

c) In smaller infants, vibration transmission affected the entire body, resulting in the excessive bouncing first observed by Dr Muntog, and probably accounting for the incidence of stomach upsets prior to the onset of white bottom.

In the heavier, older child, vibrational energy could not work against the whole of its body, but was confined to the area closest to the pushchair seat, i.e. the infant's bottom.

d) White bottom was also affected by the clothing of the infant, especially the nappy that it wore. If the nappy was dry, it provided a great deal of vibration damping, but when wet, the vibration transmitted much more easily through the terry-towelling. The damping of the vibrations was found to be inversely proportional to the nappy dampening. In fact, controlled, experimental data were very difficult to obtain



Babies' 'numb bum' - a 70's phenomenon - was blamed on vibration caused by the ultra-light folding 'baby buggy'

for this factor and depended greatly on anecdotal evidence. Where older children were toilet-trained, even less damping took place.

When published, Dr Payne's findings were greeted with relief within the medical profession, who had feared the cause was due to some hitherto unknown skin complaint. Much relieved, they were able to blame poor pushchair design.

The problem was comparatively easy to remedy. The wheels were made even larger and the rims softer; rudimentary sprung suspension was incorporated.

Design engineers were left red-faced at having ignored the evolution of the pushchair, in their rush to market a modern, collapsible design. Baby's comfort had been omitted from their design brief entirely. Happily, wheels, which had first been altered in the late 1970s to aid mothers, unwittingly helped to stop the spread of white bottom in their infants.

No doubt Vibration White Bottom will re-emerge sometime in the future, but only after the current generation of design engineers has retired and they are not around to lend a guiding hand to their successors. Reinventing wheels? - It happens all the time!

Meanwhile, there is still a generation of young people who have not regained fully the feeling in their hindquarters. Are you one of them? If so, Dr Payne would be happy to hear from you.

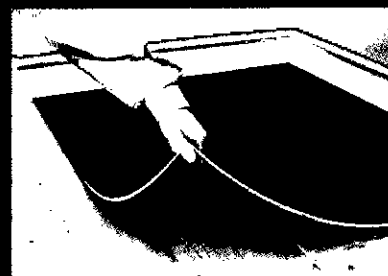
He can be contacted by email at: apayne@thearse.org.uk.

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Albert Beaumont Wood OBE DSc 1890-1965

continued from page 31

Society Meeting. Dr Wood gave a formal talk about the history of asdics, and contributed actively and most usefully to the discussions of many current problems of underwater acoustics. As a climax, his delightful and gracious speech of acceptance of his award was a pleasure never to be forgotten.

Sir Frederick Brundrett KCB KBE MA *Civil Service Commissioner*

Although, of course, I knew Albert Wood by reputation as one of the best scientists in the Admiralty Scientific Pool, I did not actually meet him until I came up to the Admiralty to join SRE Department in 1937. From then until I went up to the Ministry of Defence in 1950, I saw a lot of him.

In his special field of underwater acoustics he had, of course, an international reputation but he was worth consulting and indeed was frequently consulted on many scientific problems. He was, too, an excellent leader of a scientific team and first class at bringing out the best in the young aspirant.

He was not at his best in an administrative capacity. I remember early in the war when he was Superintending Scientist at MDD trying to help him by providing him with a first class secretary, but this gesture can hardly be said to have been successful.

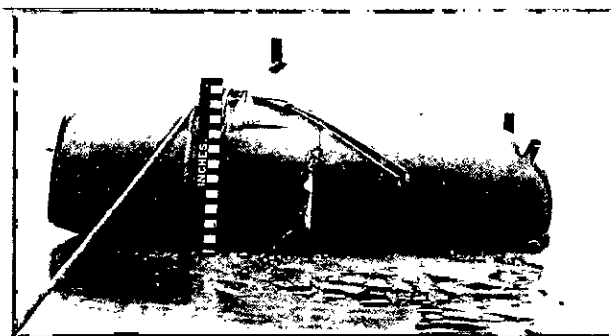
One could not have met a nicer or more modest person. He had great personal courage as was evidenced by the part he played in dealing with the first German magnetic mine recovered on 23 November 1939. He served the Admiralty well and we who were associated with him will always be the better for having known him.

Sir Edward Bullard MA ScD PhD FRS *Fellow of Churchill College, Cambridge*

I first met A B Wood when I joined *HMS Vernon* in November 1939 at the start of the work on degaussing and on the sweeping of magnetic and acoustic mines. He was friendly, gentle, quietly humorous, delightfully intelligent and deeply knowledgeable about underwater warfare. He had foreseen so many things and done so much during and since the 1914-1918 war. He had devised an acoustic mine, was largely responsible for the design of our magnetic mine and had played a large part in the work on the magnetic field of ships during the Thirties.

He and Butterworth [*his colleague at that time*] seemed to me among the best physicists I had met and it surprised me to find that they were both so doubtful about their powers of influencing policy and getting their ideas effectively used. It is a real tragedy that the Navy made relatively ineffective use of their talents when they were at their most productive. It seemed to me that it was not only money for the Navy was short between the wars, but that there was a real lack of appreciation of how to run an effective research and development organisation and how to keep scientists happy. I am sure that we really do know better now.

'It is a real tragedy that the Navy made relatively ineffective use of their talents when they were at their most productive'



The first German magnetic mine before being rendered safe
Shoeburyness 23rd November 1939



Loading the mine into a lorry after rendering it safe. Left to right - AB Vearncombe, Lieutenant Commander Lewis, CPO Baldwin and Lieutenant Commander Ouvry with back to camera

George E R Deacon CBE DSc FRS *Director, National Institute of Oceanography*

Dr Wood's keen interest in the sea and his feeling for a sympathetic approach to scientific problems were a great help to the wave group set up in the Admiralty Research Laboratory in 1944. There was some urgency about the work which sought more precise understanding of variations in wave characteristics in relation to the wind, and of their effect on offshore submarine bars and beaches, as well as requiring instruments that would make forecasting and reconnaissance easier. Dr Wood was always there to help and encourage: it was a very exciting time and he wrote enthusiastically about it in a series of articles in the *Journal*. He kept in touch with the subsequent work and was a frequent visitor at the National Institute of Oceanography.

The last time I saw him was at the meetings of the International Association of Physical Oceanography held at Berkeley in 1963 in conjunction with a general assembly of the International Union of Geodesy and Geophysics. There he was really in his element. He knew most of the men who had pioneered such research and had worked with many of them. He was excited about the new discoveries and was able to add to many people's appreciation of them.

He was always a welcome visitor. There seemed to be no major or minor difficulty in which he could not give some help or encouragement. He was particularly kind to beginners and for this he will be specially remembered.

Sir Charles F Goodeve OBE DSc FRS *Director, British Iron and Steel Research Association*

The brilliant analysis by Wood and his assistants under very difficult conditions of the first magnetic mine

found in late November at Southend restored completely everybody's confidence in the Mine Design Department. I will long remember the excitement of that night, when two of us from *HMS Vernon*, after waiting until past midnight, heard Wood's report on his return to his home outside Portsmouth. The improbable had happened. The German magnetic mine was found to be actuated solely by the change in the vertical component and was simply a refinement of the mine the Royal Navy had laid in enemy waters at the end of the Kaiser's war twenty-one years before!

Wood had measured precisely the critical firing mechanism, the time constants and the anti-sweeping characteristics. He had missed nothing. Gone was all the uncertainty about countermeasures. From then on I saw much of him. His technical knowledge was encyclopaedic and he became the technical centre around which all the many teams working on counter-measures revolved. His fertile imagination often produced key pieces to the jigsaw puzzles of the many technical developments which followed. For example he pointed out that a floating cable carrying a current gave zero vertical magnetism on the sea bottom underneath and thus would not explode a mine in a position close enough to destroy the cable.

To my regret after six months of working in close association with him, my move to other spheres meant that I saw less and less of A B Wood. I shall always remember him as a gentle person, unless provoked to anger, and one who was always ready to help the many people who came into association with him.

Curtis R Haupt MA PhD

United States Navy Electronics Laboratory

The Navy Electronics Laboratory appreciates the opportunity to add its contribution to those being written by other activities and individuals concerning the accomplishments of, and benefits derived from association with, Dr A B Wood. Such comments are particularly appropriate for Dr Wood spent most of the last year of his life at the US Navy Electronics Laboratory in San Diego, California, as a consultant in underwater acoustics.

His activities while here encompassed a wide range of subject matter in underwater technology ranging from oceanographic considerations through the physical acoustics of the medium to the implications of such knowledge in guiding the design of equipment and systems for naval use. This wide spectrum of interest, taken together with the depth of his abilities and experience in finding solutions to difficult acoustics problems, made his stay at the NEL a particularly fruitful one.

While in California, Dr Wood graciously consented to give a series of illustrated lectures, some at the Laboratory and some before other audiences such as local chapters of the Acoustical Society. Because of Dr Wood's pre-eminence in the field of acoustics, these lectures drew very large attendances. The generous use of anecdotes, many coloured with humorous episodes, and the introduction

of his listeners to various personalities of world renown in science whom Dr Wood had known intimately made these talks outstanding in their appeal and value to his audiences.

The Laboratory feels very fortunate in having had Dr Wood as a member of its staff, not only for his technical contributions but also for the enrichment of the lives of its scientific personnel who had the privilege of associating with him.

David A Keys DSc PhD FRSC

Scientific Adviser to the President, Atomic Energy Control Board, Canada

It is a pleasure to be able to take part in a tribute to my old friend and one-time colleague, Dr Albert B Wood. I first met Wood when he came to Shandon in 1919 following the close of the anti-submarine work at Harwich. I was one of the Canadians whom Professor (later Sir John) McLennan gathered together when he joined the Board of Invention and Research of the Admiralty.

I went up to Shandon on the *Gareloch* when that station was opened in late May 1918 to test out a method of measuring time-pressure curves of explosions suggested by Sir J J Thomson, using a cathode ray tube to record on a photographic plate in a vacuum, the variation in charge produced by pressure on a piezoelectric crystal. By August 1919 preliminary results had been obtained using small charges of a few pounds of explosive. I had been offered a fellowship by Harvard and had to leave in early September and Albert Wood agreed to take over the experiment and carry it on to larger charges, the apparatus being placed on a trawler, *Robert Barton*, just before I left.

Albert Wood was a devoted experimental scientist, modest and painstaking in all he did during the many years he remained with the Admiralty Research Division. His book, *A Textbook of Sound*, is a veritable source of theory and useful applications of sound to many problems in which he himself made outstanding contributions. In the few months at Shandon when we both worked there, he was occupied, like Dr Drysdale, Joseph Ford and others, on underwater type of detectors and acoustical methods of locating moving objects.

He had a good memory and both he and his devoted wife amused us with many interesting accounts of their early experiences before and during the First World War. We shall miss their congenial company and hospitality as I am sure those who knew him at the Admiralty Research Laboratory in Teddington will also. We retain many happy memories of this modest, able and devoted scientist who lived for his science, never seeking any reward for himself, and of his loving wife who took such pride in the good work her husband did.

Robert B Lindsay MSc PhD

Brown University, USA

The high point in Dr A B Wood's association with acoustics in the United States was probably the occasion of the award to him of the *Pioneers of Underwater Acoustics Medal* at the sixty-second meeting of the Acoustical Society of America in Cincinnati, Ohio on November 10, 1961. On the occasion in question the writer of this note had the privilege of presenting Dr Wood for the award. Any scientist who examines Dr Wood's published papers cannot fail to be impressed by their variety and originality.



The first records made with a magnetostriction echo depth recorder. In the sea off Sheerness in 1929

continued on page 35

The power to measure $20 \times \log_{10} \left(\frac{\text{earthquake}}{\text{eyeblink}} \right)$



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Albert Beaumont Wood OBE DSc 1890-1965

continued from page 33

This is particularly evident in those involving the design and development of acoustic instruments of high precision.

I, of course, knew him in a professional sense for a very long time, but it was only some 15 years ago that I had the privilege of getting acquainted with him personally and learning the charm of his personality. At that time he had just surrendered his administrative duties at the Admiralty and had returned to research work at the ARL in Teddington. It was a delight to note the infectious enthusiasm with which he was taking up again studies in sound propagation.

Sir Frank E Smith GCB GBE DSc FRS

I first met Dr Wood about fifty years ago when he was working with Professor (later Sir) William Bragg at an Admiralty Station at Harwich for the detection of submarines by acoustical methods. It was, I estimate, some time in 1915-16 that Wood and Bragg came to the National Physical Laboratory, at the time I was in charge of Electrical Standards. I recall the impression I got of Wood; a charming personality, no superiority complex, indeed he was exceedingly modest, always ready to listen to others while giving his own ideas on a problem with some hesitation but a desire to help. So it was during his whole lifetime.

John G D Ouvry DSO, Cdr RN (Retired)

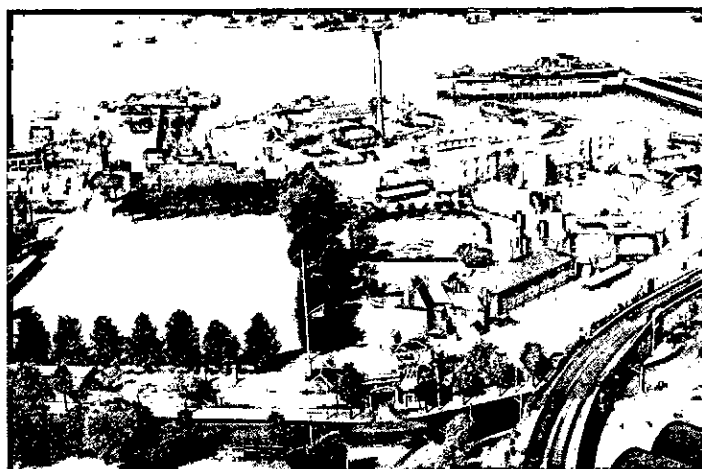
It was my duty during the Second World War to take charge of the Enemy Mining Section of the Mining Department, *HMS Vernon*, Portsmouth, and provide specimens of German and Italian underwater weapons for Dr Wood (Mine Design Department) and his assistants to examine and to probe into their secrets. The Germans never failed to provide plenty of problems of this sort, and we were pleased to keep Dr Wood busy.

We had a good start with the arrival of Hitler's first 'secret weapon', the magnetic mine. On this occasion Dr Wood arrived on the scene at Shoeburyness when we were stripping the weapon of its external fittings. After it had been conveyed to *HMS Vernon* the following day a personal message was received from the First Lord of the Admiralty, Mr Winston Churchill (as he then was), to state that investigation was to proceed without ceasing until the answer was produced. This Dr Wood was able to give in detail within twelve hours of the reception of the mine.

We in *Vernon* found Dr Wood a most capable, charming and modest man and very easy to work with. He certainly rendered great service to his country and over a long period.

Sir Charles S Wright KCB OBE MC MA

When I blew into the Admiralty - the day I was demobilised in 1919 - Wood was busy putting the finishing touches to his report on underwater range-finding using a cathode ray timing system which used photo plates inside the CRO. One could always rely on 'AB' to contribute something quite new, whatever job he took on. What will always stick in my memory is Churchill's meeting in the Admiralty (late at night as usual) to receive the report from Ouvry and Wood on the recovery and opening of the first magnetic mine we recovered. 'AB' was a great man, but very self-effacing.



HMS 'Vernon' in July 1955. In this Photo, from left to right; part of the rebuilding programme with North Block under construction, one of the Coastal Minesweepers of Vernon Squadron alongside the pier, with two inshore Minesweepers at the head of the creek.

Summary

The above accounts give a good idea of how the man was regarded by others. At the request of the Editor of the JRNSS Wood himself wrote at length in the Journal about his four and a half decades of experience in naval research, and these articles are reproduced in the July 1965 Memorial Number. Since the work covers 81 pages and is largely anecdotal and very detailed, it has been left to the interested reader to access it direct. However, it is of interest to read how Wood regarded this request.

He commented: "I have encountered considerable difficulty in deciding not only 'where to begin' but 'how to proceed' and 'where to stop'. It must be obvious to everyone that almost any account by a single author cannot be expected to be a complete factual history. Such an account, even if attempted, would require several volumes to complete, covering as it does a period of 46 years, *ie* from 1915 onwards.

"This is not a history of science in the Navy, but merely an impression, almost an autobiography, based mainly on personal recollections and a few papers and diaries, of a somewhat reminiscent and superficial character, during the years subsequent to 1915 when I made my first close contact with the Navy. Soon after the war began, staffs were augmented by civilian engineers converted into RNVR officers. As the war progressed, contacts between our civilian research establishments and the purely naval establishments increased until, as we now know well, civilian research staffs of the RNSS can be found in almost all naval establishments concerned with the application of research in the service of the Navy."

As a fitting conclusion to this *Pioneer* article, I quote Albert Wood's final paragraph.

"Looking back over the period from 1915, when the Admiralty Board of Invention and Research was formed, to 1944 when it became transformed into the Royal Naval Scientific Service, the civilian scientific and technical staffs have good reason to be proud of their achievements in two wars and the intervening period. There has been no lack of achievement from 1944 to the present day and I have no doubt the future has much more in store. All those of us who have lived through the two war periods must hope that the call for war science will never come again, and the process of converting swords into ploughshares will long continue."

Albert Beaumont Wood died suddenly on 19 July 1964 whilst on holiday and, to quote W L Borrows again, 'with his passing, an era in Naval Scientific Research came to an end'.

There is a slightly different approach to our parliamentary reporting in this issue. A proposal was debated on 21 February 2005 to amend the Road Vehicles (Construction and Use) Regulations 1986 as follows (inter alia).

Vehicles registered from January 2007

General restrictions on audible motor vehicle alarms on certain motor vehicles first used after 1 January 2007

The audible motor vehicle alarm of a motor vehicle (to which this regulation applies):

- (a) may not at any time emit a noise exceeding 55 decibels;
- (b) may not emit a noise for a continuous period of more than ninety seconds;
- (c) may not emit a noise for more than ninety seconds in response to a single event initiating the emitting of a noise; and
- (d) shall be maintained in good working order so as to comply with the requirements of sub-paragraphs (a) to (c).

Vehicles registered since October 1982

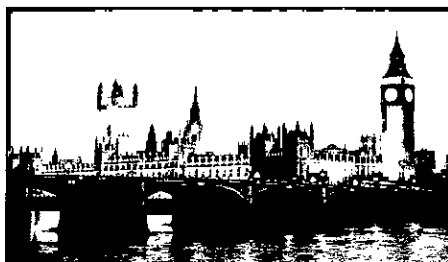
Subject to paragraph (2), this regulation applies to a motor vehicle first used on or after 1 October 1982.

The audible motor vehicle alarm of a motor vehicle to which this regulation applies:

- (a) may not emit a noise for a continuous period of more than ninety seconds;
- (b) may not emit a noise for more than ninety seconds in response to a single event initiating the emitting of a noise; and
- (c) shall be maintained in good working order so as to comply with the requirements of sub-paragraphs (a) and (b).

Norman Baker: I am pleased to have the opportunity to introduce these new clauses. Those who pay particular attention to the workings of Parliament may note that there is a striking similarity between them and the Bill that I introduced that is due for a Second Reading on 18 March. I also record the fact that that Bill, which is replicated in the new clauses, has the support of Conservative and Labour Members of Parliament, and I hope that it will generate a response similar to the all-party support that I had for my motion on climate change two weeks ago. The Minister is not nodding now, but perhaps he will later on.

There is undoubtedly a problem with car alarms in environmental and noise nuisance terms. The Government has correctly identified the need to tackle noise nuisance through the Bill's proposals concerning audible intruder



Commons Debate

alarms. My colleagues and I broadly welcome what the Government has done on that issue. However, the Minister will also accept - he referred to it in an intervention on Second Reading - that there is a nuisance from car alarms. They can legally sound up to 120dB - the same level as a pneumatic drill or a rock concert. They tend to go off quite frequently, and they are assumed by those who hear them to be false alarms. When people hear an alarm go off, they do not say, 'My goodness. A car has been broken into. I must telephone the police.' Instead they curse the alarm, put pillows over their heads and try to go back to sleep. Car alarms are not even effective in what they try to do.

The new clauses have two aims. The first is to eliminate the environmental nuisance associated with car alarms and the second is to improve the security of motor vehicles. If people assume that a car alarm going off is a false alarm, it is obviously no deterrent. When I first raised the issue, one journalist to whom I spoke said that his car was broken into in the street in broad daylight, the alarm went off and the intruder just looked at passers by and said: "Bloody car alarm" - if I am allowed to use that phrase in the Chamber - and carried on with the theft of the car. All the people in the street simply walked by without responding. It is clear that car alarms are ineffective.

The Minister may be aware of the attempt made in New York to ban car alarms. If he has seen the evidence, he will know that 75 per cent of 800 New Yorkers polled said that car alarms interfered with their sleep and 90 per cent said that car alarms diminished their quality of life. More to the point in terms of the crime element, the New York police department, in a booklet that it produced, labelled audible car alarms as an annoying and sometimes unbearable disturbance for residents in their homes. It said that audible car alarms frequently go off for no apparent reason, and that such devices invited both further disorder and serious crime.

In other words, alarms not only fail to arrest crime, but generate it. The report pointed out that in Williamsburg during the year in question, two cars were purposely set ablaze because their alarms kept being triggered. There have been other stories of cars being vandalised because alarms have spontaneously erupted, so we can

assume that car alarms create crime, rather than preventing it.

A better way forward would be for manufacturers to stop using 1960s technology - that is essentially what car alarms are - and move towards more effective crime prevention measures that are also less environmentally intrusive. The Minister will be aware of alternative existing technologies, such as immobilisers, which prevent a car from being driven away. He will be aware of pager alarms, which replace the siren in conventional alarms by instead sending a signal to the mobile phone, pager or landline telephone of the car's owner. He will also be aware that tracking systems are up and running that allow a signal to be sent from a car that has been taken, to its owner. That technology has the benefit of not only returning the car to the owner, but identifying the criminal who takes the car. Other systems that are currently available include anti-carjacking systems, so plenty of technologies exist that are far more effective than conventional alarms at detecting crime and preventing car theft, and much less environmentally intrusive.

The Minister might be aware that Val Weedon, the secretary of the UK Noise Association, wrote to the Secretary of State for Environment, Food and Rural Affairs on 10 February. The letter read: 'I am writing to ask whether the recent

'alarms not only fail to arrest crime, but generate it'

Private Member's Bill on audible car alarms, presented in parliament yesterday by Norman Baker MP, could be incorporated into the new

Clean Neighbourhoods and Environment Bill, presently making its way through parliament? I understand a similar thing was done with the *Anti Social Behaviour Act* and a Private Member's Bill on fireworks.'

I am pleased to say that the letter went on to support my Bill. Incorporating my Bill in the Government's legislation would be an excellent idea, so the new clauses make that possible. I hope that the Minister agrees that alarms are ineffective and 'alarmingly useless', to use the phrase of a pressure group campaigning against them. I also hope that he will take the view that manufacturers should be encouraged to replace traditional audible car alarms with devices that prevent crime more effectively and eliminate the noise nuisance that currently exists.

It seems to me that insurance companies are the driving force behind the continuing use of car alarms. Although I do not wish to misquote the manufacturers, they tell me that insurance companies require such alarms to be fitted. Insurance companies should examine whether there are more effective ways of preventing car theft and change their policies accordingly.

Train horn noise is not directly addressed by the new clauses, but it is germane to the matter that we are discussing because it leads to people suffering an intrusion similar to that caused by car alarms. Train horn noise is also

about 120dB and new trains require louder horns than the old slam-door rolling stock. I am disappointed that the Government has not addressed that problem. Individual hon. Members of all three parties have been required to put pressure on the relevant rail companies and we are making a little progress.

The Bill addresses intruder alarms sited at a fixed point, but it singularly fails to deal with alarms on mobile technology - if I may call cars and trains that. The new clauses would limit the maximum sound emitted from a car alarm to 55dB, which is the equivalent to background traffic noise, and would set a maximum sounding time for a car alarm of 90 seconds.

The Minister responded to a point about the matter that my hon. Friend the Member for Guildford (Sue Doughty) made on Second Reading by citing the *Noise and Statutory Nuisance Act 1993*, which states that noise that is prejudicial to health or a nuisance and is emitted from or caused by a vehicle, machinery or equipment in a street can be dealt with. He also pointed out that local authorities can enter or open a vehicle, if necessary by force, to silence a car alarm and to remove the vehicle from the street to a secure place.

That is undoubtedly true, but the legislation is not working. Not all local authorities operate 24-hour services, and those that do will not respond within 90 seconds, which under my private Member's Bill would be the maximum

time for which a car alarm could sound. In practice, local authorities come out only if an alarm has been sounding for two, three or four hours, by which time an entire neighbourhood could have lost its sleep.

The new clauses plough the same furrow as the Government's attempt to limit noise nuisance. The Government has identified the problem of noise nuisance, and although it has addressed stationary alarms in the Bill, it has missed a trick by not dealing with car alarms. It is

not sufficient to hope that manufacturers will adopt modern alarm systems, because they are relying on 40-year-old technology instead. I hope that the Government will give a sympathetic hearing to the new clauses, because they are an attempt to make life better not only for car owners, but for those who suffer from the noise nuisance caused by car alarms.

Alun Michael: I am aware of the enthusiasm of the hon. Member for Lewes (Norman Baker) on this subject, and I acknowledge that a range of options is now available for people who want to try to prevent car crime - both the theft of vehicles and breaking into vehicles. Indeed, one could point out that that range of options has made a significant contribution to the reduction of car crime. In addition to achieving excellent public relations for his private Member's Bill, the hon. Gentleman recalled that I

commented about car alarms on Second Reading. In fairness, he went on to remind the House that I also pointed out that legislation exists to address the problem. I reinforce that point now. Car alarms can be silenced under the *Noise and Statutory Nuisance Act 1993*, which amends the *Environmental Protection Act 1990* to include noise that is prejudicial to health or a nuisance and is emitted from or caused by a vehicle, machinery or equipment in the street. It allows local authorities to enter or open a vehicle,

if necessary by force, to silence an alarm and to remove the vehicle from the street to a secure place.

The hon. Gentleman acknowledged that point, but suggested that the legislation was not working. However, I suggest that we should not consider whether that legislation is working, but the extent to which a real problem exists. He will know that consultation on the elements that form the Bill arose from considerable discussion with local authorities, and that the provisions are based on problems with which local authorities must deal after the public has brought them to their attention.

It is worth pointing out that under the *Police Reform Act 2002*, the police can seize any vehicle that causes annoyance or nuisance. It must also be borne in mind that there might be occasions when a car alarm needs to sound for longer

continued on page 38

'the police can seize any vehicle that causes annoyance or nuisance'

NoiseMap 2000 — WS Atkins



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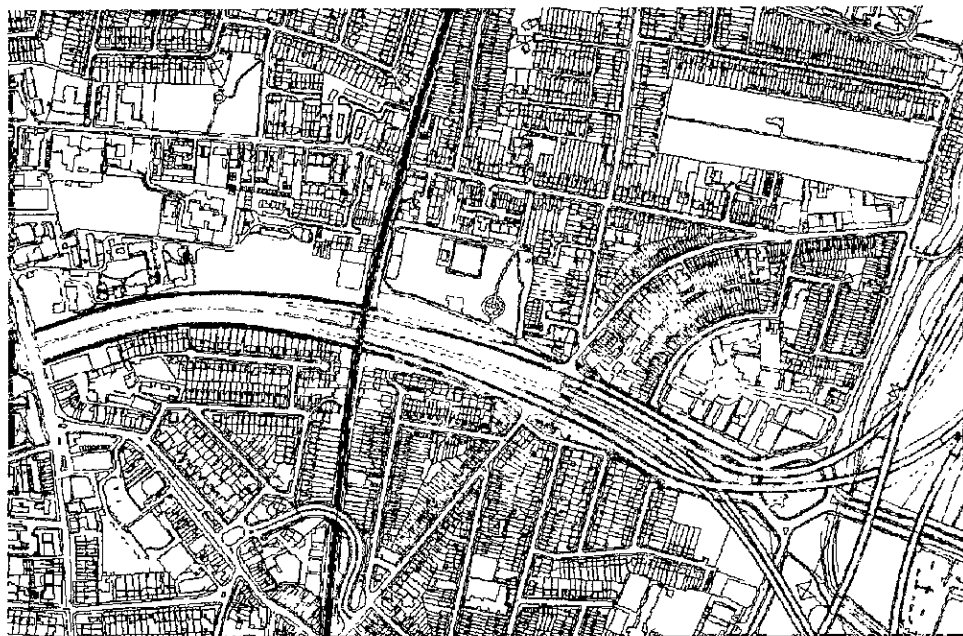
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Commons Debate

continued from page 37

than 90 seconds - for example, if it detects continued interference. Additionally, establishing requirements for the duration of alarms and assessing that during MOT tests could generate a lot of alarm noise around MOT stations, which might not be all that popular.

The hon. Gentleman told us about the experience in New York, so he might be interested in some of the findings from this country, as they come from rather closer to home - the area in which he wishes to legislate. In 1999-2000, the Department for Environment, Food and Rural Affairs national noise attitude survey questioned 2,849 people - I am not sure where the 2,850th person, to allow the figures to be rounded up, was. One question was:

'When you are at home, how much do you personally feel bothered, annoyed or disturbed by noise from car alarms?'

The UK results were 39% 'not at all'; 13% 'a little'; 5% 'moderately'; 2% 'very'; 2 'extremely'; and 40% 'don't hear'.

If we rank specific traffic noise sources in terms of the proportion of respondents bothered, annoyed or disturbed, we get an interesting hierarchy of complaints. At the top, at 34%, are vehicles accelerating or going too fast; private cars and taxis are at 27%; heavy lorries are at 24%; motor bikes and scooters are at 24%; music from vehicles is at 23%; and problems associated with residential estate roads and country lanes are at 22%. Car alarms are only seventh in the hierarchy, at 21%. We are not aware of specific statistics on complaints to local authorities about noise from car alarms, because they do not show up on current record keeping and reporting statistics. However, the complaint does not seem to get the attention from local authorities that the hon. Gentleman gives to it.

Norman Baker: I challenge the Minister's logic. The fact that six things are higher on the list does not mean that the seventh, about which 21% have complained, should not be dealt with. It is a curious logic to say that we should deal only with the top one or two on a list. There is an issue to address. Many people are irritated by car alarms, and the Minister should be less complacent.

Alun Michael: I am not being complacent. I am saying that measures are in place to

allow local authorities and the police to tackle the issue when it is a real problem. I tried to give a sense of proportion to the extent to which it is a nuisance. Clearly, it is a nuisance in some circumstances, and provisions are available to use in those cases.

The new clauses are not appropriate because their provisions could be achieved by changing relevant regulations made under the *Road Traffic Act 1988*.

More importantly - this would be a serious concern for the House - they would

involve the use of primary legislation to amend secondary legislation made under a different Act. That would result in amendments that could be amended or revoked only by primary legislation, while the rest of the regulations would still be amendable or revocable by secondary legislation. That would produce an unworkable hybrid.

I acknowledge the enthusiasm with which the hon. Gentleman tries to address the problem in his private Member's Bill and in the new clauses, and the way in which he has pursued the problem. My point is that if more action needs to be taken - although that does not come through strongly in the consultations that we have undertaken or in the views of the Local Government Association - the means are to hand. The hon. Gentleman will clearly pursue the matter further in his private Member's Bill and will receive a response to that when it is debated in due course, but the provisions are already in place. If a local authority has a problem, it can tackle it.

The primary problem is that the new clauses are

not appropriate. They would require primary legislation to amend secondary legislation under a different Act, and that makes them totally unworkable as a proposition. The hon. Gentleman has succeeded, as he has a talent for doing, in airing the issue, but I hope that he accepts my problem with the technicalities, if not the principles, behind the new clauses. He raises his concerns quite genuinely, but I urge him to withdraw the motion.

Norman Baker: I am grateful to the Minister for considering the issues. I am always happy to accept that anything tabled by people who are not on the Government Benches may be imperfect, because we do not have the advantage of a parliamentary draftsman. He knows that the reason for tabling amendments and new clauses is to raise issues. We do not necessarily expect them to be adopted by the Government - although I always remain hopeful that that will be the case.

The Minister addressed one issue - the problem of noise nuisance, which is, after all, the primary purpose of this

part of the Bill. I do not accept that the nuisance is as limited as he suggests. I have had correspondence from people up and down the country saying, 'Thank God someone's raising the

problem'. Those of us who have followed the issue have had some indication that there is popular support for further measures to tackle car alarms. It may well be the case that for many people that has never been an issue, but for some it is a big nuisance and affects their quality of life dramatically. It is incumbent on us to find a way to help them, and I am sorry that the Minister did not come up with an alternative.

The Minister says that relevant provisions exist in legislation enacted in the past

10 to 15 years. I do not agree that they are effective. I do not agree that the police are interested. They are stretched - overstretched, one might say - and their general response when an environmental health issue arises is to refer people to the local council.

I spoke to Sussex police about car alarms. Their standard response when they are telephoned is to assume that it is a false alarm and refer people to the council unless there is immediate evidence that someone is breaking into a car. If someone rings up and says, "I can hear a car alarm," Sussex police say, "Ring the council." The police assume that no crime is being committed. The nuisance issue is not as minimal as the Minister suggests.

The provisions are not effective because they rely on councils taking action.

They invariably take a long time before they do so, because if they responded

immediately every time they were called out to a car alarm, they would do little else. I am not convinced that current legislation is effective in dealing with the

nuisance.

The Minister did not refer to my point that car alarms, as used, are largely ineffective in preventing -

Alun Michael: I did.

Norman Baker: I beg to differ. It passed me by. I do not mean to be discourteous, but the Minister concentrated on the nuisance rather than the crime aspect.

Alun Michael: I concentrated on the nuisance aspect because that is what is in the Bill. I also acknowledged that there is a wide range of other ways of preventing car crime and that there are effective options and means for people to consider.

Norman Baker: The Minister did say that, and I am happy to accept his point. However, he did not conclude, as I hoped he might, that the new clauses - or at least the spirit behind them - would propel manufacturers to consider more effective, readily available and comprehensively applied ways of limiting car crime. Manufacturers are resting on their laurels with existing car alarms. They are covered by insurance companies. The manufacturers say that they have done their job and can tick the box, but they are not doing people who buy cars a service and providing decent effective alarms. The spirit behind the new clauses would have the effect of driving manufacturers further along that road. The need to do that has not been fully accepted.

However, I have had my run around the track. I may get another one - who knows? - if my Bill's Second Reading on 18 March is successful. I beg to ask leave to withdraw the motion.

Motion and clause, by leave, withdrawn. It must be reasonably gratifying that a proposal to restrict car alarms to effective inaudibility was thrown out - even if it was not for practical, scientific reasons!

'The primary problem is that the new clauses are not appropriate'

Assessing the environmental significance of underwater sound



frequency $1/2\Delta t$ for which aliasing does not occur.

I am surprised the author states that: 'The noise power, or noise intensity, has the benefit of closer links to possible damage mechanisms compared with acoustic pressure'. In air, high level standing waves in an enclosure that possess little intensity, can certainly be responsible for hearing damage. Maybe this is not so for

animals underwater.

In reference to *Fig. 1*, the author states that: 'the flat region at 0.06 W/Hz now clearly gives 12 watts total to 200Hz'. My reading of the figure suggests a 'flat' level of about 0.15 W/Hz up to about 100 Hz, giving 15 watts.

In attempting to explain the physical origin of the 'red' spectrum the author says: 'However, a better explanation is likely to involve the water-damped response of the hull'. I have three reasons for questioning this suggestion. First, although surface wave radiation damping may be substantial in the very low frequency range of interest, it is unlikely to be significant over most of the range. Second, the viscous damping of a hull is generally much less than the sound radiation damping. Third, vibroacoustic theory shows that, in this case, the radiated sound power per unit means square excitation force is independent of frequency. It seems more likely that the shape of the radiated power spectrum is related to the spectra of input forces, isolator insertion losses and hull radiation efficiencies.

The uninitiated would be puzzled by the reference to: 'The revised keel aspect directional data'. The spectra in *Fig. 3* show quite different speed dependencies at low and high frequencies, suggesting different noise generation mechanisms. If the engine power varied with engine speed the radiated sound power should not be simply related to the rated engine power.

Frank Fahy FIOA

Dick Hazelwood replies

I am very pleased that Prof Fahy approves the overall aim of my article, and I will try to respond to his detailed criticisms.

I used the term 'random noise', perhaps rather loosely, contrasted with single frequency 'tonal noise' (or unwanted sound), where the measurement bandwidth exceeds the frequency spread. For the latter case, important in acoustic positioning applications (see *reference 15*), the bandwidth implications are hidden. Using a 'white' (ie uncorrelated) spectrum

for the low frequency model aims to give an average distribution over ships and other machinery, where the detailed tonal noises cannot be assessed individually. Whilst I suppose all noise is ultimately deterministic, the high frequency ship noise spectra appear so well distributed that it seems reasonable to consider them as 'random', although the 'red' nature of the spectra does indicate some autocorrelation.

I do not know the reason for this widespread 'red' characteristic, but feel that there could be a relatively simple explanation. I agree entirely that the radiated power spectrum is likely to be controlled by 'the spectra of input forces, isolator insertion losses and hull radiation efficiencies'.

Regarding the DFT, for a fixed calculation complexity (the array size) the bin size is controlled by the record length, so the proportionality then holds. However, I agree his statement does provide useful extra detail.

Regarding the significance of noise power and noise intensity, I used the term intensity rather loosely, mainly to highlight the significance of the power per unit area, in circumstances where the reverberation is limited. In highly reverberant circumstances (*reference 14*), the relationships become more complex as the sound echoes around. The relative significance of pressure and intensity must depend on biological detail, but in many medical applications it is watts/cm² which is limited to minimise heating.

Unfortunately, *Figures 1 and 2* suffered errors in processing. Notably the straight lines representing the Urick model were lost, but the levels are also suspect. I can supply better ones on request.

The linkage between engine power specification and acoustic output is necessarily fairly loose. But such compromises are an inevitable consequence of simplicity. The aim is to be able to make a 'ball park' assessment of likely maximum output noise power from the engine size, as a crude indicator of vessel capability. Dynamic positioning vessels make much noise going nowhere, but they do have rather large engines to enable them to hold station.

The errors induced by misunderstood decibels often far outweigh the errors of simple 'first cut' calculations, which thus serve to provide a well understood base onto which more detail can be added as necessary.

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'The presentation of random noise: Why do underwater acousticians do it differently?' by Dick Hazelwood (*Acoustics Bulletin* vol.30 no.1) was both interesting and pertinent. In my experience, the diversity of forms of expression of measures of acoustical field quantities and their spectra causes much confusion even among 'air' acousticians; and the disparity of reference quantities used by 'air' and 'underwater' acousticians compounds that confusion.

The need to relate physical measures to the effects of sound on biological systems, with their diverse auditory systems, sensitivities and damage susceptibilities, further complicates the problem. The writer is to be commended for his attempt to explain the nature of this problem and to suggest forms of data reduction and presentation that can be used to assess the environmental significance of underwater sound. I strongly support his contention that the widespread failure to appreciate the crucial importance of stating, and accounting for, the effective bandwidth of a spectral estimate has often led to incorrect conclusions about frequency-integrated values.

Further clarity needed

However, it is unfortunate that the author does not explicitly distinguish between propulsion-generated noise, flow-generated noise and machine-generated noise. It is not clear whether the cited spectra include noise generated by all these components. The article would appear to concern principally the last mentioned; if so, I am unsure as to the origin of the 'random noise' of the title since most machinery generates periodic multi-tonal noise.

The author states that: 'The closer the time between samples, Δt , the finer the resolution of the spectrum Δf '. The frequency resolution of a spectrum derived from a Discrete Fourier Transform of a digitised signal is determined not by the sampling rate but by the temporal length T of the sample records employed in the averaging process: $\Delta f = 1/T$. The sampling rate determines the maximum

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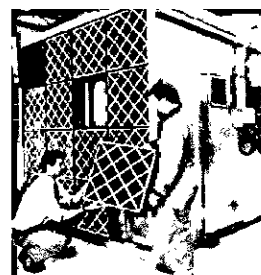
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DEFRA consults on proposals to implement Environmental Noise Directive

Defra has launched a consultation process to seek views on how best to implement Directive 2002/49/EC on the assessment and management of environmental noise, also known as the Environmental Noise Directive. Environmental noise, such as that from traffic and industry, can affect people's quality of life, particularly in towns and cities. The Directive is expected to complement current Government work to lessen the impact of environmental noise on people's lives, offer a clearer picture of the noise climate, and allow future government action to be targeted more effectively.

The directive aims to define a common approach across the European Union with the intention of avoiding, preventing or reducing on a prioritised basis the harmful effects, including annoyance, of exposure to environmental noise. This will involve:

- * informing the public about environmental noise and its effects;
 - * the preparation of strategic noise maps for large urban areas (referred to as 'agglomerations' in the directive and in this document), major roads, major railways and major airports as defined in the directive; and
 - * formulating action plans based on the results of the noise mapping exercise.
- Such plans will aim to manage and reduce environmental noise where necessary, and preserve environmental noise quality where it is good.

The noise mapping and action planning



The directive aims to develop a common EU approach

process is to be taken forward on a five-yearly rolling programme. The first round of mapping and action planning applies to the largest of the agglomerations (including the industries and ports within them), the busiest major roads and railways, and all airports. Maps must be produced by 30 June 2007, with the action plans following a year later in 2008.

During the second round (2012-13) all agglomerations, major roads, major railways and major airports as defined by

the directive will be mapped and then action plans will be developed for them.

The consultation paper seeks comments on proposals to:

1. Designate the competent authorities and bodies responsible for implementing the directive. However, Member States remain ultimately responsible for ensuring that the requirements of the directive are met. The competent authorities will be responsible for aspects such as making and, where relevant, approving noise maps and action plans for agglomerations, major roads, major railways and major airports; delimiting quiet areas within agglomerations and open countryside and collecting noise maps and action plans.

2. Set out the process by which the noise maps and action plans will be produced (including public consultation for the action plans).

3. Set out the process by which the completed noise maps and action plans will be made available to the public.

The consultation is available on-line at <http://www.defra.gov.uk/corporate/consult/end-two/index.htm>

Hard copies can be requested from the Environmental Noise Branch, Defra, Zone 4/H16, Ashdown House, 123 Victoria Street, London, SW1E 6DE.

Closing date for the consultation is 12 noon, 16 May 2005.

Responses can be sent to the Environmental Noise Branch at the address above, or by e-mail: noise@defra.gsi.gov.uk

Scientists as journalists the Media Fellowship scheme

Scientists are being invited to find out how the media functions as part of a scheme to increase awareness and understanding of the workings of the media among practising scientists, social scientists and engineers. The Media Fellowship scheme is run by the British Association for the Advancement of Science (BA). This nationwide, open membership organisation is dedicated to connecting science with people, so that science and its applications become accessible to all.

As BA chief executive, Roland Jackson, observes, to many scientists, the process by which a story moves out of the laboratory and onto a news page is as much a mystery as the peer review process is to the general public. As a result, many scientists still believe that the media misrepresents their research, either through misunderstanding or hyperbole. The BA's experience of working with the UK science media is that it is amongst the best and most professional in the world, and that the insights offered scientists through the Media Fellows scheme are valuable and mutually productive.

Through the Media Fellowship scheme, practising scientists and engineers are offered placements in media organisations

which in the past have included the BBC, the *Guardian*, the *Daily Telegraph*, *Nature* and the *Times Higher Education Supplement*. Following placements, it is hoped that the scientists will utilise their experience back in the workplace. Lisa Wright from the Institute of Astronomy, Cambridge, a former beneficiary, said that when she left the *Financial Times* after a month's placement she felt she really had been a journalist during that time. Working with media professionals taught her, as a scientist, a great deal about how to communicate more effectively. She found that science journalists have a breadth of knowledge that puts most researchers to shame.

Placements are offered during the summer and include a week at the BA Festival of Science in September, to be held this year in Dublin. During placements of between three and eight weeks, Fellows learn to work within the conditions and constraints of the media to produce accurate and well informed pieces about developments in science.

More information on the scheme can be found at www.the-ba.net/mediafellows. The deadline for applications is Friday 15 April.

DEVELOPMENTS IN NOISE RESEARCH

National Motorcycle Museum, Birmingham

Tuesday 24 May 2005

The meeting will be of interest to all those who work in the field of environmental and neighbour noise both as consultants and regulators

Don't miss this opportunity to discuss the latest developments in noise research, including construction noise, low frequency noise, sound insulation, Codes of Practice and industrial noise mapping

For further information, or to register please contact Linda Canty at linda.canty@ioa.org.uk or visit the IOA website.

ENG workshops

The IOA's Environmental Noise Group is also organising two one-day workshops to discuss the Government's Consultation Document on the implementation of the Environmental Noise Directive. Details will be posted on the IOA website.

NSCA calls for action to reduce noise from hard flooring

The environmental protection group NSCA has called for action to tackle the problem of noisy flooring, claiming that impact noise from laminated and hardwood flooring has become an increasing headache for flat dwellers. A recent report from the Building Performance Centre indicates that this escalating noise nuisance could be reduced, given robust guidance for installation and performance of products. The report, which examines the acoustic problems caused by the increasing trend towards laminated and hardwood flooring, and the problems it can cause for those living underneath, recommends:



A report calls for better guidance and product labelling to alleviate a growing misery for flat dwellers

- * A non-technical guide for consumers on installation of flooring to encourage proper insulation and minimise inappropriate installation;
- * Substantiation of manufacturers' claims of insulation performance (the report finds that these can be misleading);
- * Implementation of a standardised labelling scheme for the acoustic performance of products;
- * Establishment of a working group (flooring industry, landlords, local authorities etc) to create a Code of Practice to ensure management of noise impacts; and
- * Environmental Health Departments to record complaints from footfall/impact noise to clarify the extent of the problem.

Mary Stevens, noise campaigner at NSCA, said that impact noise from poorly insulated hard flooring is causing increasing nuisance and disturbance for the UK's flat dwellers. Some 20% of the population lives in flats, many of which have poor sound insulation. The fitting of inadequately insulated hard flooring can have a major impact on quality of life. The NSCA welcomed the report and fully supported its recommendations for better guidance and product labelling. *Laminated and wooden flooring, a guide for noise control*, published by the Building Performance Centre, can be found at <http://www.defra.gov.uk/environment/noise/hardfloors/index.htm>

Invitation to participate

Forum Acusticum 2005

Budapest, Hungary 29 August - 2 September 2005

The history of the development of the Science of Acoustics also reflects the development of natural sciences, economics and human society. We can marvel at the wonders of the Ancient World and the Middle Ages with pleasure, and these masterpieces of art can still be used today either in their original condition or after reconstruction. But with the development of modern science in the 18th century, industrialisation, urbanisation, and the demand for mobility brought numerous challenges and tasks to solve regarding acoustics.

- * The acoustic quality of the human environment became an acknowledged environmental and human factor, as well as an aspect with economic influence;
- * Throughout this period, acoustics have developed direct and growing connections with the fields of engineering as well as the natural and social sciences, the centre of which has always been the quality of human life;
- * The demand for good quality communication signals and clear transmission of acoustic information became common;
- * The conscious preservation of the acoustic quality of our environment demands global

solutions, not only because of the effects, but also because of the global growth of human habits and noise sources.

Organisers of the *Forum Acusticum 2005 International Conference* want to establish the best possible conditions for the presentation of a wide range of problems and results within this complex process. More than 40 structured sessions in various fields of acoustics will be organised. The Technical Committees of EAA will hold open discussion meetings and offer platforms for co-operation. Frigyes Reis, General Chairman of the conference and Michael Vorländer, President of EAA, "welcome our colleagues and friends working in the different fields of acoustics to *Forum Acusticum 2005* in Hungary with great pleasure".

Participants are invited to present their results, new methods, products, and procedures; discuss important, conceptual conclusions; and in the meantime, enjoy the abundant opportunities that are offered by the rich cultural life, architectural and historical treasures, as well as the recreational, folk art, and culinary opportunities available in the city of Budapest.

For further details visit: www.fa2005.org

Important deadline: 30 April 2005 is the last date for submission of word-processed papers, and payment of advanced registration fees.

PEOPLE

New faces at Scott Wilson



Dr Mike Fillery, Steve Burdis and Ruth Dawson have joined the Noise and Vibration team

The Noise and Vibration team at Scott Wilson continues to expand, recently adding three new faces to the Chesterfield office. First is Dr Mike Fillery, who is heading up the team. He joins Scott Wilson from a two-year stint in the Altrincham office of Capita Symonds, which followed on from a 23-year academic career at the University of Derby.

Mike says: "While I had a really enjoyable time at Capita Symonds, working on some interesting and novel projects, my new job gives me a chance to develop a young and forward-looking acoustics team. As a leading player on the world scene, Scott Wilson is involved with numerous major multi-disciplinary development schemes and is committed to growing the in-house noise and vibration services. Our team will be based in the Midlands but will have a national and international brief for both internal Scott Wilson projects and for external work." Despite the new workload Mike is hoping to continue with his activities for the Institute. He has been Secretary for the Midlands Branch since 1995 and a regular contributor to conferences. Currently, he is also Chairman of the Education Committee, where he maintains his interest in the education of acousticians.

The second new face is Steve Burdis who joins the organisation from Bombardier. Steve's career to date has been within the rail industry, working at British Rail Research for a number of years followed by spells at ALSTOM and Bombardier. Steve has considerable experience across the whole range of engineering and building acoustics and will be focusing on noise modelling with *Soundplan*.

The last new arrival is Ruth Dawson who was recruited straight after finishing an MSc in Environmental Management at the University of Derby. Her MSc project, which earned a distinction, examined the noise impact of the planned flyover at Abbey Hill, Derby. Ruth is already a holder of the Diploma in Acoustics but we have yet to convince her to commit fully to noise and vibration as she is also a dab hand at air quality monitoring.

Support the IOP's 'Lab in a Lorry'

Volunteers sought for community outreach initiative

The Institute of Physics is looking for enthusiastic individuals to share their expertise and interest in physics through an exciting community outreach programme, *Lab in a Lorry*. The eponymous lorry is an interactive mobile physics laboratory staffed by volunteer practicing physicists and engineers.

During 2005 a fleet of three 13m lorries will visit schools, youth centres, science festivals and other events. Young people will have the opportunity to do experimental physics, including exploring the phenomenon of resonance, under the guidance of experienced scientists. Volunteers will be asked to donate one day of their time (or

more if possible) to staff the lorry, with full training on the experiments given.

The itinerary is as follows:

18 May: Official launch at IOP, 76 Portland Place, London

7 May-25 June: Northern Ireland Tour (Fully Booked)

13-19 May: Telford - Midlands (tbc)

10-29 June: Loughborough University

8-13 June: Cheltenham Science Festival

20-26 June: Leicester University

13-14 June: Science Festival - Herefordshire

15-27 June: Gloucester SETPOINT South West tour

29 June-13 July: Yorkshire Branch Tour

27 June-1 July: Cumbria touring

4-11 July: Sellafeld Visitor Centre (tbc)

4-18 July: South Central Branch Tour (between London and south coast incorporating Portsmouth and Southampton)

18 July-1 Aug: Manchester & District Branch Tour

29 July-10 Aug: Scouts Euro Jam - Chelmsford

30 July-6 Aug: Eisteddfod - Wales (probable Welsh tour following)

5-9 Sep: BA Festival - Ireland

11-24 Sep: TECHFEST - Aberdeen (tbc)

12-19 Sep: Waterford Institute of Technology - Ireland

19-26 Sep: NUI - Galway (tbc)

26 Sep-3 Oct: Cork - Ireland (tbc)

For more information about *Lab in a Lorry* or to volunteer, see www.labinalorry.org.uk or contact Judy Edrich at IOA Head Office

Noise Action Week 23 - 27 May 2005

Noise Action Week 2005 offers local authority officers and other agencies involved in neighbour noise management an opportunity to raise awareness of noise issues and educate and inform the public on practical solutions to everyday noise problems. Defra, DOE N Ireland, the National Assembly for Wales and the Scottish Executive have confirmed funding for a UK wide Noise Action Week this year.

The week-long initiative, which follows on from successful Noise Action Days, will allow participants more flexibility in fitting their awareness raising activities around other work commitments.

Noise Action Week supports those involved with noise management at local level in:

- ★ Promoting practical solutions to everyday noise problems;
- ★ Educating and informing both noise makers and noise sufferers about the impact noise can have on our everyday lives;
- ★ Promoting communication and consideration between neighbours;
- ★ Supporting local authorities, mediation services and housing providers in informing the public of services available and highlighting local noise issues; and
- ★ Encouraging everyone to take a quiet moment to consider the noises they make and the noises that affect them - and what they can do to reduce the impact.

At national level the Action Week will raise the

profile of neighbour noise issues by securing media involvement, and provide a platform for high profile government activity and announcements on noise.

Plans include encouraging partnerships at local/regional level and involving agencies concerned with managing neighbour noise. The *National Society for Clean Air* (NSCA) will be producing: a detailed 'how to' guide to help you manage promotional activities; a dedicated Noise Action Week website with information, updates and downloads; a toolkit of background information and resources available; and a basic free package of promotional materials.

To register for Noise Action Week updates contact: noiseactionweek@nsca.org.uk

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British Gypsum



The Sage Gateshead, Hall One, showing deployment of acoustic curtains
Photos by Sally Ann Norman

Triple E and J&C Joel Tracking acoustic curtains at The Sage Gateshead

The Sage Gateshead, the stunning new £70m home for live music in the North of England, is at the heart of Tyneside's regeneration. Funded by the largest Arts Lottery grant outside London, this building for the performing arts designed by Foster and Partners, aims to be an inclusive, open-for-everyone music venue. It includes two concert halls, the Northern Rock Foundation Hall for rehearsal and performance and a 25 room Music Education Centre designed to pioneer a fresh approach to musical discovery.

Such a venue must offer a wide range of music, from classical pieces, choral works and 18th century chamber music to folk, jazz, rock and pop and solo artists - and the acoustic requirements for each are completely different. With variable acoustics among the highest design priorities, both main concert halls, nominally called Hall One and Hall Two, and the rehearsal space are equipped to international standards. Theatre Projects Consultants was responsible for the technical design, working with acousticians Arup Acoustics.

Hall One, with a capacity of 1650, is the largest of the two concert halls and uses



Detail of Triple E Chaintrack with acoustic curtain in Hall One at The Sage Gateshead

retractable acoustic curtains, as does Northern Rock Foundation Hall, whereas the unusual design of Hall Two called for acoustic banners. The fabric of choice for acoustic drapes and banners is wool serge which, constructed as a flat woven fabric, felts during the wet finishing process and so closes the natural air gaps created during the weaving. Specialist manufacturer **J & C Joel** was selected to both supply the fabric and manufacture a total of 153 drapes, which weighed in at an impressive 6½ tons, for all performance and rehearsal spaces. As contracts director Mark Taylor explained: "Wool serge has the ideal characteristics for use in acoustic areas, but we also had to be mindful of the aesthetic qualities when the

drapes and banners are deployed".

In Hall One, the curtains when deployed cover some 90% of the walls and the challenge for Theatre Projects Consultants was to find a way of storing them, in the minimum space, behind the auditorium walls and so isolating their acoustic properties when not required. The **Triple E Chaintrack** system was chosen by Street CraneXpress, which was responsible for the stage engineering equipment.

The construction of *Chaintrack* enables it to navigate 180° within a radius of just 40mm. Using a standard duplex roller chain for driving and suspension, the top half of the chain is used for driving and the lower section for attaching the curtains. The curtain is kept flat while it is travelling, including around tight corners. The fact that the track can double back on itself, coupled with the facility to store curtains flat rather than bunched, provided the solution.

The acoustic curtains, the largest of which weighs 375kg and is 39.5m wide, with a drop of 5.8m, are stored in pockets behind the auditorium walls. Triple E managing director David Edelstein explained: "The deployed length of the curtain is duplicated in the storage pockets but the track in the storage areas is formed into a series of short parallel tracks and, in the case of the largest curtains, spiral storage layouts. With the curtains at 50% fullness, as the largest ones travelled in opposite directions, they would have tangled." The answer was to design certain areas with a spiral stack, enabling the curtain to always travel in the same direction.

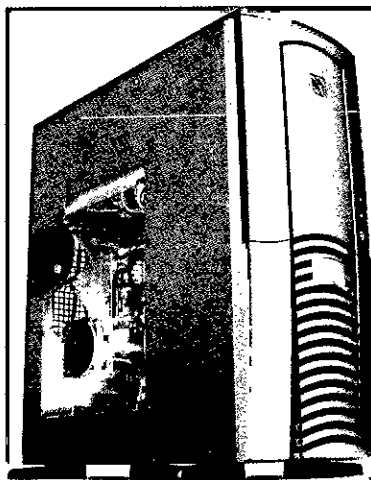
At the time of writing the specification, *Chaintrack* was a relatively new product, so the company was asked to carry out simulated tests of the system, to ensure it could promise a working life of 20 years plus. During these, added David Edelstein: "The track received no attention other than adjustment to the chain tensioner."

Further details: Triple E tel: +44 (0)1959 570333 fax: +44 (0)1959 570888 e-mail: info@3-eee.com website: www.3-eee.com J & C Joel tel: +44 (0)1422 833835 or visit www.jcjoel.co.uk Street CraneXpress, tel: 0114 243 1142, or visit www.scx.co.uk

Sundance Multiprocessor Technology Optimised PCs promise quick start for DSP projects

Original equipment manufacturers and embedded system designers can give their digital signal processing projects a jump-start using the innovative **Sundance SMTPC** range of optimised PCs. The company supplies high-performance processor and I/O modules for use in single and multi-processor DSP equipment. They can be found in demanding applications including imaging, sonar, simulation and industrial control. A range of PCs customised to bring the best out of this world-class technology was seen as essential. Powerful DSP systems demand robust power supplies, adequate cooling, and space for all the hardware. Off-the-shelf PCs, says the company, are rarely up to the job. DSP hardware with a PC built for the job avoids any risks and saves project leaders valuable time by providing configured, tested and ready to run systems, says managing director Flemming Christensen.

The **SMTPC** range of optimised PCs is available in desktop, tower and standard portable platforms and also includes a rugged portable version for heavy-duty use in harsh environments. All machines share the same



The SMTPC range of optimised PCs is available in desktop, tower and standard portable platforms

integration with Sundance's hardware and are delivered configured to the customer's order requirements.

Though customised for the best performance of DSP applications, the PCs are based on well-specified components throughout, including Intel processors, DDR2-400 RAM, ATA hard disks and DVD read/writers, and come complete with Microsoft Windows XP Professional.

Added features include more robust power supplies to ensure stable operation with power-hungry processing systems. Multi-fan through-flow cooling prevents overheating while a front panel two-channel LCD temperature display with two internal probes gives visual assurance that all is running well. To help users start their DSP projects immediately, all Sundance hardware and software is pre-installed to guarantee compatibility and allows the company to provide whole system support.

Further details: tel: +44 (0)1494 793167 e-mail pctech@sundance.com web: www.sundance.com

ETS**Developing a natural sound barrier**

In a world where the need to reduce noise nuisance pollution is becoming a necessity, and very soon a legal requirement of development, **ETS** can claim an ecological and environmental success story. By combining willow trees and modern technology, the company has developed the *Green Barrier*, a living sound barrier that can provide instant natural soundproofing in any area where noise is an issue and visual impact important. The system is made up of living willow elements that when planted sprout into life to provide a living hedge that needs no further planting. It is formed into specially built panels which, just a few weeks after planting, give the appearance of a long-established willow hedge.

Woven (dead) willow panels, which are made up of dead willow rods woven between galvanised steel rods held between hardwood posts, are also available. The systems can be used for industrial or domestic screening in a wide range of applications. The appearance of the green barrier changes with the seasons, and can be varied according to the species of willow used.

By using a double skin of the panels to enclose a noise reducing core, an efficient acoustic barrier is formed which provides excellent sound insulation, and has acoustically absorbent surfaces thus minimising sound reflection. The new barrier



Willow trees and modern technology provide a living sound barrier

has proved successful in both motorway and industrial locations across the UK and Europe, where it has resulted in the significant reduction of otherwise intrusive noise. According to the relevant CEN standards, the green barriers in living and woven willow both have the highest insulation (class B3) and absorption (class A4) values available on the market for barriers of this type.

The *RockDelta* soundproof core is 240mm wide, and the living and woven elements effectively double the finished width, making about 0.5m. The living barrier then sprouts and the final width depends on how often it is clipped.

ETS can supply the green barrier in heights from 1m to 5m (in extreme cases). The final height depends on location and the noise reduction performance required. The barrier in living willow requires good soil depth and is tolerant of most soil types. It requires reasonable levels of sunlight, but will not thrive in dark shady or north facing locations. As all materials used are fully recyclable

and blend in with both urban and rural surroundings, the product is arousing great interest amongst architects, planners and the construction industry. The recommended planting time is between January and June, although the *Green Barrier* in woven willow can be installed at almost any time of year. ETS offers a full design and installation service, but the customer's own labour can be used after training and with supervision. The living hedge comes with a programmed drip irrigation system to prevent problems during dry spells. The application of a small annual amount of slow release fertiliser is recommended to maintain plant vigour and health. Annual trimming keeps the hedge neat and tidy.

The *Green Barrier* in woven willow requires very little maintenance over and above that normally associated with the climbing plants selected as landscape enhancers. It has excellent wind resistance properties and is complementary to both hard and soft landscape designs. Harbours a rich variety of insects, small mammals and invertebrates which in turn attract birds, it can also help prevent soil erosion.

Further details: Dr Adrian Bowles
tel: 01289 386664 fax 01289 386750
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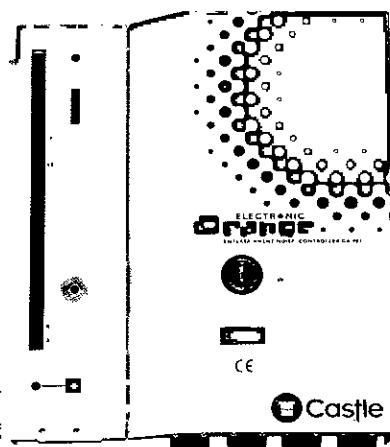
Castle Group

Silence is Orange

With the invention of the Electronic Orange in 1972, the **Castle Group** pioneered the control of amplified entertainment noise by the cut off principle. Time has proven it to be a most effective method and thousands of units are now in use throughout the world.

The GA904 is the latest version and has many enhanced features without losing the original's simplicity. It is a sound level switch designed for installation into a main power supply feeding amplification equipment. If the sound level is allowed to go above a pre-set value, the warning lights will flash in time with the peaks to warn the operator to reduce the volume. Allowing the warning level to be exceeded by a pre-set amount will result in the trip being activated, cutting off the power to the amplification equipment. After a pre-set 'off' time the power will be restored automatically or manually depending on the key switch setting.

Other features include a three-colour LED bar graph display showing Sound Pressure Level (SPL) which makes calibration easy. There is a choice of 'A' weighting or the 'B' weighting characteristic, which is more effective for bass control. In addition to the standard



measurement microphone input, there is a facility for an external trigger, for example, on a contact on a fire door/exit. The device is fitted with an anti-tamper circuit and the cause of cut off is clearly indicated by the 'Level', 'Microphone', and 'External' indicators.

Further details: Dianne Hamblin,
tel: 01723 584250 fax: 01723 583728
e-mail: sales@castlegroup.co.uk

Autograph Sales

Sound of Eden

A range of loudspeaker cabinets from EM Acoustics has been installed and supplied by **Autograph Sales** at the Eden Project in Cornwall. The system was initially supplied for *A Time of Gifts*, a season of events that celebrate Christmas and other global festivals, which share many common themes.

These take place in the warm temperate biome, and include the long awaited official Eden Project soundtrack *First Breath*. This uses the newly installed system and is accompanied by a live performance three times a week, alongside a projected film journey.

Owing to the size of the biome, Mike Mann, Autograph Sales' project consultant, together with Lucy Gaskell, Eden Project's consulting technical manager, selected 13 cabinets. EMS-81s, an EMS-121 and I-8 mini subs have been employed, the last for its impressive low frequency response, which complements Jim Carey's newly composed soundtrack. MC2 T-Series amplifiers provide power for the system. The speakers are all hidden in and around the foliage, blending harmoniously into the natural surroundings.

Monalisha Metals

Aluminum foam - a new material for sound absorption

The benefits of using aluminum foam as an effective sound absorption material were introduced after years of research and testing. The product's structure makes its characteristics - non-flammable, high sound absorption, light weight (0.3kgm⁻³), durability, damp resistance, electromagnetic insulation - aesthetically pleasing and environmentally friendly. Aluminum foam is now available in a honeycomb version as sound-resistant panels. Whilst having high strength, the large-scale units remain ultra-light. The product can be used in places where normal 'soundproof' walls cannot be considered as it is 100% metallic.

The structural composition comprises 9mm aluminum foam as a sound absorbing panel at the front, a 40mm honeycomb made up of various metals in the middle and a 1mm aluminum sheet at the back to finish off the panel. The honeycomb panel is available in different versions and thicknesses, depending on the sound absorption and noise reduction criteria to be achieved. The material has been subjected to a sound insulation test in accordance with the international standard ISO R 140/3-1995 and ASTM E 90-97.

Since **Monalisha Metals** took on the exclusive marketing rights to sell *Al-foam* and its various versions in Europe, reaction has been positive. The honeycomb version has received a great deal of interest especially within the infrastructural and industrial areas of the acoustics and noise control industry.

The material is being considered as an external wall cladding system for a power and gas refinery project in Nigeria by a leading UK engineering consultancy. The honeycomb version is also being considered for a major tunnel project and as an acoustic bulkhead within the shipping industry. Acoustic enclosure manufacturers are also very keen on this robust but lightweight material.

Further details: Kunal Advani
tel: 0208 863 5258 mobile: 07930 666 017
e-mail: kunaladvani@hotmail.com

OBITUARY

Dr Robert Christopher Chivers (1948-2004)

JP MA PhD DSc Eurlng CEng CMath EurPhys CPhys SRCS FIMA FInstP
FIPEM FIWSc FRSA, Barrister

Dr Robert Christopher Chivers, a former Fellow of the Institute, died at home on 25 November 2004.

After school in Wimbledon, London, Bob read Natural Sciences at Exeter College, Oxford, from 1966 to 1969. He then went on to do research at the Institute of Cancer Research, University of London, on the scattering of ultrasound by human tissues. After a year as a technical officer running the Ultrasonic Holography Unit at the Institute of Ophthalmology and Moorfields Eye Hospital he was appointed Lecturer in Physics at the University of Surrey in 1973. In the same year he was awarded a PhD of the University of London. Promotion to Senior Lecturer followed in 1987 and to a Readership in 1993. He retired on ill-health grounds in August 1996.

Bob taught acoustics at all levels in the Physics Department and to Tonmeister students and medical physics to nursing degree students. At the postgraduate level he made important contributions to the Medical Physics MSc. He received a Commendation in the UK 1992 Partnership Awards for his innovative use of the Socratic method for science teaching. Bob's research interests centred on the propagation of ultrasonic waves in inhomogeneous materials with applications in medicine and industry, including imaging. For his contributions in this field he was awarded the DSc of the University of London in 1992 and the *R W B Stephens Medal* of the Institute of Acoustics in 1997. He was an active member of the Institute of Acoustics; he helped initiate its Physical Acoustics Group and also served as Chairman of its Education

Committee. Overseas recognitions include the *Westerplatte Medal* of the Polish Naval Academy, and two awards from Gdansk Technical University, the *Medal of Merit* (2001) and the *Jubilee Medal* (2004). He was also an elected Fellow of the American Institute of Acoustics. He supervised 13 PhD students and was awarded three patents.

A prolific contributor to scientific literature, Bob's CV lists over 270 items including articles on experimental and theoretical research in ultrasonics and in science education. He took on a large amount of editorial work and was instrumental in the development of Polish and Indian Physics Journals as well as sitting on the Editorial Boards of several major journals of acoustics and ultrasound.

His many contributions to the general life of the University of Surrey included membership of Council 1984-1987, Senate 1980-1987, and the Academic Assembly 1980-1987 (latterly as Chairman). After his retirement Bob continued to be as active as his health permitted. He was well-respected and held visiting appointments at Cambridge (Senior Scientist, Department of Applied Mathematics and Theoretical Physics) and Southampton Universities (Professor, Institute for Sound and Vibration Research). As well as being appointed a JP for South West Surrey in 2002, he was awarded Law qualifications by London Guildhall University in 1997 and by the Inns of Court Law School in 2000. Bob was called to the Bar at the Middle Temple in October 2000.

In April 2000 Bob married Dr Pritilata Nayak who nursed him full-time until his death.

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Publications
St Albans

2 June

Membership
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7 June

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14 June

CMOHAV
Examiners &
Committee

16 - 17 June

Diploma
Examinations

21 June

Research Co-
ordination
London

23 June

Distance Learning
Tutors & Education

28 June

Engineering
Division
St Albans

30 June

Executive
St Albans

7 July

Meetings
St Albans

14 July

Council
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9 August

Diploma
Moderators
Meeting
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15 September

Membership
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29 September

Medals & Awards
& Executive
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6 October

Diploma Tutors
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Conference 2005
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20 October

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18 November

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24 November

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ADVERTISERS INDEX

Acoustics Noise and Vibration	OBC
AcSoft	IFC
Association of Noise Consultants	23
W S Atkins	37
Brüel & Kjær	2
British Gypsum	44
Building Test Centre	21
Campbell Associates	IBC
Cirrus	11
Coyle Personnel	40
Data Physics Corporation	34
Flo-Dyne	18
Gracey & Associates	IBC
IAC	16
Martin Summers Associates	43
Oscar Engineering	7,27
Pennine Instrument Services	46
SoundPlan	13
Sound Reduction Systems	29
Wardle Storeys	IFC

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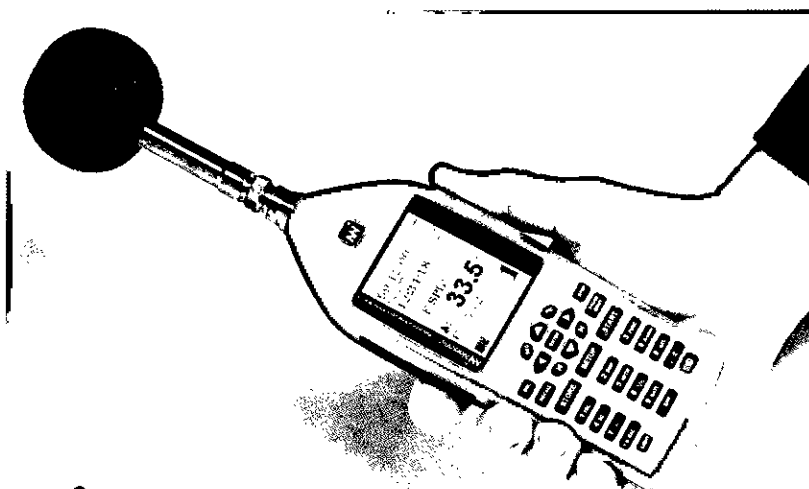
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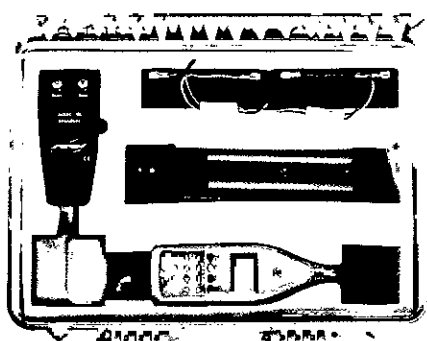


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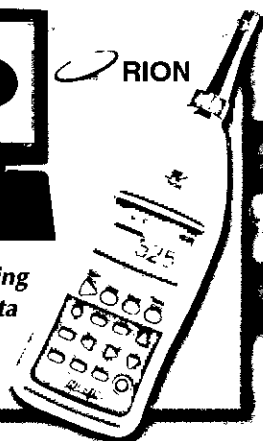


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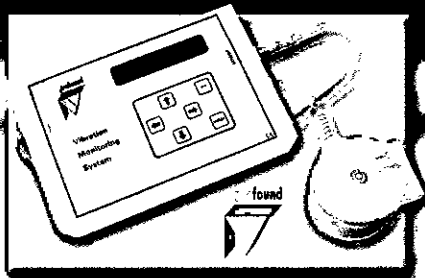


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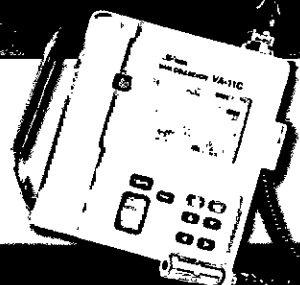
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