



25th Anniversary Issue

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Keynote Addresses

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Let's Talk Speech

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Volume 24 No 3
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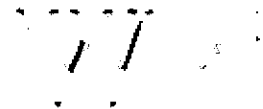
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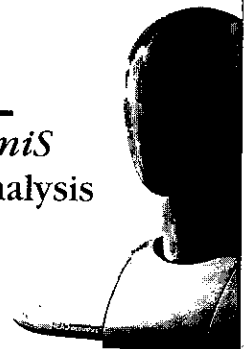
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May – June 1999

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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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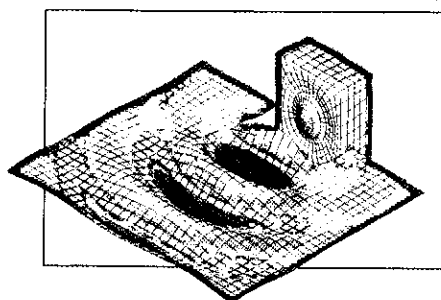
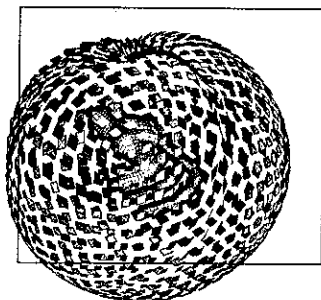
The fact, that approaching two hundred people were at the Barbican Centre in London for our Silver Jubilee Conference, was indeed encouraging and sets us on a firm basis for the future. This issue carries a full report of the meeting along with the revue papers delivered by the nominees of each of our Specialist Groups; making a valuable resource in ensuring a broad understanding of the world of acoustics. Full details of the papers presented in the eight technical sessions can be found in the most recent volume of our Proceedings. Organisation of the Conference was a major task for the Meetings Committee and our thanks go to Steve Turner and his team for developing the new concept for our main Spring Meeting and seeing it through to a successful conclusion.

The other event at the Barbican on the 13th May was the Institute's 25th Annual General Meeting and it was good to see a record attendance for that as well; I am sure it was the subject matter and not the champagne reception afterwards that was the reason for this! We were able to report on another successful year for the IoA; membership continues to strengthen, the number of delegate days at our meetings is at an encouraging level, recovering numbers of students sitting our examinations, new publishing ventures, relocation to our new offices, etc. All of this has been achieved within existing resources allowing the Treasurer, Keith Broughton, to report that a reasonable surplus was available to add to our reserves. New policies have been applied to the treatment of the stocks of Proceedings to avoid them appearing on the Balance Sheet and at the same time increasing the rate of depreciation charged on our computers to bring it into line with modern expectations of replacement rate. Plans for next year are already being developed and we have a sound basis on which to build. A full report of the meeting will appear in due course; at this stage I would just like to record my comments that it could not have been achieved without the efforts of the many members who have played an active part in the life of the Institute over the year. To all of them many thanks.

Most of our members are professionally involved in the field of acoustics and hence in employment matters, either as employer or employee, and to improve the service that we offer to them we are extending the situations vacant section of our web site. It will continue to complement the facility available in both the Bulletin and conventional mailings but will have a new look and be timelier. If your interest is career development keep an eye on it, and if your interest is attracting the best staff your contact remains Keith Rose.

With best wishes, I remain

Ian Campbell

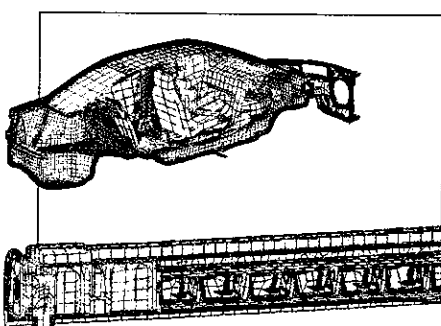
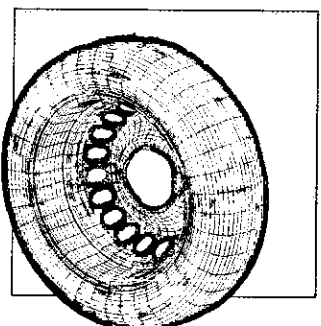


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THE INSTITUTE'S 25TH ANNIVERSARY CONFERENCE

The Barbican: 13 May 1999

The Institute's Silver Jubilee Year has been celebrated by this unique conference attended by almost two hundred delegates. The morning's activities began with a Presidential Address, reproduced below, in which Ian Campbell gave an interesting, sincere and often light-hearted summary of the development of the Institute from its beginnings as part of the Institute of Physics through its inception as a stand-alone Institute in 1974 and its progress over the ensuing 25 years.

This was followed by eight Keynote Addresses in which a leading expert from each of the Institute's specialist groups briefly reviewed progress in their field over the lifetime of the Institute and printed versions follow this account. Physical acoustics is covered by a joint Institute of Physics/Institute of Acoustics group and Professor Richard Challis of that group presented a similar review. In the afternoon there followed eight parallel technical sessions organised by the respective specialist groups in which current developments were explored in more detail by current researchers in the fields. I am indebted to those chairmen who provided notes to help with producing an accurate record of the proceedings.

John W Tyler FIOA

President's Address

When the history of the Institute is investigated it is apparent that we are in fact celebrating our second 25th, as it was the merger of the Acoustics Group of the Institute of Physics and the British Acoustical Society in 1974 which formed our Institute. The Acoustics Group of the IoP had its origins back in 1947; in the post-war austerity environment the founding fathers were laying the foundations for the first organisation in the UK dedicated to the furtherance of the science of acoustics. In the year when Ford's production of cars exceeded 30 million, the first aircraft were landing at Heathrow and man broke the sound barrier it was apparent that we were going to need to understand the effects of the developing post war world on our acoustic environment. In the swinging sixties we saw the formation of the British Acoustical Society who were dedicated to taking a more practical view of the subject to ensure that the principles were correctly applied. The key acoustic event of that time was without doubt the publication of the report of the Royal Commission on the Problem of Noise, a unique piece of work that laid the framework for most of the practical control and mitigation measures that were to follow over the ensuing decades. The two organisations co-existed through to their merger in 1974 to give us our current Institute; dedicated to the science of and practitioners in acoustics.

There were clear visions at the time of the merger of the role the Institute should play and over the years the members and officers have steadily worked to achieve those objectives. Professional grades of membership were

introduced in 1977 and the Institute's Post Graduate Diploma in Acoustics and Noise Control was established as the primary qualification for membership. We are still one of the only Acoustical Societies who has taken control of academic standards. From this basis we have expanded our education activities with the introduction of the Certificate of Competence programme that is designed for the technician and more practical minded. Certificates are already established covering Noise at Work, Environmental Noise Assessment and the Measurement of Sound Transmission in Buildings, with new programmes under development. The support of the many Universities and Colleges who have worked with us in the development of our courses is much appreciated.

Having established a 'standard' for the acoustical professional it is important that it is maintained. Much of the normal activity of the Institute is dedicated to that end; our meetings and publications are as much about keeping the membership informed of activity in the broad field of acoustics as they are a platform for the announcement of new work. In these fast changing times it is also important that the acoustics professional can adequately document that their knowledge is current and the task of meeting that need has been given to the new Professional Development Committee. The Bulletin, Proceedings and Web Site along with the Meetings and Conferences programme represent a major resource for our members to develop their contribution to the field of acoustics; they are only possible thanks to the efforts of the members who willingly give of their time to make them happen. They are too many to name here but all of us who benefit from their efforts are grateful for the contribution that they make.

In the early days we remained at the IoP offices but by 1979 we were ready to stand on our own two feet and moved to new offices in Edinburgh. At this time the management of the Institute came under the control of Cathy Mackenzie and her team; it is not possible in looking back over the history of the Institute to fail to appreciate the contribution she made to the development of the services we offer our members. Right up to her recent retirement just over a year ago her quiet but determined approach to the tasks in hand kept us moving in the right direction. We all wish her well in the retirement challenges she has undertaken and were pleased to welcome her to the ranks of our Honorary Fellows. We are now well installed in our new offices in St Albans and have an administrative resource that is well matched to the tasks that are going to be set over the coming years. It has been a major change programme for the staff but they have coped well and we are ready to move forward.

The future for the Institute looks bright with many new ideas, including a completely new format for the Autumn Conference; but that is for another day. For now I thank you for coming and wish you a useful and enjoyable day.

PROGRESS IN ACOUSTICAL MEASUREMENTS AND INSTRUMENTATION

Alan D Wallis MIOA

Preview – 1945 to 1974

From the end of World War II up to the late 1960s, there were two main players in the acoustic instrumentation market, Brüel and Kjær (B&K) and General Radio (GR). B&K, in Denmark, was almost entirely export based, while GR in the USA had a huge home market and had only minimal exports. In other countries, there were 'second tier' companies, for example Dawe Instruments in England, LEA in France and Rhode & Schwarz in Germany, but they had little effect on the world market. Throughout this period, many instruments were physically big and the needle and dial display was almost universal.

All this changed when the American Walsh-Healey act appeared in the late 1960s. This controlled noise in the workplace and consultants produced reports suggesting that large quantities of instruments would need to be sold; a figure of 100,000 units annually being commonly used. Many salesmen thought that they could have an instrument designed far better than those of the established companies and that their superior instrument

would take 20% of the total market, but unfortunately about 15 people had the same idea. Salesmen however do not always deal in reality, which in this case was that the total demand was overestimated by about ten to one and as well, the established companies were more than capable of meeting the new requirements.

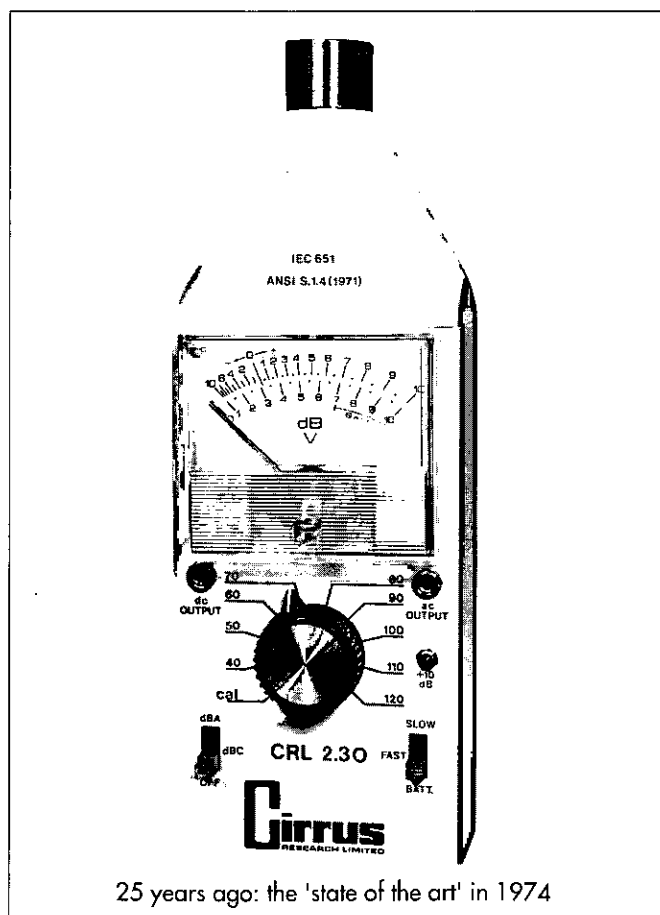
The result of this situation was a plethora of new companies, many of whom quickly failed, but a few continued on to 1974. Some of these small companies had very good ideas which were put into commercial instruments, among them linear scaled sound level meters (Hanley at Pulsar), digital sound level meters (Hardenburg at Digital Acoustics), the body worn dosimeter (Wurm at Quest), sound exposure meter (Wallis at Castle), equal energy dosimeter and noise average meter (Norgan at Computer Engineering, now called CEL), dedicated computing monitor (Astor at Cirrus) and many, many others. Not all of these were original ideas in themselves, but where they fit the picture is their use in acoustic instruments at the start of our 25 year review.

The two major companies made sensible, incremental advances in the technology with a reduction in instrument size and increase in performance, exactly what was needed for a maturing market. In hindsight, the sound level meter field in 1974 was a little like the 'Wild West', with many small companies trying to shoot it out with the big two established names.

1974 – A Snapshot

To cover the whole history of 25 years year by year is not practical, but we have the possibility of looking at a series of snapshots by looking at exhibits shown at the International Congress on Acoustics (ICA). This takes place every three years and in 1974 was in London. What was being shown as 'new technology' there? Whilst clearly not every producer will be at every ICA, the commercial imperative ensures that successful companies will probably attend such an event – even if they do not wish to – they cannot afford to be absent.

The first point of note is that there were probably more brands of instrumentation represented than ever before, at least twelve, six of which still exist today and all the instruments came from the USA and western Europe. New products featured were sound level meters with built-in filters, linear scaled sound level meters, low cost level recorders and large dedicated laboratory instruments, including a real time frequency analyser. As well, due to the influence of the Open University in the UK, a range of simple instruments was shown by Castle, designed by the author, at exactly half the price of their



nearest competitor – a price not chosen at random. One small new milestone was reached when Wurm from Quest presented a technical paper on OSHA dosimeter requirements, one of the first at ICA not to come from the 'big two'. Naturally, as at most major conferences there were papers from B&K, who were the standard bearer for the acoustic measuring industry as well as the clear market leader, with over half the total market. Their power and influence on acoustical measurement technology should not be underestimated and in 1974 they were the target to shoot at for any aspiring acoustic instrument designer. Indeed, while many acoustical societies have honoured Per Brüel and his staff over the years, a further tribute paid here is inadequate to express the gratitude owed to them by the field of acoustics.

For data analysis in 1974, we could plot either the time history of the pressure weighted signal or the frequency response, both on paper charts and storage was achieved by photocopying these charts. Almost every serious acoustic laboratory had such a high speed level recorder and it gave data many people thought would never be bettered.

1974 to 1983

There were few really major milestones in this period, except one, the introduction by GR of the electret condenser microphone instead of the 200 volt air condenser unit we had all used before. Today, this is standard technology used on almost all sound level meters and it is strange to look back and remember the outcry that greeted its introduction at ICA 1977 in Madrid and the claims made at the time that the electret would never be good enough. In this period, we also had consolidation, where the new ideas generated in the 'wild west' days became standard techniques for measurement. Instruments became smaller, digital displays were no longer unusual and dosimeters became just another method of measurement, with the Quest M-8 and the CEL 179 leading the way.

During these nine years, many of the smaller start-up companies of the late 1960s and early 1970s collapsed or were taken over, a process which has continued right up to the present day. Another major change during this time was the realisation by major safety distributors that the sound level meter was now a sellable item and as a result many of these companies commissioned their own brand of instrument. From being a curiosity, it was now a commodity.

1983 – ICA Paris

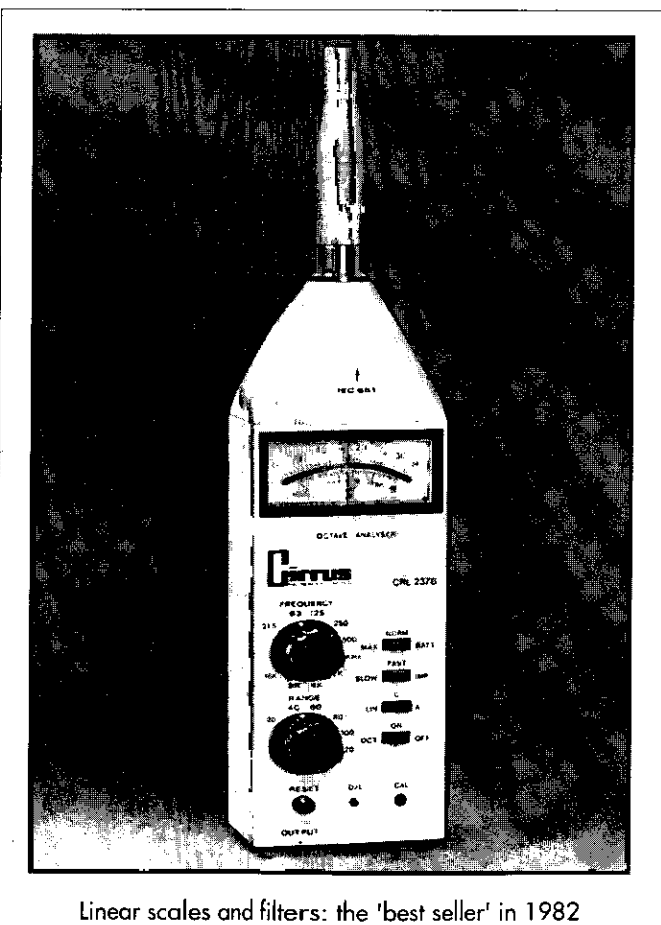
At ICA that year several major milestones were reached, although at the time very few realised it and the great revolution in acoustical measurements had occurred. The first and most important was that computers entered acoustics as a significant device. The second was that a few smaller companies became respectable when their engineers were asked to sit on standards bodies and present technical papers. This was in fact a value judgement by the profession that these smaller companies

were becoming a serious force, a sensible judgement, albeit a little late for some.

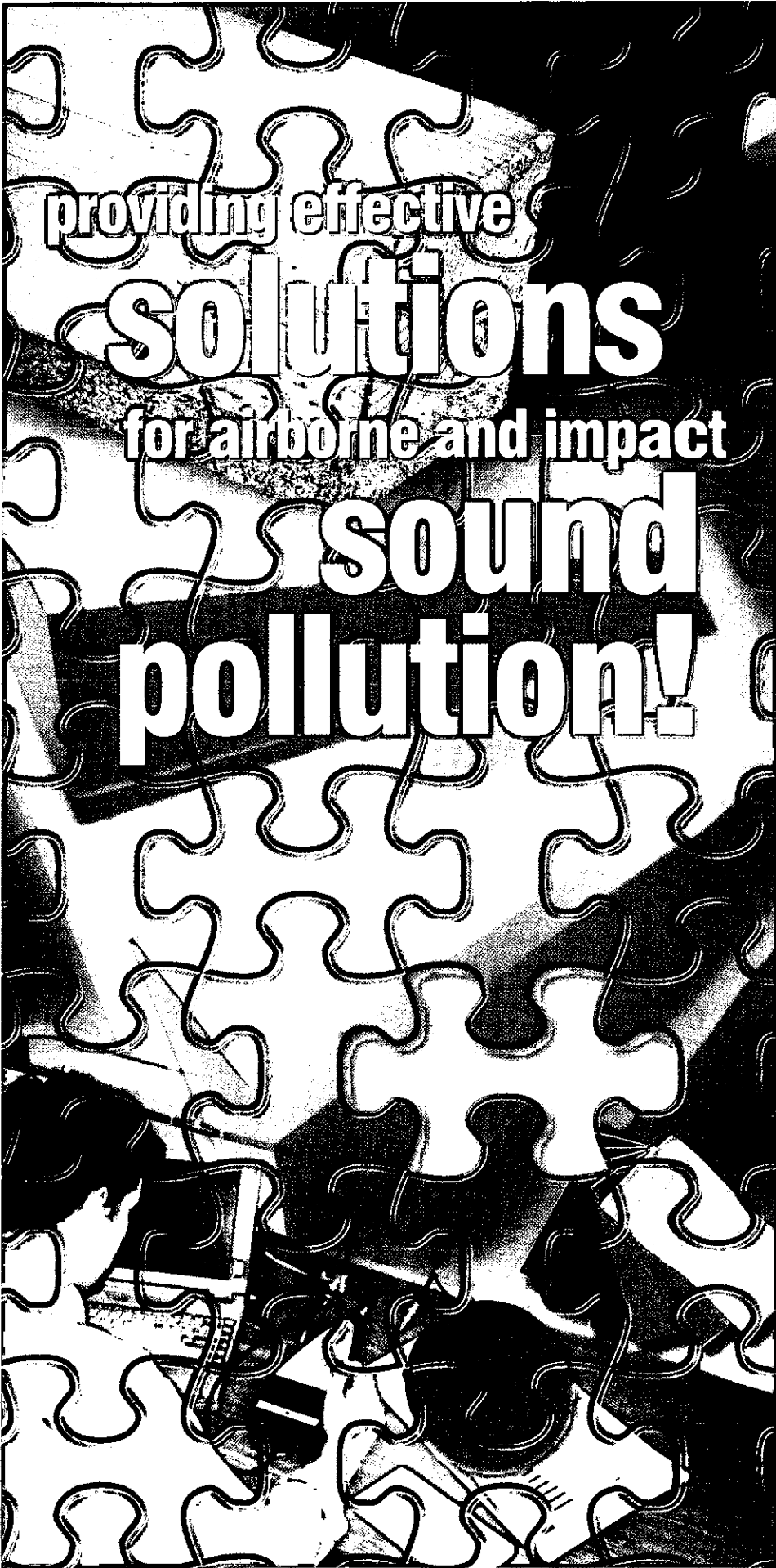
One revolutionary new idea was shown commercially and that was Short L_{eq} . The concept had been presented in a 1981 paper by Luquet and Komorn, but now a new French company Soeur Anne, showed a physical realisation of it. At the time, it was a revolution as raw data could now be field acquired and the actual measurements done afterwards, as the whole time history was stored digitally. In more conventional progress, survivor companies of the 70s generation, such as CEL showed their totally new and revolutionary instrument, the CEL-393 with an embedded micro-processor, while Cirrus showed their first SEL meter, the CRL 222, which was advertised as a computer front end.

With these new techniques, we could see the time history of the linear integrated signal, store this data and post-process the stored data. The storage by photocopied chart was doomed.

What was evident at each ICA from 1974 on, was that there were many companies, with claims that their instrument was the best, but the user did not have any method of evaluating these claims. Now computers were getting involved, this became even harder for the user to do. In fact for many years some users and many manufacturers had pleaded with national test houses to start a program of type testing and certification, so that users could be reasonably sure that they had bought an accurate measuring instrument. Despite the fact that several countries had National Laboratories who were tech-



Linear scales and filters: the 'best seller' in 1982

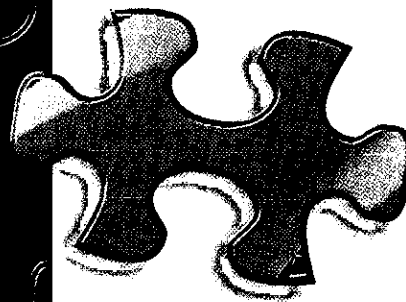


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nically able to carry out such testing, many of them would not even consider such type approval certification. As a result a few companies made specification claims verging on the ludicrous and some instruments were sold with barely lip service paid to meeting their claimed standards. It is sad to say but I think history will show that this will forever remain one of the very few blots on the otherwise unblemished reputation of these National Laboratories. Thankfully today the climate has changed and such a service is now effectively available. Now the task remains of making such type approval certification an essential document before instruments can be sold.

1992 – ICA Beijing

A conference in China would not seem to be the obvious place for introducing new technology, so we can use this occasion to see how the mainstream was progressing. Commercial companies who were willing and able to pay the huge costs of going to Beijing were clearly seriously involved in the field. GR were now out of the acoustic field, but at least B&K, CEL, Cirrus, Larson Davis, Quest and Rion were there; five newcomers and the old master. The 'second tier' preWalsh-Healy companies had all gone, the 'new' companies in Beijing all being formed after this watershed.

In 1992 MS-DOS computers were very evident with programs to run dosimeters and sound level meters, to re-calculate different metrics and to act as data stores. In fact computers and computer chips were now commonplace both as embedded devices and as external machines. Real time analysis could be performed with each narrow band stored to give waterfall data, or three dimensional information, something we could not have imagined at the start of our period. In fact, every technology we now take for granted was there, at least in embryo.

1992 Until Today

From 1992 to today almost every new design, even the ones from some fringe companies, has an embedded computer chip inside as this is cheaper than mechanical switches. Once a computer chip was involved, data could be stored. Once data was stored a program could format and present the data, thus overnight every remaining significant company became computer experts; but the remaining companies seemed to become fewer every year.

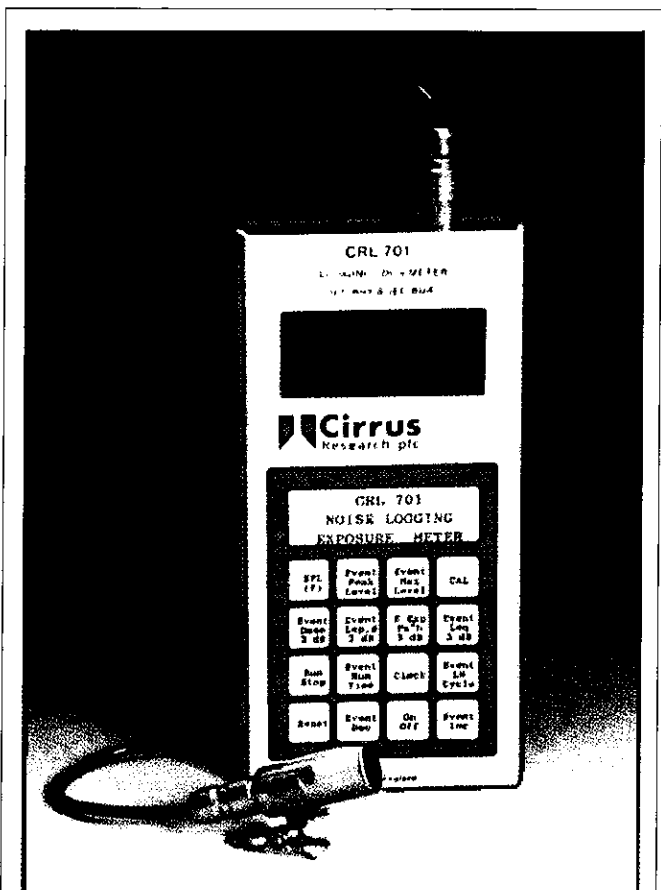
By 1992 as well as B&K, the sole true survivor from the 1960s, CEL, Cirrus Research, Larson Davis, Norsonics, Ono Sokki, Quest and Rion had all been involved with IEC working groups, something in 1974 they could not have dreamed of. All these companies contributed to the production of instrument standards such as IEC 61252 for Personal Sound Exposure Meters, and IEC 61672 for all types of sound level meters, by bringing practical reality to some of the more esoteric discussions.

As well, users could reasonably expect that all these companies were technically able to meet the standards

they were helping to produce, even if some others were not; a sort of de-facto approval.

Behind these few serious companies, there remained others, a few of whom could reasonably be called cowboys. For example, from these smaller companies came instruments where peak and F response read the same on a sine wave, where the rectifier was mean and not rms, where a microphone with a response of 8 kHz was claimed to be suitable for a Type 1 (precision) instrument. There were even instruments with the acoustic shape of a brick – the list is almost endless. Was this a problem that earlier type approval could have stopped? Also in this period there was at least one new professional start-up company. 01dB SA were formed in France to commercialise data logging, using a PC with a plug-in card as the instrument and by today have become a major force in the field and this concept becomes a further significant milestone in our story. As well, the new technologies were used to allow versatile dedicated noise monitoring systems to be designed. Accurate real-time full spectrum frequency analysis entered small hand held instruments, releasing these from the laboratory.

Among other innovative techniques were systems using telephone lines to take data from several noise monitors to a host computer for display, processing and storage. Now where was the sound level meter, when the microphone could be in New Zealand and the display in England? The new standard IEC 61672 will address this point.



1994: Computer control and data storage

Today and Forwards

The range of models from each of the main companies is reducing and this will continue as one instrument is now designed to do what ten did a few years ago. Almost every new instrument is now computerised, in that its functions are controlled by an embedded computer chip, meaning less electronic and more software development content. Parallel processing in both frequency and time domains is common and as they have so many functions, it is no longer possible to have one control for one function and so menu driven operation is common. The fact that many users find this control method difficult to understand seems not to matter; it's modern so it must be good!! The days of analogue circuitry seem numbered as direct digital sampling of the output of the microphone, itself perhaps on a silicon chip, is used simply as an input to an embedded computer chip. Several such instruments exist today, but despite some sales claims, they still have a few performance disadvantages over the previous generation of mixed technology instruments. Not only are these instruments cheaper to manufacture, but the overall technical advantage will probably change in their favour in the near future. The next generation will probably have the overall performance of classical instruments coupled with headline specifications meant to dazzle us. Storage size is no longer limited and dedicated signal processing chips will soon have a speed/current ratio large enough to be fitted in even simple instruments. The range of measurements available and

the processing of the acquired data will probably be governed by the power of the computing system employed and no longer by the 'instrument' in use.

Very soon, it is expected that the new sound level meter standard, IEC 61672 will be introduced and this, together with 'all digital' technology will force more and more consolidations and make the number of different models even less, as prototype development and testing becomes more and more expensive requiring it to be spread over a larger number of instruments. It seems clear that being forced to meet the new standard, or indeed any standard, will become a barrier to entry for small start-up companies, as their level of technology will have to be much higher than it was in 1974, when our review started. As in the wild west, will the cowboys now vanish?

In a previous review paper given at the 1992 Euro-noise conference, I commented that 'The more complex the acoustic instrumentation becomes and the longer it takes to develop, the more likely it is that it will be replaced by a computer system of some sort. The only real question is where the computer takes over from the instrument.' Today the answer is clear: the computer will take over at the output from the microphone as there is nowhere further forward for it to go!

This contribution is presented on behalf of the Instrumentation and Measurement Group.

Alan D Wallis MIOA, formerly at Cirrus Research plc, is now at ISVR, Southampton University, UK.



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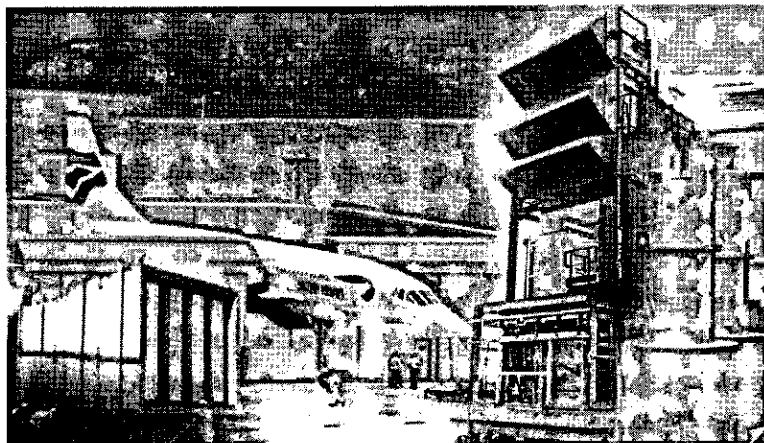
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LET'S TALK SPEECH

Roger K Moore FIOA

A UK Speech Group is Born

On the 17th of December 1976, representatives from all corners of the UK speech research community crammed the Haldane Theatre in Wolfson House at University College London. They were there to share, perhaps for the first time, presentations across the broad multi-disciplinary variety of speech activities that were under way in the different speech laboratories around the country. Topics included hearing, speech perception, speech production, experimental phonetics, prosody, speech analysis, speech coding, speech synthesis and automatic speech recognition.

Such was the excitement of that unique event, it was immediately agreed that the time was right for the creation of a UK-wide Speech Group, and that an opportunity to do so existed under the auspices of the newly established Institute of Acoustics. As a result, a committee was formed to get things rolling.

That very first committee comprised:

John Holmes (JSRU) – Chairman
Celia Scully (Leeds University) – Hon Secretary
Mike Underwood (ICL) – Hon Treasurer
Bill Ainsworth (Keele University)
Chris Darwin (Sussex University)
Adrian Fourcin (University College London)

From its inception, the Speech Group acknowledged the wide breadth of disciplines reflected in its subject area, and it was realised that affiliation to the Institute of Acoustics would only be of major interest to a proportion of the community. As a consequence, a scheme was introduced whereby membership of the Group could be achieved either by joining the Institute or by becoming an 'adherent'. Speech Group adherents enjoyed most of the benefits of regular members (such as mail-shots and the newsletter) but were unable to vote in Group decisions or join the committee. The adherent scheme (which is still in force today) has been a resounding success in retaining Group membership from a wide range of non-acoustic disciplines, and throughout the history of the Group roughly half of the membership has chosen to adopt adherent status.

The Group quickly established a pattern of holding regular free half-day or one-day open meetings – three or four times a year – which would be of interest across the breadth of the community. Three meetings were held in first year: *Techniques of Physical Analysis of Speech* at Loughborough University of Technology, *Synthesis and Perception of Prosodic Aspects of Speech* at Sussex University and *Machine Recognition of Speech* at the University of Aston. Meetings flourished, with regular audiences of anything between thirty and seventy people, and the Group got off to a flying start.

Chairpersons of the Speech Group have been:

1977-1980	John Holmes (JSRU)
1981-1983	Bill Ainsworth (Keele University)
1984-1990	Roger Moore (RSRE)
1990-1992	Peter Roach (Leeds University)
1992-1996	Steve Young (Cambridge University)
1996-1998	Michael Brooke (Bath University)
1998-....	Steve Cox (University of East Anglia)

Other members of the committee over the years have been: Peter Bailey, Ron Beresford, Laurie Moye, Pete Howell, Quentin Summerfield, Anne Cutler, Stuart Rosen, Briony Williams, Marcel (Mark) Tatham, David Howard, Martin Russell and Andy Breen. It is also interesting to note that Laurie Moye has been a continuous member of the Speech Group committee since 1981 and Hon Treasurer since 1983.

Membership of the Group peaked around the two hundred mark for many years (including both members and adherents). A Membership Survey conducted by the Group and published in 1988, contained a description of the responsibilities and interests of over seventy speech researchers and listed the areas of work and the facilities of thirty-two laboratories.

The Speech Group in its early days also spawned a pair of energetic specialist sub-groups. The SRU Synthesiser Research Group (SRUS-RG) was founded in 1989 by Marcel Tatham (University of Essex). The aim of SRUS-RG was to foster informal co-operation amongst researchers who were actively working with the speech synthesiser developed by the Joint Speech Research Unit. Six years earlier, the Speech Group had established its first specialist sub-group on Speech Technology Assessment.

Speech Technology Assessment Group

The upsurge in speech technology R&D in the early 1980s prompted the Speech Group to organise a workshop on *Speech Input-Output Assessment* in December 1983. Such was the interest in establishing common corpora and test methods that a second meeting on *Speech Technology Assessment* was called in July 1984. As a result, a new specialist sub-group of the Speech group was formed, initially called the Speech Input-Output Assessment Group (SPIOAG). Sensibly, SPIOAG almost immediately changed its name to the Speech Technology Assessment Group (STAG) – complete with logo.

STAG remained active for many years and, as a direct consequence of its activities, 1986 saw the start of an Alvey project on Speech Technology Assessment (STA) involving Logica, Smiths Industries, University College London, the NPL and RSRE. STAG was also instrumental in the establishment of the internationally influential ESPRIT proposal on *Multi-Lingual Speech Input-Output Assessment: Methodology and Standardisation* (SAM)

involving the UK, France, Denmark, Italy and the Netherlands.

The STAG steering committee in 1987 consisted of: Roger Moore (RSRE) – Chairman, Hilary Fuller (NPL) – Hon Secretary, Ellen Bard (CSTR Edinburgh), Ryan Beddoes (Plessey), Bob Damper (University of Southampton), Chris Darwin (University of Sussex), Frank Fallside (University of Cambridge), Adrian Fourcin (UCL), John Holmes (IOA Council and PA Technology), Dennis Johnston (BTRL), Laurie Moye (STL), Jeremy Peckham (Logica), Ed Stansfield (Racal), Mike Taylor (Smiths Industries) and Jeff Wilson (GEC Marconi).

In 1989, discussions within STAG were dominated by the committee's participation in the establishment of a UK national speech database project – *Spoken Corpus Recordings in British English* (SCRIBE) – funded by the DTI-IED programme. STAG was asked by the IED to approve the SCRIBE corpus on behalf of the UK speech community, and the STAG chairman was invited to attend all SCRIBE project meetings.

STAG continued to operate until the mid-1990s, by which time the international speech technology assessment scene was dominated by the US DARPA programme, the EU EAGLES (*Expert Advisory Group on Language Engineering Standards*) initiative and COCOSDA (*Co-ordinating Committee on Speech Databases and Assessment*) – all three of which had been influenced by the pioneering work of STAG. Notwithstanding these international initiatives, STAG was never formally wound up so, if the need arises again, it is ready to swing into action on behalf of the UK speech community.

Speech Group Newsletter

The Speech Group's popular bi-monthly newsletter – *Speakeasy* – was launched in 1987 after a survey of the community to select a suitable title and Editor. The name *Speakeasy* was chosen from a shortlist which included suggestions such as Talkback, Hearsay, Smalltalk, Whisper and Chit-Chat. Three volunteers for the role of Editor stepped forward, and Mark Huckvale from University College London was chosen by the Speech Group committee to kick things off.

From the beginning Mark set an exceptionally high standard with regular features including news items, letters, meeting reports, job advertisements, exam howlers ('Low frequencies have more harmonics than high frequencies.', 'Bandwidths are the resonant frequency of a spectrum.'), BACKCHAT comment and gossip, and the satirical cartoons *Graphic Equaliser* created by Sliney D Berne – an acronym of the names of two well known speech researchers – and *Speech Trek* by Bess O'Nacker (not forgetting a brief sequence of contributions by one 'Ben Pear').

Not without controversy – '... What kind of dream-world does the writer of the editorial live in to be capable of writing such preposterous rubbish? ...' (April 1991) – and a couple of close shaves with actual litigation, Mark maintained a regular flow of high quality, informative and entertaining issues until 1993. After a brief pause, it

reappeared in 1994 and 1995 under the care of Christine Cheepen and James Monaghan from the University of Hertfordshire. It then made a second comeback in 1997 under the Editorship of Martin Russell from the DERA Speech Research Unit (now at the University of Birmingham), and is still in production at present.

Throughout its lifetime, *Speakeasy* has been a popular vehicle for the rapid dissemination of Speech Group news-and-views. A particularly humorous regular feature was supplied by SPLAT Systems Inc the '*British speech technology commercial giant*' (sic). Apparently SPLAT Systems had its origins in pioneering research conducted in the mid-1980s at the UK's Really Small Research Establishment which resulted in the 'SPLAT high-cost, low-performance speech recognition system'. The original paper, published in *Speakeasy* in June 1988, was considered to be of such ground breaking importance that it was immediately translated into French and republished in *Tchatch' Com' Bulletin de liaison du Groupe Communication Parlée de la SFA*.

SPLAT Systems prided itself in making extensive use of its own products and, in particular, its showcase system, the SPLATWriter™ voiced hype writer. However, this policy caused great embarrassment when a document dictated by Adey Jamuser (the company founder) was leaked to *Speakeasy* in October 1988. Despite this setback, Jamuser received a knighthood in 1989 and was honoured with the title BNIOA (Big Noise in the Institute of Acoustics) in 1990. The company continued to produce a series of innovative products, including the AGHASt system (Automatic Generation of Homely Acronyms for Speech Technology). Unfortunately, SPLAT's subsequent reliance on its own technology brought it to the brink of financial disaster when a management instruction to 'amass the world's largest training set' was incorrectly transcribed as 'amass the world's largest train set'.

Also, meeting reviews in *Speakeasy* have always been especially informative and insightful, as this particularly memorable example from the December 1990 issue illustrates – Alex Monaghan reviews the ESCA workshop on Speech Synthesis held in Autrans earlier that year:

'... By far the most challenging event of the working day at Autrans was the obligatory two-hour lunch. This normally began with a light course of freshwater fish or charcuterie accompanied by a mixed salad, bread and a local white wine. Next came the main course: generous helpings of meat in a rich sauce, accompanied by steamed or sauteed vegetables, potatoes (Dauphinoise, boiled or croquettes), a good Bordeaux red and more fresh bread. The dessert was generally not too rich – fresh fruit in light pastry, or sorbet with aromatic liqueur – and was followed by a local sheep's or goat's cheese washed down by another bottle of vintage red wine. Not wanting to overdo things, I generally skipped the coffee. ... The afternoon sessions were followed by the main meal of the day, ... soup, salad and cold meats were followed by ... At the end of the second night's dinner, as we struggled to raise ourselves from the feast, it was

announced that the conference banquet was scheduled for the following evening. ... the banquet began with a tasty seafood soup accompanied by ...' etc etc (for 32 column inches!).

The European Connection

In 1986, prompted by informal contacts between key members of the UK and French speech communities, the Speech Group signed a co-operation agreement with the Group Communication Parlée (GCP) of the Société Française d'Acoustique (SFA). This paved the way for a joint meeting between the two groups hosted by CNET in Lannion (Brittany) in June 1987. Twenty-five attendees from each country enjoyed a productive and informative three days, outlining their respective research activities.

The main aims of the initiative were to promote possible collaborative work, to increase knowledge of each country's activities and to provide a basis for contacts between individual groups of workers. The first day of the meeting was devoted to mini-presentations from each participant, the second day covered longer presentations by representatives of the main centres in each country, and the third day gave an opportunity for free discussions on possible future collaborations.

In order to cement the relationship, a return match was organised the following year at the University of Sussex. Unlike the 1987 gathering, the second event was aimed specifically at the younger members of both communities, and involved a more tutorial element.

Following these early forays between the two speech communities, 1988 saw the beginning of more high-level discussions aimed at the establishment of a more permanent framework for European co-operation – specifically a *European Speech Communication Association* (ESCA). A working party, headed by Renne Carre from ICP Grenoble, was tasked by the IOA Speech Group and the GCP to investigate the possibility. Roger Moore, chair of the Speech Group at the time, joined the leaders of the other European speech communities at a series of planning meetings held in Brussels and hosted by the European Commission. Later that year, ESCA was launched with Joseph Mariani (LIMSI, Paris) as President and John Laver (University of Edinburgh) as the UK representative on the first ESCA Board.

ESCA has subsequently grown from strength to strength and has just celebrated its 10th anniversary. The biennial EUROSPEECH series of conferences attracts attendees from all around the world (the latest attracted over 1100 delegates), with one of the largest contingents coming from the UK. ESCA also organises regular international workshops, and a significant number of these have been hosted in UK, including the very first such

workshop – *NEUROSPEECH* – which was held in Edinburgh in 1989.

Windermere

Although the Speech Group had always participated in one of the Institute's annual conferences, it was not until 1986 that membership of the Group was large enough to warrant setting up the first IOA conference on *Speech and Hearing* (in collaboration with the British Society of Audiology). This biennial event – always held at the Windermere Hydro Hotel, always in November, always organised by Bill Ainsworth and always accompanied by torrential rain (or worse) – has established itself as a warm and friendly regular gathering of the UK speech community.

Whilst the programme over the years has come to be increasingly dominated by speech technology (as opposed to the phonetics and acoustics of speech), the conference has nevertheless provided a much needed coherence to a significant proportion of the UK speech community. The 1996 conference, in particular, contained a range of high quality and informative papers of international standing, and the whole event was made even more memorable by the arrival of several inches of snow during the final session on the Sunday morning. Some people did manage to get home – eventually.

A UK Strategy for Speech

Due to its central position in the affairs of UK speech research, the Speech Group has often been called upon to contribute to the debate on the future directions of speech R&D in the UK. In the mid-1980s, the Alvey Speech Technology programme was getting up to full steam, bringing with it a considerable number of new faces into the field. The Speech Group sat easily alongside the 'Alvey Speech Club' (which was chaired by John Holmes – past chairman of the Speech Group), and provided opportunities for Alvey speech projects to present their wares at the regular Speech Group meetings.

In 1988, Roger Moore (the Speech Group chairman at the time) presented to the community a discussion paper entitled *SALTUS 2000 – Speech and Language Technology: A UK Strategy*. The proposal attempted to identify a broader agenda than the contemporary government-funded programmes, and proposed common tasks, common databases, a national speech archive, and a competitive element for UK speech research. At the 7th FASE Symposium at Edinburgh, a specially convened evening meeting mandated an approach by the Speech Group chairman to the IED to arrange a general meeting of the community to address the issues. This meeting subsequently took place in December at

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Worcester College Oxford but, despite the community's strongly expressed wish for government investment in infrastructure (as proposed in SALTUS), the meeting foundered against procedural constraints much to everyone's disaffection.

1989 saw the formation of the DTI-sponsored *Speech and Language Technology* (SALT) Club, a much more active entity aimed at bringing the UK speech and natural language processing communities together under the DTI-IED funding banner. The SALT Club took it upon itself to organise a strategy meeting at Keele University in March that year, and considerable disquiet was caused by the lack of involvement of the Speech Group. Various documents and position papers were rapidly constructed and, after suitable political stances had been taken, the two groups got down to the co-operative business of creating a UK strategy.

The SALT Club (and committee) continued with EPSRC funding until the end of the DTI SALT programme, meanwhile in 1997, the IEE established a new Professional Group on *Speech and Language Processing* (PG A8). The proliferation of potentially competing groups in the speech arena prompted the establishment of the SALT2 committee as a brokering body with representatives from the main funding agencies, the IOA Speech Group, IEE PG A8 and the Computational Linguistics UK (CLUK) group.

What Happens Next?

The success of ESCA, the internationalisation of the field and the emergence of parallel groups have put considerable stress on the Speech Group in recent years. The proliferation of international meetings in the UK and continental Europe, have made it difficult to raise the enthusiasm for the organisation of UK-specific events. Also, what was once a tightly knit but broad community has evolved into a diverse range of speech-related disciplines each with their own national or international society.

Having been in the doldrums for a couple of years, the Speech Group organised a meeting in January 1998 to review *Current Research in Speech in the UK*. The gathering was held at British Telecom Laboratories in Martlesham, and was described by a correspondent in *Speakeasy* as a 'get-to-know-you session' deemed necessary by the lack of recent meetings.

The meeting enjoyed a large turnout, and enthusiasm was expressed for the Group to continue to function as the main centre of gravity for the UK speech community. Time will tell if this can be achieved, although there has been very little activity in the intervening period. Probably it is time for the Speech Group to re-establish its early links with all of the speech-related organisations and societies within the UK, to actively promote co-operative meetings, and to concentrate once more on providing a unique focus for all speech workers in the UK.

This contribution is presented on behalf of the Speech Group.

Dr Roger K Moore FIOA is at DERA Speech Research Unit, Malvern, Worcs.

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UNDERWATER ACOUSTICS DURING THE LIFE OF THE INSTITUTE

David Weston FIOA

Introduction

What is underwater acoustics – besides sonar pings and whale noises? In fact most aspects of above-water acoustics are also represented in underwater acoustics – the basic physics is the same and the wave equation is the same and there are plenty of environmental problems in both subjects. The engineering and the applications do appear just a little different, as seen through a water glass. Note that water is a much better medium for sound propagation than is air.

The subject of underwater acoustics is, naturally, much smaller than that of above-water acoustics – and in the Institute of Acoustics (IOA) it centres round the Underwater Acoustics Group (UAG). Thus it is not one of the larger groups, having about 150 members, but it is one that is both keen and lively. The relatively small size together with the water-glass effect means that as well as strong connections within the Institute there are very strong connections outside ie the UAG has a healthy international outlook.

Conferences

Probably the most important function of the Institute lies in the organisation of conferences and the publication of the proceedings of those conferences. This activity made a good start in 1974 with the holding of the 8th International Congress on Acoustics (ICA) at Imperial College London; the formal inauguration of the IOA in 1974 being triggered in part by the need to deal with the ICA workload. Underwater acoustics played a full part in the main ICA Meeting just as it has in many other centrally organised IOA conferences and in 1974 included an ICA Satellite Conference on Underwater Acoustics. Since 1974 the UAG has run a long series of successful international conferences, now extending to some 42 in number [1].

Rather than make up a list according to some logical approach, I have preferred the quasi-experimental method of looking at the subjects of the UAG conferences cited above. Unfortunately I am forced to leave out some areas. But four important subjects stand out as represented at many UAG conferences, see Table 1.

Conferences on fish showed their importance early in the lifespan of the Institute, largely because of the importance of acoustics in assessing fish population statistics. Note that meetings may cover any or all of the problems of a given application or equipment: for a fish sonar or echosounder, usually short range, we have projection, propagation, target scattering, reception, background, signal processing, display, inter-

pretation etc.

Transducer conferences are the most numerous – perhaps because any experiment must include at least one transducer. (It is a challenge to try to work without one!) A great variety of transducers exist – for example in frequency some need to go down to the order of 100 Hz or even less, bringing us into the fields of geophysics and seismology. Others go up to a few MHz, for laboratory work or medical ultrasonics. The complexity of transducer design is well illustrated in a book by Dennis Stansfield [2] which is unique in that it was backed by the Underwater Acoustics Group of the Institute of Acoustics.

Sonar signal processing has received increasing attention over the years after a relatively slow start. This reflects the increasing power of digital processing – everything now seems so easy and there is nothing we cannot do. (I include these comments to try and stir up dissent!)

I tend personally to regard propagation and environmental effects as THE central and most interesting problems; they lead us to an enormous spread of questions covering transmission loss, reverberation and ambient noise. However I am certainly biased and cannot deny the important part played by the other subjects of Table 1.

Some UAG Conference Subject Areas

Fish and Fisheries Acoustics, Bioacoustics
Transducers: Receivers and Projectors
Sonar Signal Processing
Propagation and Environmental Effects

Table 1

Awards

Underwater acoustics specialists are eligible for all the Awards from the IOA. In addition the younger ones are lucky to have a special line to the A B Wood Medal and Award in Underwater Acoustics, given in alternate years to someone from the UK and someone from North America.

The first recipient after the start of the IOA was Paul Crowther from the UK in 1977, reporting on acoustic boundary scattering. The latest is Grant Deane, originally from New Zealand but latterly working in the USA, for his 1998 Award when he talked about bubbles and the sound of breaking surf. In all this the international flavour comes through strongly.

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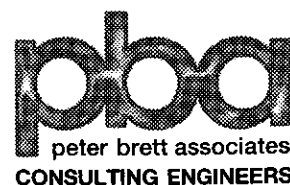
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Transducer Example

I believe that examples can help to bring a subject to life, though there is only time and space for two examples, covering different areas. Figure 1, taken from Oswin and Turner [3], shows a flextensional transducer which we will treat as a projector, though in principle it could also be used as a hydrophone.

Figure 1 shows that instead of a single piezo-electric disc we use the enhanced driving force from a stack of discs, and this trick to increase the power is one employed in many transducer designs. The stack is mounted along the major axis of an elliptical cylindrical shell. Acoustic alterations in the length of the major axis cause magnified changes in the length of the minor axis, leading to a large acoustic volume displacement. It is this large volume displacement that allows an efficient matching or coupling to the water medium, even if the transducer is of compact size and correspondingly low mass. Efficiencies of 60 per cent are quoted, impressively high. Note that the high efficiency goes here with a wide bandwidth, which is not always the case, and Q can be of the order of 3.

Example with Fish on a Long-Range Sonar

Many long-range sonar records showing fish and other features were made in the decade 1960-1970, using the experimental sonar looking into the shallow coastal waters off Perranporth. Reference [4] describes the unusual and extensive concentration of sprats seen in May 1967, together with part of the neighbouring record as shown in Figure 2. This work was first presented in 1974, soon after the start of the Institute. To some degree the subject matter concerns all four of the areas listed in Table 1.

Operating frequency was 2 kHz, with radiation from a powerful projector mounted on the sea bed. Reception was on a bottom-mounted 18 m long rigid array, beam-width 2 degrees. Performance was greatly improved by the trick of correlation processing, in which the returning signals are continuously compared with that projected. Thus transmitted pulses were FM with duration T of 4 seconds and bandwidth B of 100 Hz.

The effective energy is associated with the 4 second length, and the time resolution is not 4 seconds but is the reciprocal bandwidth of 10 ms, a nominal 8 m in range resolution. Processing gain against noise is equal to BT , a healthy figure of 400.

Figure 2 shows the returns in the 2 degree beam as a function of elapsed time and range. Each wandering line on the left-hand side corresponds to a shoal of pilchard, moving according to the currents and also to their own whim. The variable shading on the right-hand side corresponds both to variations in the diffuse fish concentration and to sound transmission interference effects. When night falls the shoals break up, and this break-up is usually quite abrupt. The unusual feature of this record, and some neighbouring ones, is that here they can be seen to do so by a diffusion process. Over a period of about 2 hours the tracks fan out, until at the point of disappearance they are about 1 km across.

The Future

Underwater acoustics started life as an art, some would say a black art, and this is true for such diverse aspects as transducing and propagation. But for many years now it has been a respectable and forward-looking science. It must be recognised that much of the original impetus for underwater acoustics came from Defence considerations, and with detente we would expect and do indeed see some falling off in sup-

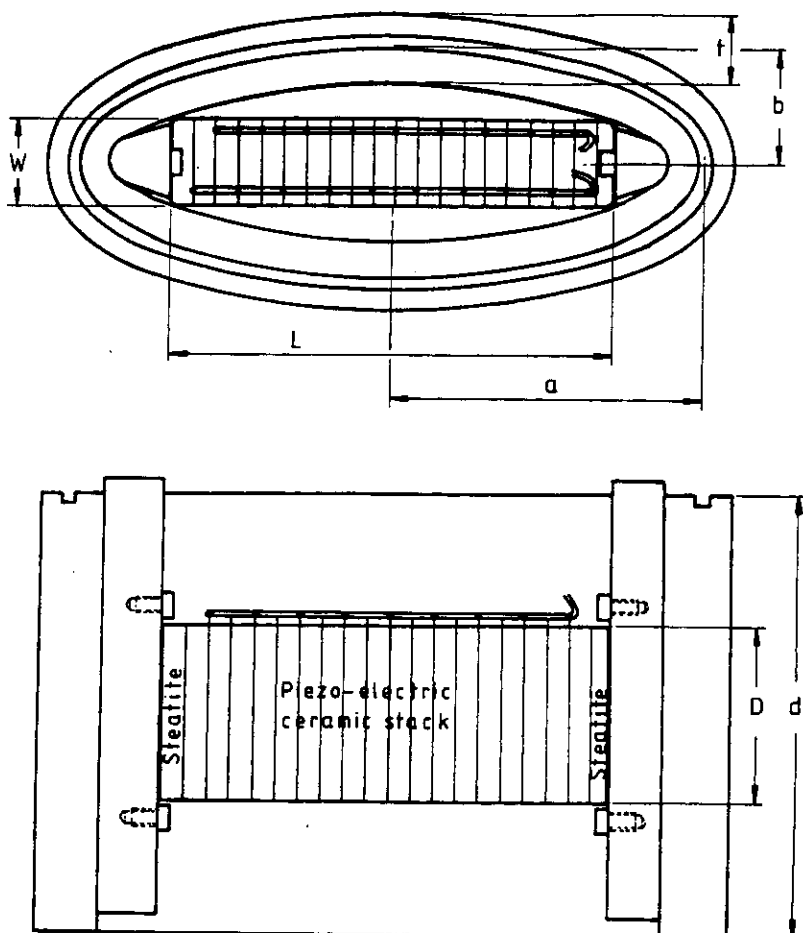


Fig. 1. Class IV Flextensional transducer - general lay-out and variables

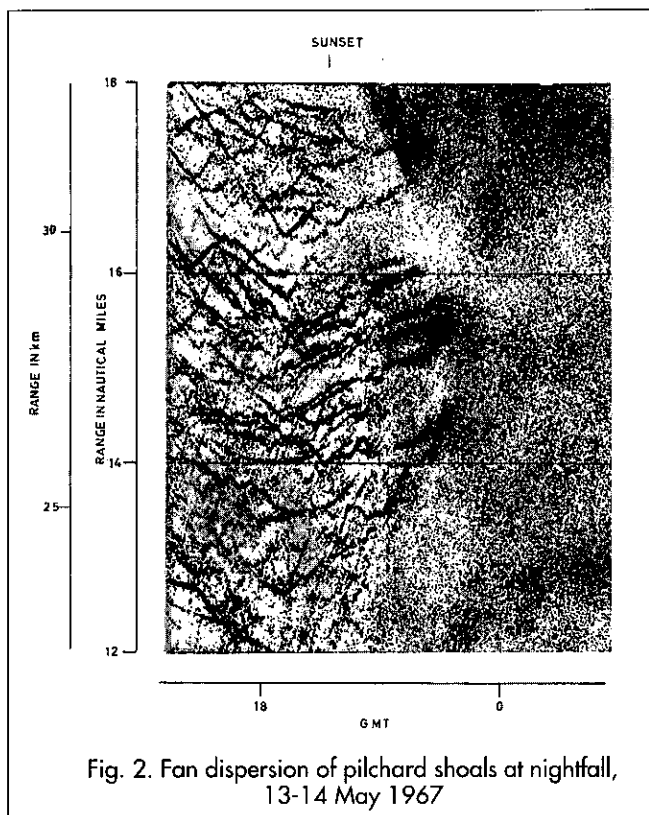


Fig. 2. Fan dispersion of pilchard shoals at nightfall, 13-14 May 1967

port from Defence. But there are also strong inputs from civil interests, allowing the subject to continue in good heart.

There is a connection here with the suggestion that

we should put comparable weight on underwater acoustics and on acoustical oceanography. The former is the efficient development of applications and equipments, making use of all possible acoustic information including that on the environment. The latter is the inverse process, ie the use of acoustics to learn both qualitatively and quantitatively about the environment for its own sake.

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Acknowledgements

I acknowledge with gratitude the use of the material from Oswin and Turner in [3]. I am also grateful to the Committee of the Underwater Acoustics Group, especially Peter Dobbins.

This paper is presented on behalf of the Underwater Acoustics Group.

David Weston FIOA is a former President of the Institute.

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BUILDING ACOUSTICS – ART OR SCIENCE?

Duncan Templeton FIOA

The answer to the question 'Building acoustics, is it art or science?' is of course that it is both. What is fascinating is the shifting balance, sometimes science providing the groundwork for the art application to practical situations, sometimes empirical art prompting scientific follow-up.

Firstly, let us consider some definitions. Science in the context of building acoustics means either pure science – the technical understanding of the behaviour of sound in rooms and in transmission between rooms – or applied science – measurement and prediction for what happens in the myriad combinations of materials defining the boundaries of a built form.

Art is arguably the design acumen in considering all the data and coming up with a finalised envelope, spaces subdivision, and detailed construction, that meets the building users' acoustic brief. It is also the balancing of acoustic needs with the other constraints in designing buildings – cost, buildability, appearance, and durability.

Next, let us consider the history of the 'shifting balance'. Originally, building acoustics was very much art, because the science was not in existence. Buildings were put up constrained by the basics of keeping out the weather, of defence, and of availability of local materials.

Scientific development starts with classic philosophic statements by ancient Greeks, later eighteenth-century mathematicians sorting out some of the calculus, physical scientists the behaviour of sound, and Rayleigh and Sabine founding the modern approach. Classical records start with Aristotle (384–322 BC) who referred to the nature of sound in *De Anima* and *De Audilibus*. Phenomena like echoes and speech were examined, although the understanding of propagation was limited: sound was thought to involve motions in air but the wave concept was not grasped.

Early attempts to impose mathematical order and sense involved linking the proportion of parts of the human body, to proportional relationships in buildings and the harmony of musical scales. All parts of a building, all elements of its language, were considered to conform to a single cosmic order. Vitruvius (c25BC) in *De Architectura* and *The Ten Books of Architecture* [1] offered detailed prescriptive solutions to acoustical aspects of classical theatre design, including building in resonant *echea* and the placing of surfaces to avoid echoes for speech.

Generally, however, spaces evolved to particular layouts to suit purpose over a long time frame. The acoustics of mediaeval cathedrals had a reverberant quality which engendered a special tradition of organ music, incantation, and recital. Large churches were built with a sympathetic tone, somewhere near A or A

flat, so that if the priest recited in this sympathetic tone, the sonorous Latin vowels would boom across to the entire congregation. Early Christian plainsong evolved through to the rich tradition of Purcell, Bach, and Handel. Speech as well as music needs in churches led to efficient ambros with commanding position and sounding boards over. Sir Christopher Wren wrote guidance on the limits of speech intelligibility of the average parish preacher, recognising the fall-off of the human voice to the sides and rear.

Opera houses and theatres evolved with efficient groupings of audience close to the performers, respecting visual and aural limits. Speech without amplification can only be acceptably appreciated within a distance that corresponds with that for discerning facial expression or nuances of dances, all seats preferably within twenty metres of the stage. For music, it suits to group people back from the orchestra but reasonably centrally, so all enjoy a blended, balanced concert in a full-volumed space, preferably within thirty metres. Building forms for auditoria were thus arrived at without conscious acoustic design. Problems resulted, however, when the size of venues increased. Acoustical difficulties were not confined to opera houses: the Theatre Royal designed by Henry Holland to replace Wren's old Drury Lane, was built to house 3,600, a great number for the time, and the vast scale of the edifice led to a population of bel-lowing actors.

Science needed to come to the rescue, as some attempts to correct gross acoustical defects involved misguided installations. A favourite one was stretched wires several miles in length at high level in large spaces, the presumption being that the wire would absorb sound as it was excited into vibration like violin strings.

The work of Wallace Clement Sabine (1868–1919) to find a law connecting reverberation time with room volume and the total amount of absorbing material was inspired, considering the contemporary lack of instrumentation to measure or record sound levels. Painstaking estimates of the duration of sound decays were made using the ear and a stopwatch, in the quiet of the night for an adequate noise floor, with absorption quantified by numbers of similar cushions progressively introduced. Over a two-year period, similar tests took place in dozens of various sized rooms. Forsyth [2] describes the unfolding drama:

'In 1898 Sabine was asked by the chairman of the building committee for the proposed new Boston Symphony Hall, Henry L Higginson, to act as acoustic consultant. President Eliot of Harvard University tried to persuade Sabine to accept, but he hesitated. The problem was that he could not find a mathematical expression for the curves on his reverberation charts that would enable

him to design the acoustics of a room of any size, using materials other than Sanders Theater cushions. However, the history of science is punctuated by moments of revelation – Archimedes' 'Eureka!' and Pythagoras' realisation of the theory of musical harmony on hearing a blacksmith's anvil are well-known apocryphal examples. A similar but documented moment occurred in the history of acoustics when, one autumn evening in 1898, Sabine, who was living with his mother on Garden Street in Cambridge, was poring over his notes. Suddenly he shouted from his study, 'Mother, it's a hyperbola!' He had realised that the absorption of the room multiplied by the reverberation time is a constant number.'

A bellwether for the scientific approach could be the acoustic design of broadcast studios. The first spaces used for studios were little more than ordinary rooms, for example the BBC's 1923 studio consisted of a room with walls damped with six layers of hessian felt. Response at upper frequencies was poor, so the next development was to have several studios, each to suit particular recordings.

By 1930, artificial reverberation and other effects could be added to recorded sounds. The importance of special forms of construction to isolate studios from outside noise was quickly realised and double-leaf partitions and sound lobbies came to be used. Particularly short reverberation times were required, so better methods of measuring them were developed. The early technique was for a pulsed sound from a loudspeaker to decay 60 decibels and the time measured. To avoid standing

waves, a warble tone came to be used. However, there was no check on how sound decayed at different frequencies. This was remedied in the 1950s by the introduction of the pulsed glide, where a photographic record was made of the decay of sound pressure with simultaneous traces at different frequencies. A further development used phase-coherent detection and correlation methods to diagnose coloration in small studios and to identify the various modes. Post-war developments included low frequency absorbers. The introduction of stereo requiring precise image position, multi-track recording technology, and the increase in bandwidth of recording and reproduction put further technical demands on the design of specialist rooms. Recent practice is compiled in Keith Rose's *Guide to Acoustic Practice* [3].

This progressive meeting of challenges suggests that science can, and must, solve all the key building acoustics questions. However, the holy grail remains as elusive as ever. Harold Marshall, writing the Foreword for Michael Barron's definitive *Auditorium Acoustics and Architectural Design* [4], opens as follows:

'There was a time about 40 years ago when physics reigned unchallenged in the world of science. Its derivative profession, engineering, seemed to offer recipes for everything from earthquake engineering to genetics, and everything that could be thought have would sooner or later be realised. People contemplated with equanimity the possibility of creating harbours by subterranean thermonuclear blasts, moon walks, universal health – concert

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halls in which by following step-by-step instructions 'perfect acoustics' would be produced for all. Alas for the brave new world. Things have turned out to be much more complicated than they seemed in an age so full of hope and as naïve as the lyrics of the popular music of the day suggested.'

A further perspective on the 40-year time frame is given us by the career-long experiences of two prominent Institute stalwarts, Alex Burd and Peter Lord. Past Acoustics Bulletin articles [5, 6] set out the contrasts of then and now.

By comparison, the 25 year point of reference prompted by the Anniversary celebration still shows amazing contrasts. In 1974, acoustics consultancy was advice an architect or his client might seek from some specialist individual, in exceptional circumstances. Design and construction standards generally were at a nadir. Building acoustics might be considered for the occasional concert hall and studio. Housing should comply with the Building Regulations provisions, but as testified by the BRE, many airborne and impact sound insulation values were poor in practice.

The 1999 situation is of burgeoning numbers of commercial consultancy firms who can offer advice in all aspects of the built environment, focusing on building acoustics but including environmental and planning matters, services noise and vibration, sound systems, and expert testimony. Advice may be offered worldwide from a number of the leading exponents. The early 1980s saw the rise of some of the key players. Let us look at what they are doing, and where the demand is.

It can be argued that consultants in such firms are the artists, practising their discipline on the basis of the plethora of data now available. Modern lightweight sound level meters are part computers and collect an awesome array of numbers; computers allow calculation spreadsheets routines to allow many 'what ifs?' to be studied before advice is proffered. Room acoustics modelling systems like ODEON and CATT have moved from university research devices to reliable tools validated by commissioning measurements at many built examples. Physical modelling, not to be outdone, still offers equivalent or better prediction: a large example is the 1:12 scale walk-in Royal Albert Hall acoustic model. The prediction, and measurement in completed halls, of impulse responses at various locations is the latest step on the road to aural virtual reality.

There are already some claims to 'auralisation' simulations that can impose on standard pieces of orchestral music played in a baseline anechoic setting, the characteristics resulting from room geometry models. This will be invaluable to demonstrate to clients and potential users, how a projected hall will 'sound', once the added complication of context is progressed: are headphones best, or a well equipped listening room?

In the realm of sound insulation, high performance lightweight partition systems have resulted from their use in multiplex cinema subdivisions. The extensive 'loft' apartment conversions are relying on such systems in their party walls. Box-in-box constructions for music

practice rooms and recording studios require great care in the selection of compatible isolated floors, walls, and ceilings.

Unlike concert halls and theatres, where solutions have evolved, new situations are demanding both science and art to come up with workable solutions. Acoustic advice is not just sought on spaces with the most obviously critical requirements, but also on shopping malls, educational buildings, interactive museums, airport termini, stadia, public buildings, industrial workspaces, and mixed leisure developments with activities like ten-pin bowling, night clubs, and cinemas. Indeed, consultancy can crop up on almost anything.

More and more materials are being developed and marketed with laboratory test data backing claims of acoustic application: the IOA Buyers' Guide is a welcome recent reference. Modern construction is lighter in weight and more likely to be prefabricated or pre-finished. Planning officers, building inspectors, funding assessors, environmental health officers, and health and safety authorities are empowered by recent legislation and guidance to demand surveys, appraisals, predictions, and, if necessary, remedial action. The external noise climate worsens, designers are trying to move away from sealed buildings back to natural ventilation allowing intrusive noise, and building users' expectations have risen.

All these considerations help explain the current scene of great acoustics design activity. Perusal of the Institute Register tells the tale of the greater number of consultancies (*aka* the artists/practitioners), than academics and researchers (*aka* the scientists). Acoustics consultancy has grown up as a building industry profession, like architect, structural or services engineer, and quantity surveyor. It has only been able to do this on the back of significant back-up on instrumentation, laboratories availability, computing, and electronics. It has only been able to do this on the back of a wider choice of well-developed acoustic products, components, systems, and manufacturers' investment in research. Let us conclude that building acoustics has art and science in a symbiotic synergy.

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This paper is presented on behalf of the Building Acoustics Group.

Duncan Templeton FIOA is with BDP Acoustics Ltd, Manchester.

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ELECTROACOUSTICS: THE CONFLUENCE ZONE

Ken Dibble FIOA

Introduction

Electroacoustics is on the fringe of the IOA mainstream activities yet it encompasses or touches on so many other specialised disciplines within the Institute including building acoustics, speech and hearing, environmental noise, musical acoustics and measurement and instrumentation. It also sits on the fringe of the activities of the Audio Engineering Society (AES) whose primary interests are hardware circuitry, component engineering and system architecture, and the Institute of Sound and Communications Engineers who are primarily concerned with systems installation. In fact, we collaborate closely with those two bodies in the organisation of the annual Reproduced Sound conference – now in its 15th year. In other words, the activity of the Group might be summarised as the interface between audio electronics, electroacoustic transducers, the influences of the acoustical environment in which the audio system or equipment is to be used, and the well being and perceptual behaviour of the human hearing system. This paper is intended to provide an overview of the principal subject areas in which the IOA Electroacoustics Group (EAG) is involved.

The Audio Chain

The input element to a live performance or public address system has traditionally been a microphone – and this remains by far the most critical source to deal with. But no matter what the quality of any particular microphone for any particular application, its performance is largely dependent on the acoustics of the specific location in which the microphone is placed, the direct and reflective paths which couple the source to the microphone capsule and to the skill of the musician or talker. So immediately we are concerned with transducer design – which itself is part electrical, part magnetics, part mechanical and part acoustical in roughly equal shares, with room acoustics, with speech, and with musical instrument acoustics.

Next in the chain comes the electronics – ie the pre-amplifier or mixing desk, the system and room equalisers, the crossover networks and the power amplifiers. Apart from a passing interest in major changes in circuit topology or filter concepts, and an obvious concern that equalisers and active crossovers in particular perform as specified, the EAG tend to regard this area as a tool box and generally leave it to our AES colleagues to stuff the boxes with the right bits and to make it work. The exception to that would be situations where the circuit layout and design approach has an influence on the final sound quality. This would include such aspects as frequency dependent phase shift, damping factor and load matching in power amplifiers, noise, crosstalk, inadequate

headroom to accommodate equalisation (EQ) requirements, inadequate bit rate in digital designs, etc. Of particular current interest is the degradation in audio quality due to unnecessarily convoluted signal paths, including excessive componentry, unnecessary switching or the inclusion of secondary functions – eg protection circuits in a power amplifier – in the primary signal path, and the objective and subjective perception of such effects.

Finally we come to the bit that returns the original signal, after due processing and tweaking, to the aural domain – ie the loudspeaker. Interestingly, this element will probably introduce far more errors and modifications to the final reproduction of the original sound than even the worst amplifier!

There is something very intriguing about loudspeakers which seems to attract the lions' share of paper contributions at both IOA Reproduced Sound conferences and at AES conventions. Everyone who owns a home hi-fi or a souped-up in-car audio system appears to consider themselves a loudspeaker expert, each with individual prejudices and whims. But rarely is that 'expertise' supported by knowledge of the complex engineering conflicts and juggling that goes on behind the baffle panel, or of the major part played by the listening environment on what is eventually heard.

The engineering of a loudspeaker transducer involves the same combination of disciplines as did the microphone, but with the addition of adhesives chemistry and thermal engineering, since most loudspeaker voice coils operate at temperatures as high as 200°C. As with the microphone, the performance of a particular loudspeaker device is hugely dependent on the way it is used, the type of acoustical loading applied to the cone or diaphragm, the highly complex phase related interaction with other drivers in the array, the resultant directional characteristics, and again, the acoustics of the space.

Loudspeaker Performance Characteristics

Consider a loudspeaker driver in a closed box in free space. As a 'rule of thumb' it will exhibit an omnidirectional, spherical radiation characteristic until the wavelength approximates to about 4 times the cone diameter, after which it becomes increasingly directional. When the wavelength is about twice the cone diameter the forward radiation will be about 180° (give or take a lobe or two) and when wavelength is about the same as the cone diameter the radiation will be about 90°. At high frequencies the radiation will narrow to a pencil beam – which is why we crossover into smaller diameter drivers as frequency increases.

But over the crossover region, two or more drivers will be operating together, and, depending on the relative

position of the listener, the signal from the two drivers will arrive together but displaced in time, thus creating a comb filter effect and also playing havoc with the dispersion characteristics over that part of the frequency spectrum. Imagine the phase problems associated with a large, 4-way crossed over, multi-element concert hall array such as used for rock music concerts and for large festivals!

If we were to place the driver in a front ported tuned reflex enclosure instead of a closed box, the low frequency response is usually extended downwards by about an octave. If we put the driver in an open back or rear ported cabinet the system becomes a high-pass filter since, over the range of frequencies where the closed box would have been near omnidirectional, the rear and front radiation cancel out. If we put this same open-back box against a reflective surface, then we find all sorts of summing and cancellation effects taking place, with some frequencies being enhanced and others diminished. Put the driver behind a horn flare and the acoustic properties of the horn control its dispersion characteristics. Some enclosure designs are in fact a hybrid, working as a direct radiating, tuned reflex enclosure at low frequencies and as a horn at mid frequencies. A dome mid- or high-frequency driver has its own set of characteristics.

Whatever the type of loudspeaker system deployed, or whatever its qualities, its ultimate performance will be largely dependent on the quality of the signal being fed into it and totally dependent on the influences of the

acoustics of the space in which it is used – eg the passenger compartment of a car, the domestic sitting room, the shopping mall, the office, the factory, the studio control room, the theatre or concert hall, the church, the sports stadium, etc. And in many instances, by using loudspeaker devices with tightly controlled directional characteristics, by using distributed instead of single point sources in conjunction with time alignment delays, by the judicious use of equalisation techniques, a loudspeaker system can substantially enhance sound quality in a hostile acoustic environment, when compared to the natural source, even in situations where little or no actual gain is necessary.

Speech Intelligibility

Since the Lord Justice Taylor report on the Hillsborough football stadium disaster, and the Kings Cross fire, this has been a major topic of concern amongst those responsible for public safety and has had a major influence upon the activities of many members of the EAG.

The most obvious means of communication in these situations is the public address system – but we are all too well aware of the 'British Rail Tannoy' where one cannot comprehend the time of the next train, let alone take in, take seriously, and act upon, an emergency evacuation message.

Based on the concepts originally set down by Houtgast and Steineken, in their seminal paper [1], Speech Intelligibility Index has become the yardstick by which the performance of voice alarm and emergency evacua-

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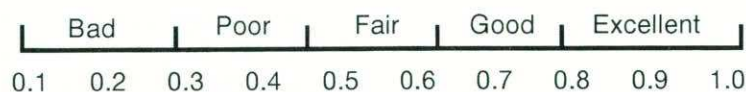
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STI / RASTI Intelligibility Scale

Fig. 1. Showing the relationship between RASTI values and the subjective assessment of speech intelligibility

tion systems has been based. In fact, BS 7443 *Sound Systems for Emergency Purposes* requires that an STI or RASTI (rapid speech intelligibility index) of 0.5 is achieved. Figure 1 shows that this has a subjective rating of 'fair' on the STI scale. STI is affected by a large number of factors including background noise and RT60 of the listening environment, the directionality and frequency response characteristics of the loudspeaker source, the number of loudspeakers sources in use, the relative volume level of the loudspeaker in relation to the combined background and reverberant field noise, the distance between the loudspeaker and the listener, and not least by the diction of the person making the announcement. In the USA, a different scale, in %Alcons is used to similar purpose.

Another way of determining intelligibility is to carry out phonetically balanced word score tests in order to establish, for a given situation, the proportion of spoken words that are properly understood by a jury of representative listeners. Since Hillsborough, certain members of the EAG – notably Peter Barnett (in association with London Underground) and Peter Mapp – have taken the work of Houtgast and Steeneken to new levels of understanding and knowledge, and engineers such as Ken Jacobs at Bose Corporation and Wolfgang Annert, the mind behind the EASE software, have developed highly sophisticated CAD algorithms by which STI can be predicted for a given acoustic space and loudspeaker systems with a fair degree of confidence. Peter Barnett will be speaking on his work and recent developments in this very important area at the EAG afternoon session. Recognising the critical role that audio engineering has to play in the public safety arena, there is to be a one day meeting on speech intelligibility, in Manchester, on Thursday October 21, the day before and at the same venue as the BAG auditorium acoustics weekend conference, which is being organised jointly by the Electroacoustics and Speech and Hearing groups.

Studio Acoustics and Monitoring

This is another area where the inter-relationship between loudspeaker design and performance and room acoustics is critical, where the technology is rapidly changing to meet present day requirements, and where various members of the EAG are actively involved – in particular, Bob Walker (BBC), Andy Munro (Munro Associates) and Dr James Angus (University of York, Department of Electrical Engineering). One way in which a diffuse sound field can be created in a smaller room is by the deployment of Quadratic Residue Diffusers as pioneered by Schroeder [2] and originally commercially marketed by RPG Inc.

However, these devices originally only addressed horizontal diffusion, are physically very large, being up to 1m deep depending upon the lower cut-off frequency, and are very expensive. It wasn't long however before Dr Angus and his colleagues at the University of York re-examined the principles based on spark-source testing in a 1:12 model room and came up with a modified theorem, resulting in a 4-fold

reduction in depth for virtually the same diffusive properties. Shortly after, bidirectional diffusers providing control in the vertical plane as well, were developed. Consequent upon this work, Quadratic Residue Diffusers are now in widespread use due to the relative ease of calculation, the reduction in physical size, and the consequent removal of the mystique and hence cost.

Another factor which is having its effect on studio control room and film dubbing theatre acoustics is the imminent arrival of digital terrestrial broadcasting, bringing with it Dolby Prologic 5.1 surround sound and other 'home cinema' formats. Clearly, the acoustical requirements for a control room or dubbing theatre handling only stereo music and speech programming will be very different from that necessary for 5-channel plus sub-bass surround sound.

Ambisonics and Spatial Perception

The advent of multi-channel digital audio in the home cinema environment and its imminent availability through digital terrestrial broadcasting has brought

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Typical Dance Music Energy Spectrum vs A-weighted SPL

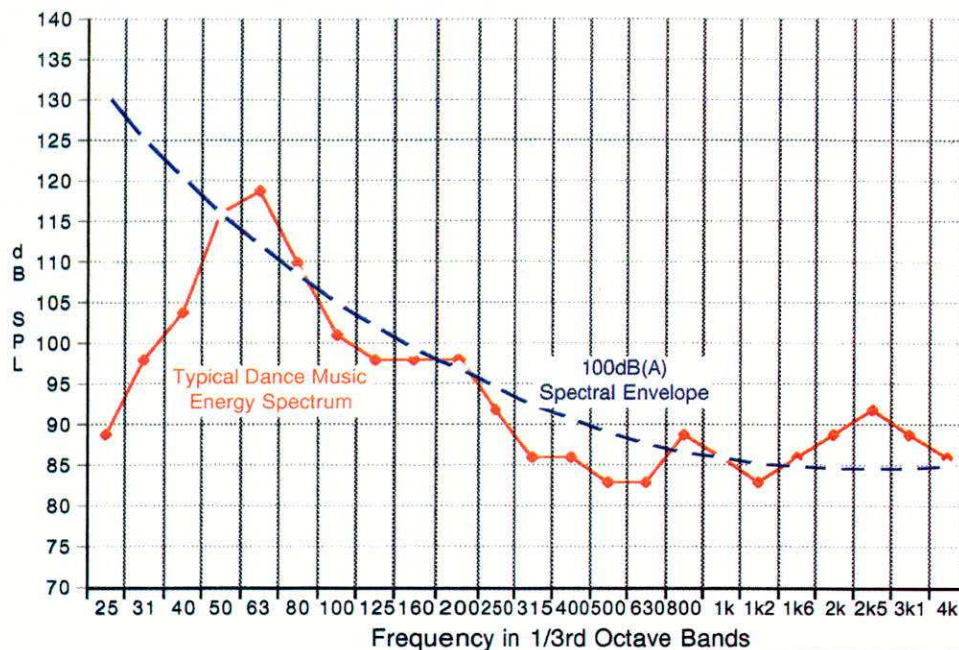


Fig. 2. Illustrating how the 63 Hz band level falls well below the A-weighted spectral envelope.

about renewed interest in this area which has far surpassed the somewhat basic and gimmicky, fortunately short-lived, 'quadraphonic sound' fad of the early 1970s.

A number of universities – particularly Salford and York, are involved in studies of the 3D spatial perception characteristics of the human ear/cranium/brain system in the resolution of spatial information and in the creation of virtual reality audio environments.

Music Noise: Environmental Control

This is another area of overlap in which the EAG are closely involved with the activities of another Group – this time Environmental Noise (ENG) – and again, there is a joint evening meeting on the management of entertainment noise being arranged for November 18 at Stratford-upon-Avon as an optional extension to the Autumn Conference and an optional prelude to Reproduced Sound 15.

Statistics show that music noise is much the largest single cause of noise complaints received by local authority Envi-

ronmental Services Departments throughout the UK. Since, in law, 'the polluter pays' appears to be the accepted rule, it follows that those responsible for the design or who operate the audio systems which create the problem, also have a duty to address the environmental ramifications of their handiwork.

The basic problem is the apparently insatiable appetite for ever higher levels of bass, which is largely stimulated by disc jockeys and artistes rather than by the general public.

This applies equally to live concert performances, discotheques and nightclubs, music bars, increasing numbers of restaurants, retail premises, fairgrounds and to domestic hi-fi. The basic problem arises from the fact that the use of a conventional A-

weighted sound pressure level meter at the complainant's residence usually shows no increase over background when the music is playing, yet the dull thudding of the bass beat is clearly audible. Figure 2 illustrates the cause of the problem. The 20 dB or so bass emphasis – usually

Ministry of Sound 3 - Dance Music @ 128bpm RTA vs Leq

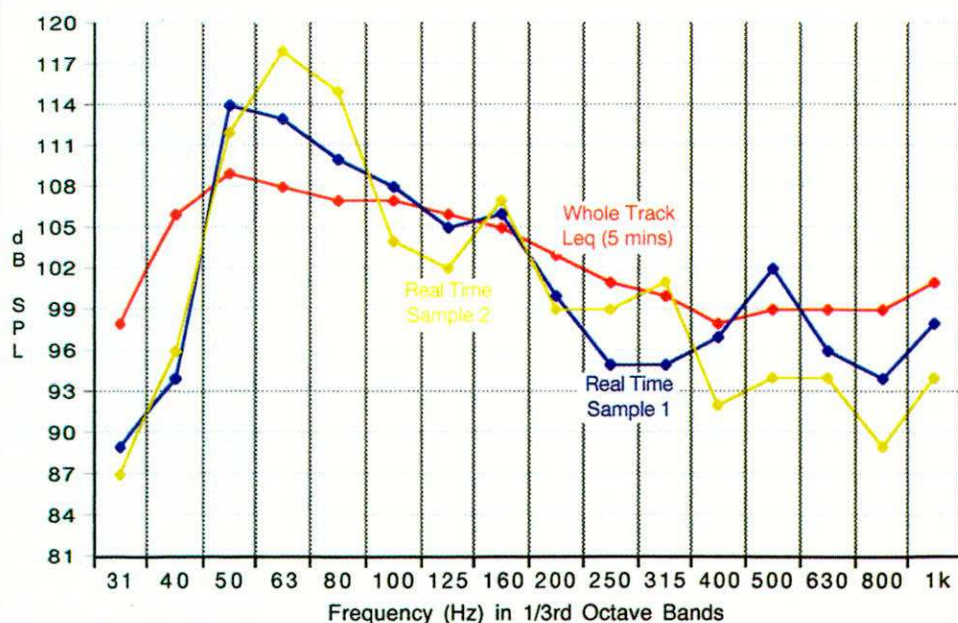


Fig. 3. Showing a typical relationship between L_{eq} and instantaneous L_{max} values

centered on the 63 Hz $1/3$ octave – falls well under the A-weighted spectral envelope (for the 63 Hz band the correction is -26.2 dB) and so is disregarded by the meter.

This situation is exacerbated if L_{Aeq} measurement is attempted since the human perception of the problem is L_{max} orientated and is independent of time. Figure 3 shows that an L_{eq} can be 10 dB lower than the instantaneous L_{max} values and that this type of measurement therefore still further underestimates the scale of the perceived nuisance. EAG members have pioneered the understanding of these problems and are currently engaged, with the Environmental Noise Group, in attempting to find practicable solutions to these difficulties that might form the basis of future measurement and objective assessment practices.

Music Noise: Acoustic Separation

In a very similar context to EAG's cross-fertilisation with the disciplines of the ENG described above, here we again cross paths with the Building Acoustics Group. With the burgeoning of multi-use leisure complexes at every other motorway intersection, many of which include a multi-screen cinema complex cheek-by-jowl with music bars, nightclubs, live music venues, etc, that same music energy spectrum causes problems when attempting to provide an acceptable level of acoustic separation between occupiers.

Just as the A-weighted spectral curve results in prob-

lems in measurement by conventional means, here, the variation of transmission loss with frequency presents the primary difficulty in that the transmission loss performance of most conventional materials and constructions is such that a minimum in the transmission loss performance curve occurs at the longest wavelengths, ie the very opposite of what might be desirable. It is the combination of understanding the excitation characteristics with a knowledge of the behavioural characteristics of building materials and structures which points to the solutions.

Conclusion

This paper can only provide the very briefest overview of the vast range of activities covered by the Electroacoustic Group's sphere of activity and the various ways in which our work dovetails and integrates with the activities of the majority of the other discipline groups of the Institute.

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This paper is presented on behalf of the Electroacoustics Group.

Ken Dibble FIOA is Principal of Ken Dibble Acoustics, Rugby and Chairman of the IOA Electroacoustics Group.

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PROGRESS IN INDUSTRIAL NOISE CONTROL

Bob Peters FIOA

Introduction

In his review of 25 years of noise control William A Lang [1], President of the International Institute of Noise Control Engineering (I-INCE) picked out four developments as being outstanding contributors to progress: sound intensity, active noise control, the virtual sound level meter, and computerised calculations. Although it would be hard to argue with these selections a more sceptical view might be that, on the surface, little appears to have changed. Certainly, active noise control apart [2], the conventional hardware of noise control, such as enclosures, silencers and anti-vibration mounts has not changed much, probably reflecting the fact that the laws of classical physics, on which the mechanisms of noise generation and those of sound absorption, insulation and isolation are based have not changed.

A wider view of the noise control process, however, involves the measurement, diagnosis, assessment, prediction of noise and legal and administrative control, and in these areas steady progress has been made, as well as in engineering methods of control. Noise control crosses the boundaries of the Institute's specialist groups and developments in the control of transportation noise and in measurement and instrumentation and in building acoustics have also contributed to progress in the control of industrial noise. The twin motivations of the push of legislation and enforcement and the pull of public demand for a quieter environment have also been important contributors to progress.

This article will attempt to review progress in these areas over the last few decades. It is, inevitably, a personal selection. The references included are not meant to be exhaustive but rather to illustrate some of the work that has been carried out over the period. Much of this progress has been chronicled in the pages of the Institute's Bulletin. A chronology of significant events in industrial noise control is given at the end of the paper. Reviews of progress in noise measurement techniques and in active noise control are reviewed elsewhere in this Conference.

Measurement and Diagnosis

Accurate measurement to quantify the level and frequency content of a noise is an essential starting point for noise control, and also underlies the process of diagnosing noise sources, mechanisms and transmission paths.

In the early 1970s most sound level meters, analogue of course, were capable of measuring only instantaneous sound pressure levels. Octave and third octave filters were available and not commonly used. The notion of continuous equivalent noise level was introduced in the 1972 Code of Practice for reducing the exposure of employed persons to noise [3], for the assessment of occupational

noise exposure, and soon became used for environmental noise as well. The capability to measure octave and third octave bands, which is essential for specifying noise control, and L_{Aeq} and L_N , difficult at the start of the period, soon became commonplace. The development of portable dosimeters followed later by the data-logging types has provided a valuable tool for the measurement and analysis of occupational noise exposure.

In the early 1970s FFT analysis was a specialist software package available only on main frame computers. The introduction of dedicated FFT analysers, first of all laboratory based, and then portable enough for use in the field has made it much easier to diagnose the sources and causes of tonal components in machinery noise. Although analogue tape recorders were available at the start of the period the availability in recent years of DAT recorders with very high dynamic range has made it easy to capture samples of machine noise, under various operating conditions, for subsequent analysis, as an aid to diagnosis.

The development of sound intensity meters, although still not commonly used, has added to the techniques available for the identification and diagnosis of noise sources. Other diagnostic techniques for noise source identification, developed for use with transportation noise sources, and which may find application for use with industrial machinery are reviewed elsewhere in this Conference.

Assessment

After a noise level has been measured it must be assessed against some specified target limit or standard, in order to decide whether and how much noise reduction is required. The method of measurement to be used may be determined by the method of assessment, although different measurement techniques may be required for purposes of diagnosis and specification of noise control measures.

Workplace noise exposure has, since the publication of the 1972 Code of Practice been assessed in terms of an L_{Aeq} over an 8 hour period (now known as the personal daily noise exposure level $L_{ep,d}$), and this has continued with the introduction of the Noise at Work Regulations [4].

The assessment of industrial noise on people in the environment, has throughout the period, been centred around BS 4142 [5], first introduced in 1967 for the assessment of complaints about industrial noise, and Department of the Environment Circular 10/73 Planning and Noise [6] (issued in 1973). BS 4142 uses the concept of comparing the industrial noise with a background noise level, now measured in terms of L_{A90} . Both of these assessment methods now use L_{eq} , as a result of the 1990 revision of BS 4142, and the replacement of Circular 10/73 by PPG24 [7] in 1994. The widespread use of L_{Aeq} for all forms of environmental noise, including industrial

noise, received impetus from the publication of a Noise Council report in 1978 [8], and by the publication of the International Standard ISO 1996 in 1982 [9].

The assessment of environmental noise should ultimately be based on the effects of noise on people. There has been much research in this area over the last 25 years [10,11,12,13] and progress in this area has been recently reviewed by Berglund and Lindvall [10], (who also made recommendations for noise limits) for the WHO, and by Lambert and Vallet [12] for the European Commission. The former has been used as the basis of some of the Noise Exposure Categories in PPG24 and the latter has informed the EC Green Paper *Towards Future Noise Policy* [14]. Research on the effects of noise on health are likely to be increasingly used in the assessment of environmental noise in the future.

The Control of Pollution Act [15], introduced in 1974 included, for the first time, specific legal provision for the control of noise from construction sites. This was followed, in 1984 by the publication of BS 5228 [16] (latest version 1997), which gave guidance on the assessment and control of noise from construction and demolition sites. It suggested assessment based on L_{Aeq} and L_{Amax} .

The assessment of noise inside buildings, from HVAC systems for example is usually assessed in terms of either NC, NR or dBA values. This has remained unchanged throughout the period, although a number of variations have been proposed, in an attempt to account for the prominent low frequency contribution present in this type of noise. BS 8233:1987 *Code of Practice for Sound Insulation and Noise Reduction in Buildings* [17] also gives recommendations in terms of L_{eq} values.

Prediction

The ability to predict noise levels is an important aspect of noise control since it allows noise control measures to be planned in advance, rather than retrospectively.

Many of the simple prediction design calculations based on idealised theoretical models such as point source propagation in a free field, or sound level distribution in or between rooms are still the same as those used at the beginning of the period. They are however probably much more widely used, because of advances in training courses in acoustics and noise control, and because of the availability of personal computers with databases and spreadsheets.

There has been much progress based on research into sound propagation over the period leading to improved prediction methods. The CONCAWE method for predicting noise outdoors [18,19] was published in 1981, and since then there has been further progress in research into propagation around barriers, ground attenuation and atmospheric effects on sound propagation. An international Standard, ISO 9631 [20,21] was published in 1993 and there are several commercially available software packages for predicting noise outdoors. The need for such predictions seems likely to increase with the emphasis on noise mapping in the recently published EC Green Paper.

The increased computational ability made possible by

the availability of personal computers has led to improvements in the prediction of noise levels indoors over those based on simple Sabine acoustics. A number of calculation procedures based on ray and beam tracing and upon image techniques have become available [22] for predicting noise levels from machines in factory spaces – a number of IOA meetings and conference sessions have been held on this topic in recent years.

Other areas where there have been advances in prediction techniques include:

- Radiation from surfaces using finite element and boundary element techniques [22], and prediction of radiation efficiencies
- Statistical Energy Analysis techniques [23] for prediction of structure borne sound
- Performance of noise control devices such as silencers [24,25] and enclosures, and transmission through factory cladding type structures [26].

Noise Control

Noise Control at Source

Controlling noise at source requires as its starting point a thorough understanding of how the machine works, diagnosis and evaluation of the various noise-producing mechanisms at work, and identification of transmission paths and noise radiating areas. A Symposium held at NPL on the Control of Noise [27] in 1961, during the period that the Wilson Committee [28] was sitting contains papers on the noise from fans, gears and bearings, aerodynamic noise sources and internal combustion engines and amply demonstrates the techniques involved were available at the start of the period. It could be argued that during our period the application of these more fundamental noise control techniques has taken second place to the use of standard 'acoustic hardware' solutions such as enclosures, silencers and acoustic lagging. Over the period much of the research effort into the design of low noise machinery has been directed towards transportation noise sources: aircraft, trains and heavy vehicles, and it is to be hoped that this will produce spin-off in the design of industrial machinery. There is some evidence that industrial machine manufactures are beginning to take an increased interest in designing for low noise emission, perhaps stimulated by the requirements of the Noise at Work Regulations, and subsequent Machinery Noise Regulations. The Health and Safety Executive has provided guidance on methods for reducing machinery noise and similar information is now becoming available regarding the latest standards issued in support of the Machinery Safety Regulations. It is noteworthy that the first set of noise control case studies issued by the HSE in 1983 [29] contained a high proportion of enclosures whereas the latest version (1995), *Sound Solutions* [30] features many more examples of noise control at source. Examples of areas where advances have been made include: design of low jet nozzles, woodworking machinery, quieter fans and motors.

Noise Control Hardware

Although the principles behind the design of silencers, enclosure and acoustic lagging will not have changed

since the beginning of the period, decades of application means the design of these devices is more reliable and cost effective, with less built-in over-design. Enclosures around large items of plant such as printing presses are now capable of providing control of the total working environment for employees, including the visual, air quality and aesthetic as well as the aural aspects, in addition to effectively controlling external noise radiated to the surrounding environment.

In the field of transportation noise recent advances in barrier design [31] should be equally effective in the control of outdoor industrial noise sources to the environment.

Materials for Noise Control

Although the same general types of sound insulating and sound absorbing and vibration isolation materials are in use as twenty-five years ago, the range of available products has increased and test data on sound absorption coefficients and sound reduction indices is more readily available. More products are also available which will enable the engineer to achieve the required acoustic performance within other environmental constraints such as hygiene, fire risk and aesthetic appearance. New products which have become available include high density mineral fibres, systems for cladding of factory walls and roofs, and for vibration isolation of floors, and abrasion resistant rubbers for lining bins and hoppers to reduce impact noise. Information on the performance of materials used for damping and acoustic lagging remains more problematic.

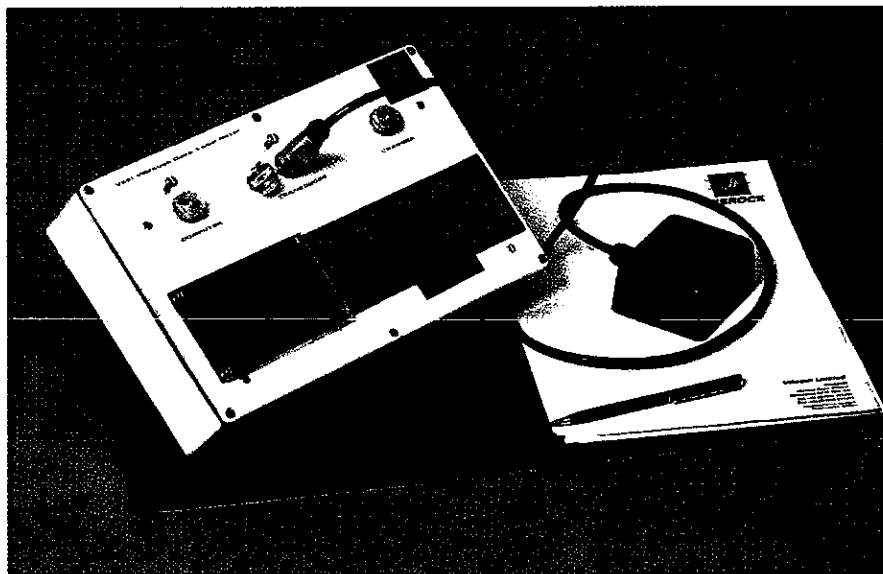
Legal and Administrative Noise Control Measures

The legislation controlling environmental noise from industry is that contained in the Environmental Protection Act, relating to noise nuisance [32], carried forward from the Control of Pollution Act, and the requirements of planning legislation leading to the advice contained in PPG24 [33]. In addition the Control of Pollution Act contains the provisions relating to construction site noise, and the little used provisions relating to noise abatement zones. The effects of the Noise at Work Regulations are considered below.

Summary – Increased Awareness, Availability and Accessibility

Two of the four areas of technological breakthrough highlighted by Lang [1], those of active noise control and sound intensity have created entirely new approaches to noise measurement and control which will no doubt continue to be further exploited in the future. The other two, the advances in digital signal processing applied to noise measuring equipment, and ready availability of computational power for acoustic calculations have accelerated progress in the more traditional approaches to noise control. They have made it relatively easy to carry out measurements and calculations which, although possible in theory 25 years ago would have taken too long to be feasible in practice.

Most of the equipment, techniques, knowledge which was available at the beginning of the period is now more readily accessible. There is a much greater awareness in



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society generally of the problems caused by noise and a greater demand for their solution. There are many more people involved in noise control: industrial safety officers, engineers, manufacturers of noise measurement equipment and noise control materials and hardware, architects and environmental health officers, as well as noise consultants. Among these there is generally a greater understanding of the principles involved because of the improved accessibility to information, literature, education and training courses. The author believes that the Institute's own Diploma, and its Certificate of Competence courses have played a significant part in this as well.

Despite the progress of the last 25 years hundreds of thousands of employees remain at risk of hearing damage from noise at work, and industrial noise in the community remains a significant problem. Industrial machinery has the potential, as it becomes more powerful in the search for greater efficiency, to emit even more noise unless there is greater emphasis on noise control at source in the future. Despite the improved availability of information there is still much ignorance about how to control noise. There remains much for the Institute of Acoustics, and the Industrial Noise Group in particular, to do in terms of education and promoting awareness of good practice in noise control.

The Last Word: The Noise at Work Regulations

Even when all the necessary elements for the control of noise are present: measurement or prediction, assessment and engineering control techniques, nothing happens without the will to act. It can be argued that the most important source of this motivation, and probably the single most important development in industrial noise control in our period has been the introduction and implementation of the Noise at Work Regulations. The Regulations place a duty on employers to reduce noise exposure of employees. Although this can be achieved to a limited extent by control of exposure duration the most effective means is to reduce the level of noise produced in the workplace. This often has the advantage of producing a more pleasant and efficient working environment and also reducing the level of noise radiated to the surrounding environment.

The Regulations also place a duty on manufacturers and suppliers of machinery to provide information about the noise emission from their products. The Regulations have been supported by the HSE through publicity campaigns such as the *Good Health Is Good Business* campaign and through the publication of guidance material [34]. The Noise at Work Regulations have been supported by a series of Regulations on machinery noise [35] issued throughout the period. It is the hope and intention that the initial coercive stimulus provided by these various Regulations will eventually lead to a competitive stimulus among manufacturers of machinery, whereby a product with a lower noise output than its competitor will have an advantage in the market place. It is certainly true that many manufacturing companies have introduced noise emission requirements into their

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machinery procurement policies since the introduction of the Noise at Work Regulations.

The latest series of Standards [36,37] issued in support of the Machinery Safety Directive provide guidance to manufacturers and designers on the design of low noise machinery, on low noise workplaces and on methods for evaluating the performance of enclosures. These and further Standards in the course of preparation, including Noise Test Codes for various types of machinery will ensure that the impetus given to industrial noise control continues into the next millennium.

Appendix

A Chronology of Events

- 1963 *Noise and the Worker* – a government booklet which was the first to warn of the dangers to hearing from noise exposure at work
The Wilson Report – a major investigation into the problem of noise in society, which shaped the direction of noise policy in the UK for the next two decades
- 1967 BS 4142 first issued
- 1972 Code of Practice: *The reduction of exposed persons to noise at work*
- 1973 Circular 10/73 *Planning and Noise*
- 1974 Health and Safety at Work Act
Control of Pollution Act
- 1978 Institute of Acoustics Diploma started
- 1986 EC Directive on Noise at Work
- 1989 Noise at Work Regulations
- 1990 Noise Review Working Party (*Batho Report*) a 'mini' review of noise policy
Environmental Protection Act
BS 4142 (major revision to incorporate L_{eq})
- 1994 PPG 24 *Planning and Noise* (replace Circular 10/73)
- 1995 Berglund and Lindvall Review for WHO: *Noise in the Community*
- 1996 EC Green Paper *Towards Future Noise Policy*

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- This paper is presented on behalf of the Industrial Noise Group.*

Bob Peters FIOA is Principal Noise Consultant, Applied Acoustic Design, Staines, Middlesex.

MEETING NOTICE

Measurement and Instrumentation Group Getting A Grip On Hand-Arm Vibration

The National Motorcycle Museum, Birmingham

Tuesday 29 June 1999

Hand-arm vibration is now becoming recognised as a significant contributor to long-term health problems like Reynaud's Disease. Many attempts have been made to quantify vibration levels that give rise to health problems but only recently have guidelines been issued. In the UK the Health and Safety Executive has launched a major awareness campaign and published guidelines and action levels. In the EU the Physical Agents Directive, although stalled for some time, now looks set to introduce similar levels that could be covered by legislation. Instrumentation is available to measure the necessary information, but measurement techniques often leave much to be desired, and the difficulty in cross-checking measurements taken is well known.

The aim of this one-day meeting is to present a series of papers describing measurement-making in all its aspects as applied to sources of hand-arm vibration. Problems often experienced and practical methods to solve them will be addressed. Information on the legal and insurance consequences of vibration exposure in the workplace and on the medical effects will be included. There will be an exhibition of relevant instrumentation.

Presentations will include:

Real-world hand-arm vibration measurements versus manufacturer's data, *Peter Barker, Wimtec Environmental Ltd.*

Experience in assessing instruments against ISO 8041 'Human response to vibration - measuring instrumentation', *Liz Brueck, HSL.*

Vibration measurement of power hand tools used in the shipbuilding industry, *Simon Clampton, Marconi Marine (VSEL) Ltd.*

Vibration measurement and risk management for a public utility - a case study, *Iain Critchley, Peninsular Acoustics.*

On-site vibration assessment, accuracy and repeatability, *Kevin Hill, Glasgow City Council.*

A hand-holding guide to the measurement and CE marking of vibrating products, *Neal Hill, European Process Management Ltd.*

Measurement and evaluation of human exposure to hand-transmitted vibration - recent work on International and European standards, *Chris Nelson, HSE.*

Measurement uncertainty in the evaluation of hand-arm vibration exposure in the workplace - an introduction to ISO 5349-2, *Paul Pitts, HSL.*

Frequency analysis for hand-arm vibration measurements, *Tim South, Leeds Metropolitan University.*

Power on the land - an environmentally unfriendly handshake, *Richard Stayner, RMS Vibration Test Laboratory.*

Pains, Trains and Roto-Peens - Implementing a hand-arm vibration management programme, *Graham Twigg & Steve Fitchett, Tecforce Ltd.*

This meeting will be followed by the Measurement & Instrumentation Group AGM.

Getting a grip on hand-arm vibration - 29 June 1999

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Please register me as a delegate. I enclose a cheque for the delegate fee:

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☐ Non-members £125 + VAT = £146.88

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CALL FOR PAPERS

One-Day Meeting

(organised by the Industrial Noise Group)

HAS NOISE AT WORK WORKED?

Chamberlain Tower Hotel, Birmingham

Wednesday 13 October 1999

The Noise at Work Regulations came into force on 1 January 1990. The Industrial Noise Group are to mark this tenth anniversary with a one day meeting.

The aim of the meeting is to review the progress made in the last ten years and develop the acoustic industry's view of the way ahead.

We are interested in receiving offers of contributions on any relevant topic of which the following are suggestions:

- Workplace Noise Exposure Assessment
- Present and Future Policy
- The View of the Insurance Industry
- Views from Manufacturing and Service Industries
- Managing the Implementation of the Regulations
- Non-Auditory Effects
- Legal Aspects
- Health Surveillance and Rehabilitation
- Sources of Noise Information
- Education, Training and "Competence"

If you would like to contribute, please send an abstract of no more than 200 words to the meeting organiser as soon as possible.

If you are interested in contributing to the event as a delegate please register your interest with the Institute of Acoustics office. Further details will be available shortly.

Meeting Organiser:

*Andrew Raymond
Philip Dunbavin Acoustics Ltd
Vincent House
212 Manchester Road
Warrington
Cheshire WA1 3BD*

Tel: 01925 418188

Fax: 01925 417201

email: PDA_Ltd@compuserve.com

MEETING NOTICE

Organised by the Electroacoustics and Speech Groups

SPEECH INTELIGIBILITY

Portland Thistle Hotel, Manchester

Thursday 21 October 1999

Programme

Overview of speech intelligibility

Peter Barnett, AMS Acoustics

Coloration and speech perception

Antony J Watkins, Reading University

Intelligibility vs. quality in objective speech performance assessment

Mike Hollier, BT Labs

Issues of intelligibility in forensic recordings

Peter French, J P French Associates

Speech Intelligibility in classrooms

David MacKenzie, Heriot Watt University

Speech Intelligibility in arena and stadia

Rajesh Patel, Arup Acoustics

Objective testing in practice

Peter Mapp, Peter Mapp Acoustics

Subjective testing in practice

Helen Goddard, AMS Acoustics

Proposals for a new subjective testing method

Peter Barnett, AMS Acoustics

Technical Programme Organisers:

Electroacoustics Group, Peter Barnett Speech & Hearing Group, Stephen Cox

Speech Intelligibility - Thursday 21 October 1999

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CALL FOR PAPERS

1999 Auditorium Acoustics Conference

(Organised by the Building Acoustics Group)

AUDITORIA: THE LEGACY OF THE 20TH CENTURY AND BEYOND 2000

Manchester, 22 – 24 October 1999

Following three very successful conferences linked to recently completed auditoria, this year's conference will be in Manchester. The city has four new or refurbished performance venues:

Bridgewater Concert Hall
Royal Exchange Theatre (refurbished)
Lowry Centre (under construction)
Nynex Arena (the largest covered arena in Europe)

Visits will be arranged to at least the Bridgewater Hall and Exchange Theatre. The 2400 seat Bridgewater Hall opened in September 1996 with a design based on a combination of vineyard terracing and the shoebox form. Delegates will have an opportunity to attend a public concert at the hall.

The conference will review the changes in auditorium design over the century, consider current design and look forward to the future. Offers of contributions are invited on acoustic aspects of auditorium design and performance. These should be sent (preferably by email) in the form of a brief abstract to one of the programme organisers as soon as possible.

Dr Mike Barron MIOA
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Pound Hill
Cambridge CB3 0AE

Tel: +44 (0) 1223 355033
Fax: +44 (0) 1223 361258
email: raf.orkowski@arup.com

Those wishing to be placed on the mailing list for further details on the conference should contact the Institute office:

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CALLS FOR PAPERS

1999 Autumn Conference
(Organised by the Environmental Noise Group)

ENVIRONMENTAL NOISE ISSUES FOR THE NEW MILLENNIUM

Stratford Victoria Hotel, Stratford upon Avon
17 - 18 November 1999

The 1999 Autumn Conference will examine the future of noise over the next few years, with emphasis on sustainability. For example: How does noise fit in with an integrated transport policy and the rejuvenation of town centres, whilst meeting likely EU, national and local authority noise requirements, and individual expectations? If we improve the noise environment, are there any implications for other environmental disciplines?

You are invited to contribute a paper on your experience in any of the following themes:

- Integration:* How well are the noise effects integrated into the decision making process?
- Regulation:* Are current regulations and standards effective? How should they be developed?
- Prediction:* How meaningful and useful are the models we use?
- Insulation:* How are we meeting the current standards and rising to the emerging challenges?
- Instrumentation:* Are we making the most of the new generation of sound level meters?
- Innovation:* What is the latest research on environmental noise?
- Education:* What are the effects of noise on teaching. How well are we teaching the effects of noise?

Please send your 100 word abstract to the Institute office to arrive as soon as possible.

15th Residential Week-end Conference
(Organised by the Electroacoustics Group in collaboration with
APRS, AES, ISCE & PLASA)

REPRODUCED SOUND 15

Stratford Victoria Hotel, Stratford upon Avon
18 - 21 November 1999

Technical Programme Committee Chairman : Julian Wright FIOA

Call for papers on topics relating to the following:

- Listening Environments
- Loudspeakers
- Microphones
- Amplifiers
- Audio Processing
- Systems Engineering
- Broadcast Sound
- Virtual Audio

Please send abstracts of not more than 200 words to the Institute office as soon as possible. Notification of acceptance will be mailed by 23 July. Papers which the authors wish to have refereed must be submitted by 27 August. Final papers for the proceedings must be received by 1 October 1999.

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CALLS FOR PAPERS

Measurement and Instrumentation Group

2 Day Conference

MEASURING NOISE OUTDOORS

17-18 February 2000, Home Counties Venue

Papers are sought on any aspect of measurement of noise outdoors. Tutorials and workshops sessions will form part of the conference with the emphasis on practical measurements.

Meeting Organiser:

Martin Armstrong MIOA, Brüel & Kjær, Harrow Weald Lodge, 92 Uxbridge Road, Harrow, HA3 6BZ Tel: 0181 954 2366 Fax: 0181 954 9504 email: martin.armstrong@bkgb.co.uk.

MAKING GOOD MUSICAL INSTRUMENTS: CAN ACOUSTICS HELP?

12 July 1999, Edinburgh

A Focus Meeting in Musical Acoustics, organised by the Department of Physics and Astronomy of the University of Edinburgh in conjunction with the Musical Acoustics Group (MAG) of the Institute of Acoustics (IOA) and in collaboration with the Stress and Vibration Group (SAVG) of the Institute of Physics (IOP), and with support from the EPSRC. The purpose of the meeting is to provide an opportunity for the exchange of information and experience between researchers in musical acoustics and makers and restorers of musical instruments.

The meeting has been arranged in co-ordination with the Conference on Musical Instruments (see <http://www.music.ed.ac.uk/euchmi/galpin/gxjp.html>) organised by the Edinburgh University Collection of Historic Musical Instruments with the Galpin Society in Edinburgh, 9-11 July 1999.

The meeting is supported financially by the Engineering and Physical Sciences Research Council, and no registration fee will be charged. Assistance with travelling may be available for University staff.

Contributions, in the form of short verbal presentations, are invited from academic researchers and musical instrument makers. Further information about contributing to the meeting from:

Dr D Murray Campbell, Department of Physics and Astronomy, University of Edinburgh,
James Clerk Maxwell Building, Mayfield Road, EDINBURGH EH9 3JZ, Scotland
Tel +44 (0) 131 660 5262 Fax +44 (0) 131 650 5212 E-mail to: D.M.Campbell@ed.ac.uk

Further information about attending the meeting from

Dr Arnold Myers, Collection of Historic Musical Instruments, Faculty of Music, University of
Edinburgh, Reid Hall, Bristo Square, EDINBURGH EH8 9AG, UK.
Tel: +44 (0) 131 650 2423 Fax: +44 (0) 131 650 2425 E-mail to: A.Myers@ed.ac.uk.

CALL FOR PAPERS

International Conference
(Organised by the Underwater Acoustics Group)

STOCHASTIC VOLUME AND SURFACE SCATTERING: RECENT DEVELOPMENTS IN UNDERWATER ACOUSTICS

Robinson College, Cambridge 15-17 December 1999

It is now over 10 years since our last conference on the theme of fluctuation effects in underwater acoustics, and a review of new developments in the field is overdue. Theoretical understanding of random volume scattering has progressed to the point where many of the major problems have been solved. Comparisons of predictions and experimental observations, however, show that further questions must be addressed in order for volume scattering theory to provide a complete explanation.

The purpose of this conference will be to review the present state of this continually evolving subject and to report on new developments and future trends. Keynote speakers will include Terry Ewart and Eric Thorsos from the Applied Physics Lab, University of Washington. Particular themes of the conference will include, but are not restricted to

Theories of stochastic volume and surface scattering.

Theories of related oceanographic and geophysical phenomena.

Measurements of acoustic fluctuations and coherence, or related oceanographic and geophysical phenomena.

Degradation of arrays, beamformers, phase-conjugate arrays, sonar systems and communication systems, as well as techniques for overcoming such effects.

Relevant contributions from other fields - astronomy, radar, laser optics etc.

The conference proceedings will be published in Vol 21 of the Proceedings of the Institute of Acoustics, and copies will be available at the start of the conference. This publication carries ISSN and ISBN numbers, and papers are classified as refereed and non-refereed. Additionally, authors of relevant papers of appropriate quality may be asked to contribute to a special issue of a well respected journal based on the theme of this conference.

Prospective authors are invited to submit an abstract of up to 300 words as soon as possible, indicating if they wish the paper to be refereed, and whether their proposed paper is better suited to oral or poster presentation. Successful authors will be notified within one month of receipt of their abstract. Complete manuscripts may be up to 8 pages long, including diagrams, and must be in the correct camera ready format (an MS Word template file will be available).

Papers for refereeing must be submitted by 12 July 1999, and all final manuscripts must be in the hands of the conference organisers by 27 September (those arriving after this deadline will not be printed).

All enquiries relating to this meeting should be addressed to either of the conference organisers:

Dr Barry J Uscinski
DAMTP
University of Cambridge
Silver Street
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Fax: +44 (0)1223 337918
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Fax: +44 (0)117 918 8422
E-Mail: InstAcoust@aol.com
or: peter.dobbins@baesema.co.uk

*Abstracts should be sent to Peter Dobbins at the above address, preferably by e-mail.
The latest conference information will be found at the Underwater Acoustics Group web site: <http://members.aol.com/InstAcoust/underwater/>*

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29 JUN

Measurement and Instrumentation Group Mtg: Getting a Grip on Hand-Arm Vibration
Birmingham

1 JUL

Executive Committee
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7 JUL

IOA CofC in Env Noise M'tment Committee
St Albans

12 JUL

Musical Acoustics Group Conference: Making Good Musical Instruments: Can Acoustics Help? In collaboration with IOP, organised by the University of Edinburgh
Edinburgh

22 JUL

Meetings Committee, Reproduced Sound 15 Organising Committee
St Albans

9 AUG

Diploma Examiners Board Meeting
St Albans

31 AUG

Diploma results posted

7 SEP

Environmental Noise Group: Pubs and Clubs Working Party
St Albans

9 SEP

Executive Committee
St Albans

16 SEP

Meetings Committee, Publications Committee, Environmental Noise Group Committee
St Albans

22 SEP

Midlands Branch Afternoon Mtg: Noise Mapping - EU Noise Policy Working Group 4
Birmingham

23 SEP

Distance Learning Sub Committee, Education Committee
St Albans

28 SEP

Measurement and Instrumentation Group Committee Meeting
St Albans

30 SEP

Reproduced Sound 15 Organising Committee, Membership Committee
St Albans

8 OCT

IOA CofC in W'place Noise Exam
Accredited Centres

13 OCT

Industrial Noise Group Mtg: Has Noise at Work Worked?
Birmingham

14 OCT

Executive Committee, Medals & Awards Committee, Council
St Albans

21 OCT

Electroacoustics and Speech Groups Mtg: Speech Intelligibility
Manchester

22-24 OCT

Building Acoustics Group Mtg: Auditoria: The Legacy of the 20th Century and Beyond 2000
Manchester

29 OCT

IOA CofC in Env Noise Measurement Exam
Accredited Centres

5 NOV

IOA CofC in W'place Noise Committee
St Albans

9 NOV

Membership Committee, CPD Committee
St Albans

11 NOV

Meetings Committee, Publications Committee
St Albans

11 NOV

Midlands Branch Evening Mtg: Computation & Measurement - EU Noise Policy Working Group 3
Derby

17-18 NOV

Environmental Noise Group Conference: Environmental Noise Issues for the New Millennium
Stratford upon Avon

18-21 NOV

Electroacoustics Group Conference: Reproduced Sound 15
Stratford upon Avon

22 NOV

IOA CofC in Env Noise M'tment Committee
St Albans

23 NOV

Distance Learning Sub Committee, Education Committee
St Albans

25 NOV

Executive Committee, Medals & Awards Committee, Council
St Albans

15-17 DEC

Underwater Acoustics Group Conference: Stochastic Volume and Surface Scattering: Recent Developments in Underwater Acoustics
Cambridge

2000

17-18 FEB

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SOUNDS INTERESTING

Murray Campbell MIOA

Introduction

From the earliest records of civilisation to the present day, the making of music has been an important human activity. It is therefore not surprising that many of the major advances in the understanding of sound and vibration have been made in the context of musical acoustics. Indeed, with a history stretching back to before Pythagoras, musical acoustics might claim to be the oldest branch of our science.

In this historical context, the twenty five years since the founding of the Institute of Acoustics seems a very short time span. However, the pace of research in musical acoustics has quickened in recent years, and in the last quarter century many important advances have been made. Rather than attempting to give a comprehensive review, I will concentrate here on a few specific areas in which members of the Institute have made major contributions; I hope that these will give a flavour of the exciting work now in progress in this fascinating and interdisciplinary field of acoustical research.

The title of this article is intended to underline an aspect of musical acoustics which distinguishes it from most other branches of acoustics. In the study of a musical instrument it is of vital importance to remember its essential function, which is to be a channel for communication between the performer and the listener. That communication is mediated through extremely subtle changes in the parameters of the radiated sound wave. Some musically significant variations seem to be at or even beyond the limits of sensitivity of modern measuring equipment; on the other hand, some relatively gross changes in the scientifically measurable properties of the sound are apparently ignored by the musical ear. In order to make real progress towards the goal of understanding the musical functioning of an instrument, it is essential that physical investigations of the instrument go hand in hand with psychophysical studies, and this partnership has been a strong feature of the best recent work in musical acoustics.

Two other important strands can be easily discerned in modern musical acoustics research. One is the recognition of the central importance of non-linear dynamics, especially in the physics of continuously excited musical instruments. The essentially non-linear nature of the driving mechanism in bowed string and wind instruments means that linearising approximations are at best of limited value, and can be seriously misleading. The other strand which links many different studies of how musical instruments behave under realistic performing conditions is the use of numerical simulations. There is a strong link between these two strands, which was brought out clearly in a seminal paper by McIntyre, Schumacher and

Woodhouse [1] in 1983. Since the non-linear equations which describe the physics of the instrument are not generally amenable to analytical solution, numerical methods must be used to obtain predictions which can be tested by comparison with experiment. The dramatic increase in the power and memory of modestly priced computers has made it possible to carry out detailed simulations in real time, leading to the development of a new generation of 'physical modelling synthesisers'. More importantly from the research perspective, the availability of efficient methods for time domain simulation has opened the way to detailed studies of the transient and steady state behaviour of musical instrument models as different parameters are systematically varied.

The first Spring Meeting of the Institute of Acoustics which I attended was in Swansea in 1984. Many interesting papers on musical acoustics were presented at that meeting, including important contributions on vibration modes of guitars, violins and pianos, the bow-string interaction on the violin, and the excitation mechanisms of woodwind and brass instruments. Each of these topics has continued as a major research area over the subsequent fifteen years, and I will touch on some of them in the following sections. The most striking memory that I carried away from the meeting was of the plenary talk by Professor Charles Taylor, on *Demonstrations in Aural Perception*. Everyone working in musical acoustics owes a great debt to Charles Taylor, not only for his own major contributions to the field, but also for the inspired way in which he has communicated his enthusiasm for the subject to a vast public through his books, lectures and television broadcasts. It is a great pleasure to dedicate this talk to him.

Physics and Psychophysics of the Guitar

No one has done more to establish the international reputation of musical acoustics research in the United Kingdom than Bernard Richardson, and I should like to start by reviewing briefly some of the work which has led to Cardiff's current reputation as the world centre for guitar acoustics. One important factor in the success of this project has been the strong links which Richardson, himself a guitar maker, has developed and maintained with professional makers and players of the instrument. This has ensured that the inevitable simplifications, sometimes drastic, which are unavoidable in the first stages of developing a physical model of a musical instrument have always been made in full awareness of the complexity of the real musical situation.

Early stages of Richardson's work involved holographic studies of the normal modes of vibration of the body of the guitar (Figure 1). These experimental investigations led to the development of a numerical model based on a system comprising a flexible body, including

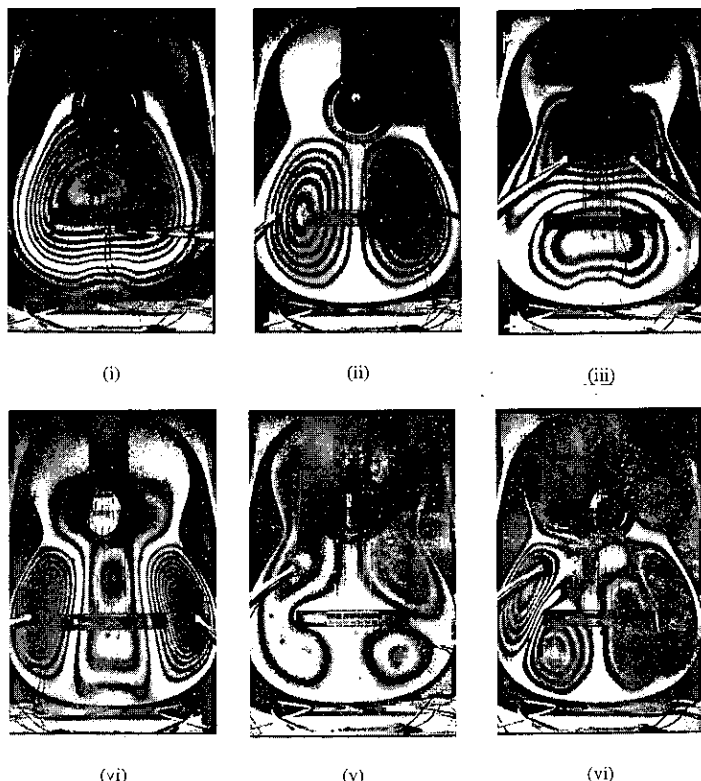


Fig. 1. Holographic records of the first six main vibrational modes of a guitar top plate (courtesy of Bernard Richardson).

structure of the body; guided by the holographic studies and by his experience as a maker, Richardson chose to concentrate attention on an accurate finite element analysis of the top plate of the guitar, coupled by rigid sides to a back plate with only a single low frequency mode. Finite element analysis was also used to compute the modes of the air-filled cavity. This simplified model was shown to retain most of the musically important features. From it, the input admittance of the guitar body at the bridge could be calculated; using this information, it was possible to couple the transverse vibration modes of the string to the body, using a method proposed by Gough [2]. The final stage in the development of the model was to incorporate the radiation of sound to the listener. The first step was to consider each vibrating element as a point sound source, and to sum all contributions at the listening point (Richardson, Walker and Brooke [3]). This did not take account of radiation from the back and the sides of the guitar, and did not predict well the sound heard by the player. This last point is a significant one: it is sometimes forgotten that the player is normally in the near field of the instrument, and his auditory experience can be very different to that of a member of an audience. The guitar is frequently played purely for the performer's enjoyment, with no other listener present, and even in a performing situation the

player is constantly adapting the nuances of performance on the basis of what he or she hears.

an air cavity, coupled to a lossy string. Limitations on computing resources made it necessary to simplify the



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In a later stage of the research, many of these problems were solved by incorporating a boundary element calculation of the radiated sound field (Richardson and Brooke [4]). The complete model was then used to compute the transfer function between the plucking point on the string and the listening point. It was in effect possible to 'play' the model by applying an impulsive force at the driving point, and to hear the resulting sound. The great advantage of such a model is that it is possible to investigate the effects of particular parameters in a way which would be impossible with a real instrument. For example, the thickness of an internal strut can be varied systematically without having to dismantle and reassemble the instrument at each step.

A vital feature of this work was the incorporation of a serious psychoacoustical study, designed to test whether changes in the model parameters produced differences in sound which were detectable by a listener (Wright and Richardson [5]). This work has led to an important re-evaluation of the significance of natural mode patterns on the bodies of stringed instruments. The precise tuning of particular body modes has traditionally been considered to be one of the most important features of the construction of stringed instrument bodies, and under particular conditions small variations in the relative frequencies of specific modes can certainly lead to audible differences in instrumental performance. Richardson and his colleagues have shown, however, that a much more sensitive parameter than the mode frequency is the effective mass of the mode. This parameter determines the response of the mode to a bridge driving signal; if a nodal line for the mode in question lies close to the bridge, the effective mass will be high and the mode will be relatively inefficient at converting the string vibration into a radiating sound wave.

The psychoacoustical studies showed that a small mode frequency change was only detectable if a string vibration component almost coincided in frequency with the mode in question. In contrast, a change in the effective mass affected the perception of a wide range of string vibration components. One reason for this appears to be that low frequency modes are important in the radiation of frequencies well above the relevant mode frequencies. This is illustrated in Figure 2, which shows model predictions of the sound radiation patterns for various guitar top plate modes coupled to a 990 Hz string vibration. The lowest frequency (T1,1) mode has a frequency of around 100 Hz, but has if anything a higher radiation efficiency for the 990 Hz string mode than does the (T4,2) mode with a frequency of around 1000 Hz. Such insights are valuable both in clarifying our understanding of the acoustical functioning of the guitar and in providing practical guidance to guitar designers and manufacturers.

Non-linear Dynamics of the Bowed String

The classic paper by McIntyre, Schumacher and Woodhouse [1] has already been referred to. Figure 3 illustrates the very general scheme of a 'musical oscillator'

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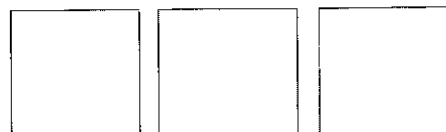
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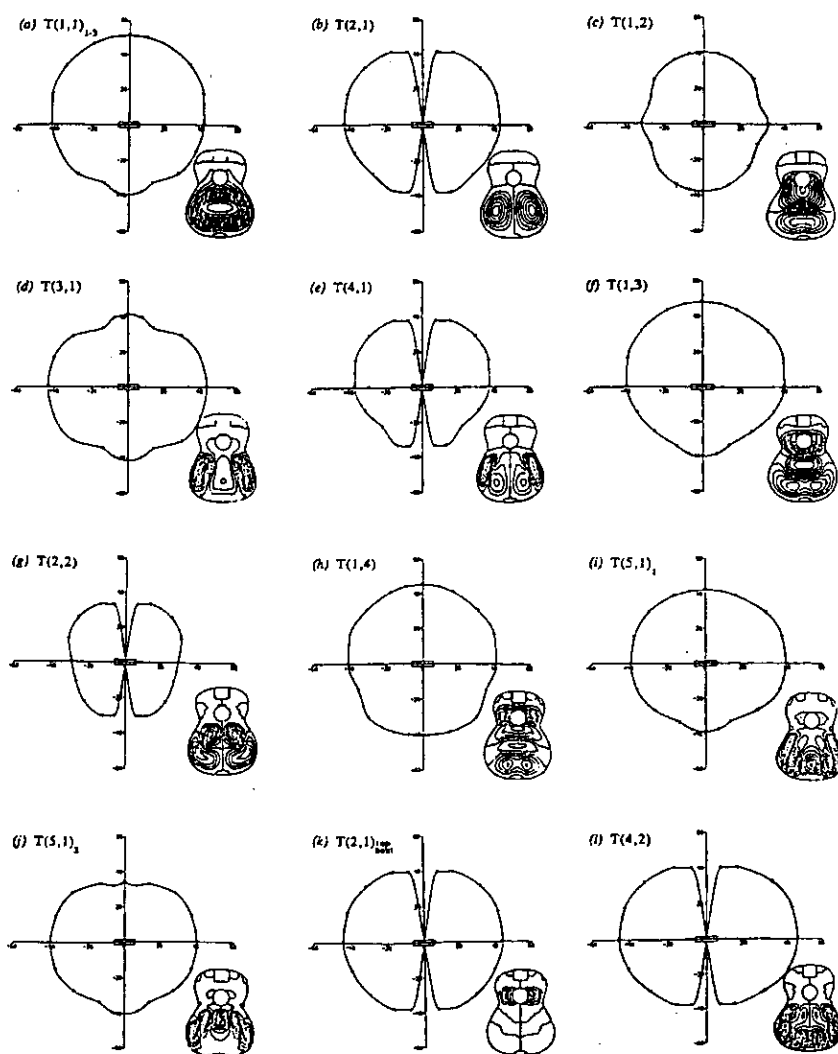


Fig. 2. Polar plots of the sound pressure radiated by guitar modes coupled to a 990 Hz string mode [4].

discussed and elaborated in that paper. It describes a situation in which the player interacts with a passive linear vibrating system through a feedback loop containing a non-linear element; under appropriate conditions the system can be destabilised, leading to self-sustained oscillation.

The case of the bowed string has been studied in great depth by Jim Woodhouse and his co-workers. In this case, the passive linear system is the string, and the non-linear excitation mechanism is the interaction between resined horsehair of the bow and the string. This interaction can be represented by a curve showing the relationship between the force applied to the string by the bow and the velocity of the string relative to the bow. A simplified version of this curve is shown in Figure 4; it is immediately evident that the relationship is strongly non-linear. Woodhouse [6] has pointed out that in this case the threshold for auto-oscillation is always unstable: it is in practice impossible to draw a violin bow across a string without exciting some kind of string vibration which will grow to a finite limit. Under these circum-

stances a small amplitude perturbation treatment cannot be used.

The most successful approach to this problem has been the use of numerical techniques to solve the equations of motion in the time domain. Instead of describing the linear system by a frequency-dependent input impedance or admittance, the input impulse response (which is the inverse Fourier transform of the input impedance) is used to characterise the string. This is the velocity response to a unit force impulse at the bowing point. It consists of a series of pulses, corresponding to successive reflections of the two initial velocity impulses which travel in opposite directions from the bowing point towards the ends of the string at the bridge and at the player's finger (or the nut if it is an open string).

The complete model of the bow-string interaction consists of the input impulse response and the non-linear relationship between bow force and string velocity. Numerical solutions for the model can be very efficiently computed if the input impulse response is expressed in terms of two much shorter temporal functions: the bridge reflection function and the nut/finger reflection function. These functions describe how the pulse is modified when it is reflected from the appropriate string termination.

Many types of string motion can be set up by bowing; most of them are usually considered unmusical,

and violinists spend many hours of practice learning how to avoid them. The type of motion corresponding to a normal musical note is surprisingly simple; it was first identified by Helmholtz, and is known as Helmholtz motion. In this regime a sharp 'corner' shuttles backwards and forwards on the string, inverting at each end reflection. As it passes the bow in one direction it triggers a sticking phase of the interaction, and as it passes in the opposite direction it triggers a slipping phase. The

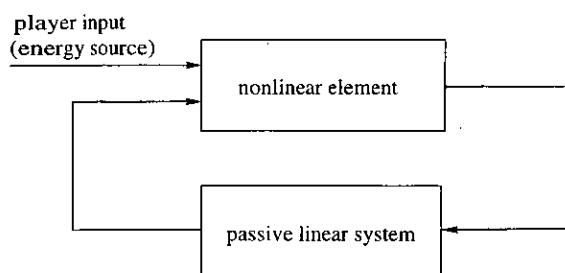


Fig. 3. Schematic diagram of a musical oscillator [6].

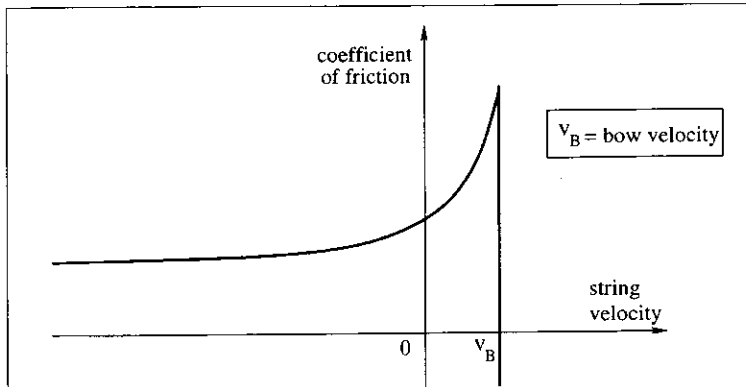


Fig. 4. Dependence of the frictional force between a bow and string on the string velocity [8].

force exerted on the bridge by Helmholtz motion is a sawtooth wave.

The above description of Helmholtz motion is of course idealised, and in practice the corner is not completely sharp. It is rounded by losses at each end reflection and it is sharpened at each successive non-linear interaction with the bow. Numerical solutions of the non-linear equations have been successful in predicting the kind of string motions which are observed on real bowed strings: not only Helmholtz motion, but a whole menagerie of other types of motion, including non-periodic vibrations.

An important concept in the musical evaluation of an instrument is its 'playability'. Musicians usually have a fairly clear and consistent view of the relative playability of different instruments, but this is one of these areas in which there is still some uncertainty about the translation from musical terminology to scientific language. Woodhouse has suggested, plausibly, that at least one aspect of the playability of a violin must be related to the stability of Helmholtz motion with respect to small variations in playing parameters. If a small variation in bow force or bowing speed is likely to trigger a transition to some other, musically undesirable regime, the instrument will be more difficult to control than if Helmholtz motion is maintained over a wide variation of the playing parameters.

Some years ago John Schelling [7] used a highly simplified model of the bowed string to predict the limits of Helmholtz motion under variation of the bow force and

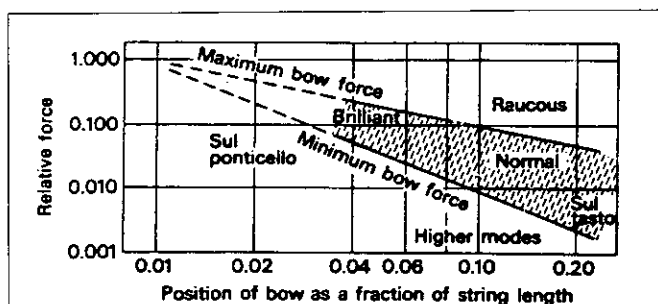


Fig. 5. Schelling's diagram showing the region of bowing parameter space in which Helmholtz motion can be obtained [7].

the bowing position. This resulted in a well-known diagram (Figure 5) delineating the musically useful area in the parameter space spanned by these two variables. Woodhouse [8] has now taken this approach much further by using computer simulations to determine which regime of self-sustained oscillation arises from a particular starting transient, and how this varies with the waveform of the applied bow force. Highly detailed maps have been obtained of a parameter space in which the horizontal axis represents the steady bow force and the vertical axis represents the relative strength of the bow force at the start of the attack. An example of one of these maps is shown in Figure 6: the white area represents pairs of parameter values for which a Helmholtz motion develops, while black areas represent any other outcome. A wealth of information about the nature of the transients and the final states of oscillation is also available, although not displayed on the map. This type of detailed and systematic study, possible

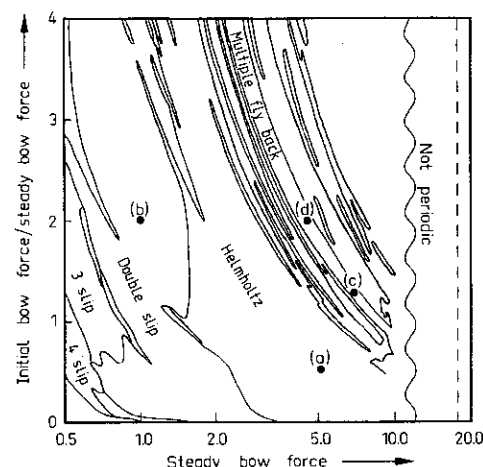


Fig. 6. (Top) Parameter map of the simulated bowing of an open A string on a simplified violin, showing regions (in white) in which Helmholtz motion is obtained; (bottom) showing axis scales and the regions in which various important regimes were found. Vertical dashed line: Schelling's maximum bow force [8].

only through the use of a powerful computer (in this case a Connection Machine), promises to bring new levels of realism to the comparison between physical models of the bowing process and the experience and perception of the human violinist.

Non-linear Effects in Wind Instruments

The generalised scheme of a musical oscillator shown in Figure 3 can also be applied to woodwind and brass instruments. The air column is taken to be a linear passive system; this assumption will be reconsidered later. The non-linear element is the control valve which modulates the flow of air from the player's mouth into the instrument. In the case of a clarinet or saxophone, the valve is a single cane reed, and the flow control characteristic can be represented by a curve of the general form shown in Figure 7. Computer simulations have been successfully used to model the large amplitude behaviour of the clarinet (McIntyre, Schumacher and Woodhouse [1]). The non-linearity here is less extreme than in the case of the bowed string, however, and some success has been achieved in using analytical methods to study the behaviour of these instruments in the vicinity of the threshold for self-sustained oscillation (Kergomard [9]).

In the language of non-linear dynamics, the onset of oscillation as the blowing pressure is increased from a low value is described as a bifurcation, in which a point attractor is replaced by a limit cycle. Interestingly, the small amplitude theory shows that in the case of the

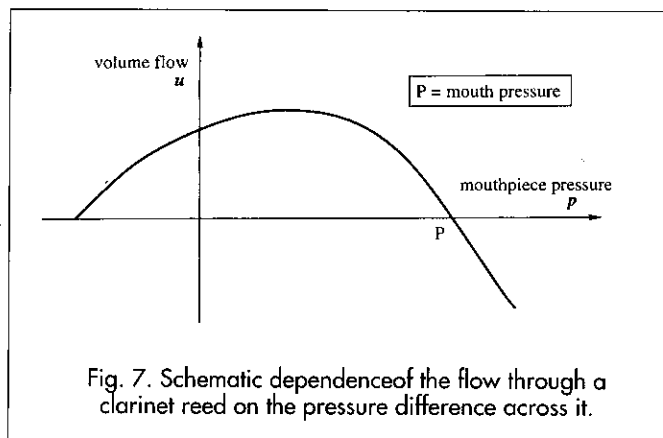


Fig. 7. Schematic dependence of the flow through a clarinet reed on the pressure difference across it.

cylindrical clarinet the bifurcation is direct, so that the oscillation state just above threshold is stable for an arbitrarily small amplitude. In contrast, the bifurcation for the conical saxophone is inverse: the oscillation state just above threshold is unstable below a certain finite amplitude. This seems to provide an explanation for the fact that the clarinet can be played at an extremely quiet level which is impossible on the saxophone.

The study of brass instrument behaviour was greatly advanced in the early 1980s through the pioneering work of John Bowsher and his colleagues in the Physics Department at the University of Surrey. In an important paper published in 1982, Elliott and Bowsher [10] developed an analytical theory for regeneration in lip-excited cup mouthpiece instruments. Inevitably, the the-

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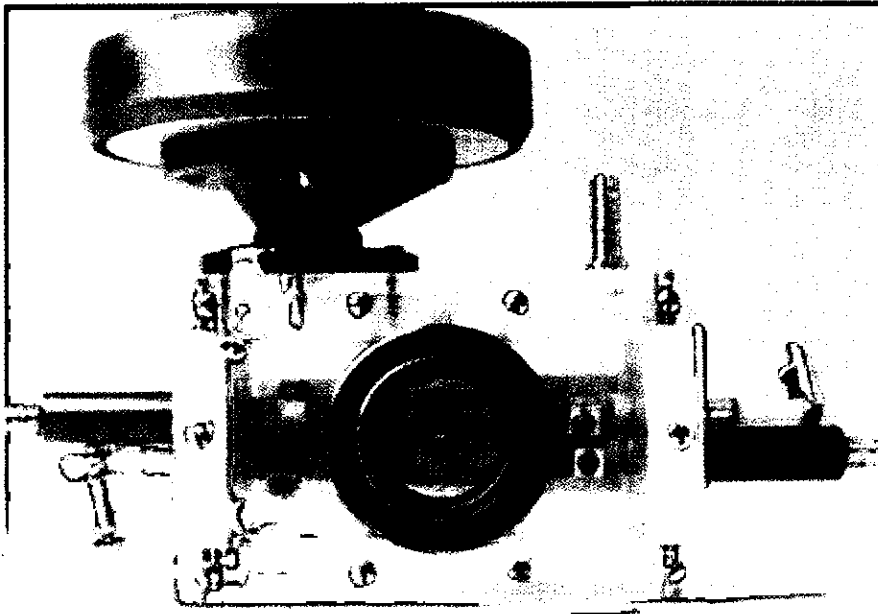


Fig. 8. View of the artificial lips in use at the University of Edinburgh; the mouthpiece of the instrument lies behind the lips. The horn loudspeaker mounted on top is used in studies of the mechanical resonances of the lips.

ory involved some drastic simplifications and approximations, but these were based on careful experimental studies, and on Bowsher's experience as an expert trombonist. The theory has had considerable success in explaining many of the small-amplitude features of brass instrument behaviour.

In the last ten years several attempts have been made to develop numerical models of the brass-player's lips, but success here has been more elusive than in the case of the reed woodwind instruments. A pair of human lips in a trombone mouthpiece is a system much harder to model as a simple driven, damped oscillator than is a clarinet reed; the equivalent mechanical parameters are difficult to quantify, and it is far from clear how many degrees of freedom are necessary to model the lip valve.

Recent work at Edinburgh has focused on an approach to this problem suggested by Gilbert and Petiot [11]: the study of the onset of self-sustained oscillation in a brass instrument driven by a pair of artificial lips. The lips are latex rubber tubes filled with water (see Figure 8), and can generate musically acceptable notes on a trumpet or trombone. By measuring both the mechanical resonance properties of the lips and the input impedance of the air column of the instrument being played, it is possible to test various possible models of lip-reed regeneration with realistic input parameters (Cullen, Gilbert and Campbell [12]).

Although the model of a wind instrument initially presented in this section presupposed a linear air column resonator, it has recently been shown by Hirschberg, Gilbert, Msallam and Wijnands [13] that when a very loud note is played on a trombone, shock waves can develop in the air column. It is interesting that this phenomenon, which explains the brassy blare characteristic of the instrument, depends on the localised non-linearity of the

flow control valve to create a rapid pressure jump in the mouthpiece, and also on the distributed non-linearity of high amplitude sound propagation which allows the wave front to steepen into a shock front during its passage down the tube.

Conclusion

Although great progress has been made in musical acoustics research over the last twenty five years, there are still many questions of fundamental importance to players and makers of musical instruments which remain unresolved. We may hope that at least some of these questions will be resolved in the next twenty five years, through a fruitful interplay between experimental measurements of real instruments, computer simulations using realistic models, and psycho-acoustical studies to ensure that our

results are both scientifically interesting and musically significant.

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This paper is presented on behalf of the Musical Acoustics Group.

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INFORMATION OVERLOAD?

John Seller MIOA

My aim in this short paper is to mention briefly some points which are of a personal interest to me after 30 years or so in acoustics; and which, as the European Commission's environmental noise programme gathers pace, I would hope to be worthy of more general reflection and discussion.

When I first started teaching acoustics we read sound pressure levels by eye from the fluctuating needle readings of sound level meters such as the Brüel & Kjær types 2203 and 2209. These instruments were bulky and heavy, and had separate filter sets which had to be bolted onto the main meter. The measurement of significantly fluctuating levels using a Fast time weighting was almost impossible; the meter reading was based on a scale with an effective range of little more than 10 dB on any setting of the range switch. Analogue tape recorders were necessary for audio recordings, and post-processing in the laboratory was awkward and time consuming without the benefit of personal computers. In short, any thorough programme of noise measurement was, by today's standards, a laborious undertaking.

Over the last 25 years we have witnessed the digital electronics revolution, which has naturally been incorporated into the acoustical instrumentation with which we now work. It has given us an almost unlimited capacity for data acquisition, storage and manipulation; and it has also enormously increased the scope of prediction models. Yet in environmental noise we have seen relatively little change in the basic nature of the indices we use. Fundamentally, we still quantify noise in terms of an A-weighted sound pressure level: indeed the L_{Aeq} value is likely to be adopted as the basis of the general harmonized European noise index.

When I started in acoustics this was certainly not the direction in which I, nor many of my contemporaries, expected the course of environmental noise to run. In the 1970s A-weighted levels were considered a poor relation of the much more complex loudness indices. But we didn't have the benefit of powerful computers and the task of calculating various loudness levels from spectral data was an onerous one; prohibitively so for routine field measurement. Our perception of the A-weighting network at that time was that of a relatively crude mechanism, adopted by default rather than by positive choice. It is worth repeating the Wilson Report's perspective in 1963: 'If it were possible to measure directly in phons (or sones), probably no other noise measurement scale would be used. Since, however, the measurement demands the resources of a standardizing laboratory, it is impractical for the majority of noise investigations.'

We have all taken part in the endless arguments over

the pros and cons of A-weighting in various circumstances, and I wouldn't wish to add to the agony here. It does seem paradoxical, however, that at a time when the technology to implement much more sophisticated noise indices is at our disposal, we should be poised to standardize on a method previously adopted because of technological constraints.

Our ability to generate and manipulate data quickly and easily is writ large in the growing trend towards 'noise mapping'. We will soon have the capacity to map large areas with a fine level of geographical detail, but I would question whether we are yet in a position properly to interpret and use such information. Fundamental questions will need to be addressed. For example, can we even begin to incorporate all important non-acoustic factors, and how limited will the value of noise maps be if we can't? How do we approach the problem of balancing increases in exposure for some against decreases for others, in what-if analyses? It appears as though the greater our ability to generate information, the more starkly the gaps in our knowledge are thrown into relief.

Our ability to resolve temporal detail has, likewise, increased dramatically in recent years. The short- L_{Aeq} is now in widespread use, allowing averaging times of only a few milliseconds or so to be implemented. Such resolution is of enormous practical value in many situations, allowing underlying noise levels to be easily discerned, individual events to be detected, and many sources to be identified. Short- L_{Aeq} records also serve as a salutary reminder of the variability and complexity of environmental noise signals, and hint at the corresponding complexity of subjective response. Yet as the European programme moves forward, statistical (L_N) levels are likely to fall by the wayside, and the trend appears to be for nominal yearly averages to be evaluated.

It seems to me that at a time when we can generate an overwhelming amount of data on our noise environment almost at will, there is a corresponding danger of being too reductive. The fundamental challenge in environmental noise remains the vagaries of human response, and our ability to understand and represent the noise environment with this in mind.

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This paper is presented on behalf of the Environmental Noise Group.

John Seller is Head of the BRE Acoustics Centre, Watford, Herts.

25TH ANNIVERSARY CONFERENCE: REPORTS OF TECHNICAL SESSIONS

John W Tyler FIOA

Building Acoustics

Chairman, Duncan Templeton

Sources of structure-borne sound in buildings: B M Gibbs, Liverpool University

The Building Acoustics session opened with Barry Gibbs describing the reciprocity principle, its measurement and experimental validation in the analysis of structure-borne sound transmission from machines to their supporting structures. The examples discussed involved fan base assemblies on concrete floors.

Building acoustics measurements: C Hopkins, BRE

Carl Hopkins discussed acoustic measurements applied to building material properties (wall ties and plasterboard were given as examples), performance of building elements (eg airborne and impact noise), connected building element performance (eg flanking transmission) and complete building performance (sound pressure and reverberation times). The advantages of making sound intensity measurements as compared with sound pressure level measurements in this field were discussed.

Elastomeric isolation mounts for buildings and structures from design to installation: A J Alder, Andre-Silvertown UK Ltd and K N G Fuller, Rubber Consultants

Tony Alder and Keith Fuller dealt with the use of elastomers as isolation mounts and described a recent project involving the construction of the new Stakis Metropole Hotel on elastomeric bearings to isolate the building from train vibration from the London Underground Bakerloo Line running tunnels. The building is on 14 floors resting at column bases on 250 mm thick spreader plates.

Architectural acoustics – research into practice: R Orłowski, Arup Acoustics

Raf Orłowski displayed some of Arup's considerable research and consultancy activities in the field of architectural acoustics including diffusion effects, audience and seating absorption, new sound absorbing materials, scale and computer modelling of room shapes and auralisation.

New horizons through glazing: C Inman, Pilkington Glass

Robin Wilson was unable to give his paper on the acoustics of porous concrete and we are grateful to Cliff Inman of Pilkington Glass who stood in at very short notice to provide a detailed overview of the effects of glass thickness, spacing, gas filling and the merits of double glazing, including PMMA, over double windows. Cliff's thirty years at Pilkington ensured an authoritative and interesting paper.

Electroacoustics

Chairman: Ken Dibble

The chairman reported an active session with each paper educating a number of questions and a lively discussion. Is it a coincidence that the chairman and all five speakers are familiar faces at the Reproduced Sound Conferences held in Windermere (now transferred to Stratford on Avon)?

Some results and experiences from subjective speech intelligibility tests: P Barnett, AMS Acoustics

AMS Acoustics has been involved in the science of speech intelligibility and in particular that associated with electroacoustic systems for the past 15 years. Circumstances often dictate that objective measures such as RASTI or STI are not applicable or would not accord with a subjective impression. In these cases either some adjustment has to be made or it is necessary to return to the more traditional methods of subjective testing. Peter Barnett's paper, delivered in his usual enthusiastic and knowledgeable manner, provided an insight to some of the basic issues and pitfalls of subjective testing.

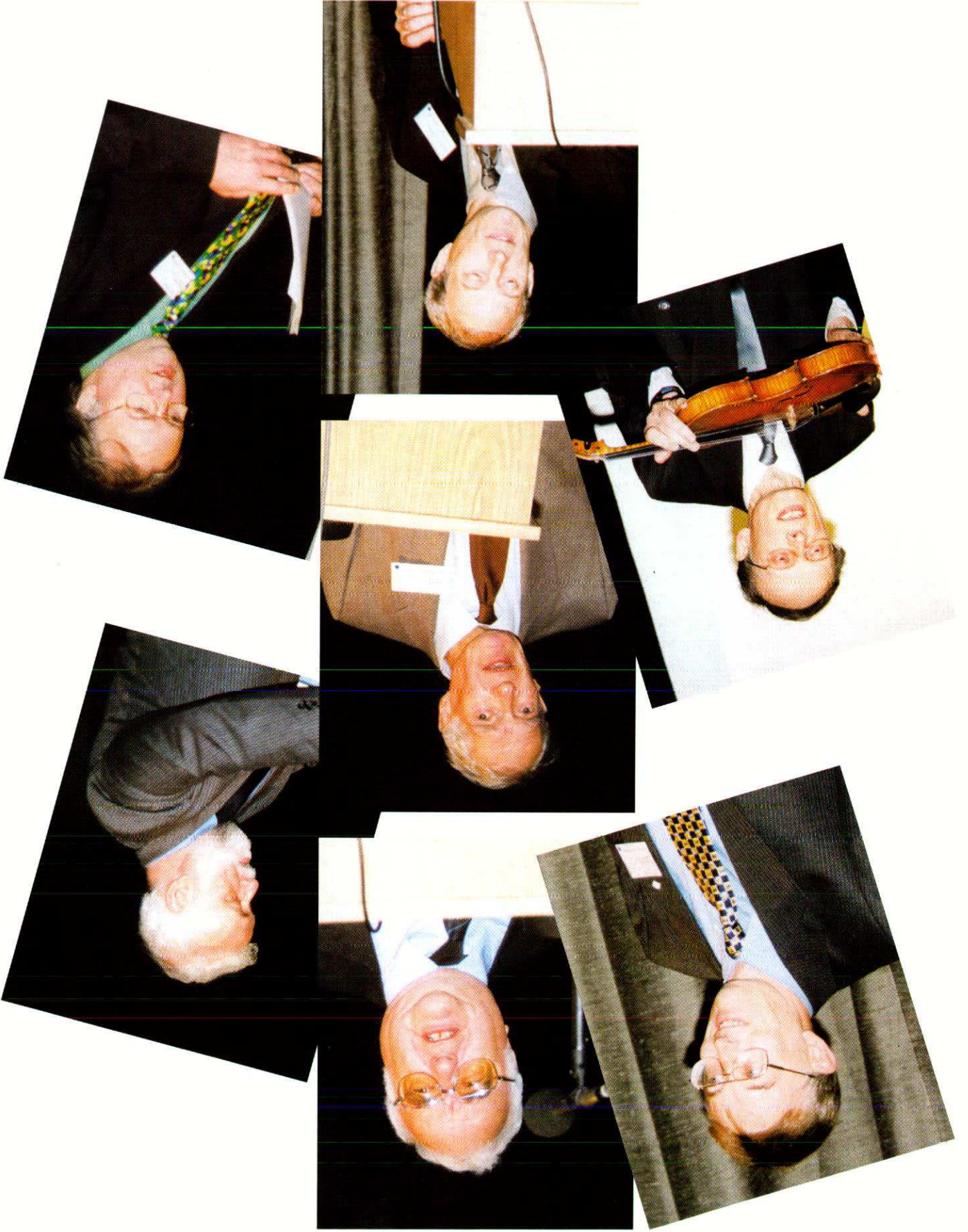
The balloon dance in electroacoustics: J A S Angus, University of York

Those delegates who attended last year's Reproduced Sound conference in Windermere will be familiar with James Angus's unconventional ways of illustrating his theories. In his paper, which was concerned with surface spherical harmonic analysis of a loudspeaker polar pattern, when describing the spherical harmonics he illustrated the phenomena using a bunch of balloons suitably shaped and held. This, together with an extreme clarity of presentation and touches of humour, contributed to the success of his talk and the session.

Measuring the future – a review of the state of the art

electroacoustic measurement techniques: P Mapp, Peter Mapp Associates

Peter Mapp gave a thought-provoking paper on the developments in electroacoustic measurement techniques and equipment, reviewing progress over the years and highlighting the effect of digital technology and increased computing power on the ability to measure and analyse data. He illustrated three new measurement techniques: polar animations, polar coherence/correlation and a spatial interference spectrograph and suggested that the next major influences are likely to be the introduction of psychoacoustic parameters and psychoacoustic modification to existing measures so that we will be able to better predict just how an item may audition or perform. Not to be outdone by James Angus, Peter produced a giant sized balloon shaped in the form of a microphone!



Presenters of the Keynote Addresses. Clockwise from top left: Roger Moore, Dudley Wallis, Bob Peters, Ken Dibble, Duncan Templeton, Murray Campbell. David Weston is in the centre.



From the left: The President, former presidents Alex Burd, Bernard Berry, Peter Wheeler, E Roland Dobbs, Chris Rice. Back view of David Weston.

Loudspeaker developments: J Wright, Celestion International

Julian Wright gave a fascinating survey of the changes in loudspeaker technology over the past 25 years. He dealt with advances in drive units, cabinet design and materials and design tools, eg computers, lasers and finite element analysis. He then looked to the future which he felt would include a greater emphasis on computer aided design, with FEA at the forefront. The field of auralisation is likely to make a major contribution to loudspeaker design, eventually providing the designer with the ability to experience his prototype in many different environments.

Audio and digital broadcasting into the 21st Century: A Mornington-West, Consultant

Allan Mornington-West, complete with trade mark tie-over-shoulder, closed the session with a most informative and clearly presented review of the future of audio and digital broadcasting, together with its ramifications, beyond 2000.

Environmental Noise

Chairman: Ken Collins

EU Noise Indicator; the DGXI Working Group position paper: I Flindell, University of Southampton

The session opened with a presentation from Ian Flindell

on the position paper being produced for the EU Noise Policy by WG 1, which relates to the EU noise indicator. Ian traced the history of the group and its work and then went on to tell us about the current position, whereby the Commission appears to be trying to ignore the views of its technical working group! Watch this space! *Noise from pubs and clubs – the good management guide: P Hepworth, Hepworth Acoustics Ltd* Peter Hepworth followed this by reporting on the progress of the proposed Code of Practice on noise from pubs and clubs. A trial to assess music noise on an octave band basis was carried out by a number of local authorities in 1998. In order to improve the robustness of the levels being recommended, the trial is being repeated over this summer. As

much information as possible is needed so the delegates present who represented local authorities likely to be interested in taking part were asked to contact John Hinton, Birmingham City Council.

Birmingham noise maps – a progress report: J Hinton, Birmingham City Council

John Hinton then gave a talk on the progress being made in producing noise maps for Birmingham. Progress is clearly good, as John was able to show us some sections



Presentation by the President to Frank Shaw

of the maps. The work that is being done is also helping to evaluate the information requirements needed to produce the maps, and the uses they can be put to, and this information is being fed into Working Group 4 (noise mapping) (EU Noise Policy), of which John is Co-chair.

Guidelines from the IOA/IEA Noise Impact Assessment Working Party: S Turner, Stanger Science & Environment
An update on the progress being made by the Working Party on the IOA/IEA Guidelines on Noise Impact Assessment was given by Stephen Turner. Stephen gave a brief history and explained that there were two different views within the committee as to the extent to which an assessment could be taken. Both views will be expressed in the draft document, which, hopefully, will be available in the summer.

Sleep disturbance and sleep prevention – what we know now: Nicole Porter, NATS

The session was rounded off by Nicole Porter who gave a presentation on the current state of knowledge about sleep disturbance and sleep prevention. Nicole started off by stating that she had been unable to get a definition of the purpose of sleep from the leading experts on sleep itself. It is not really surprising therefore, that there is no full understanding of the problem. Nicole's work on this topic is continuing and she promised to keep the IOA informed of progress.

Industrial Noise

Chairman: Andy Watson

A review of source identification and the quantification techniques: F J Fahy

Frank Fahy delivered this paper in his usual entertaining but equally important, clear and understandable manner. He dealt in some detail with the techniques designed to identify sources of radiation from the 'outer skin' of a noise generating system with special emphasis on the fundamental question of how to decompose spatially extended sources into independent components with attention paid to the difference between 'coherence' and 'correlation'. He reviewed devices and procedures which are available for locating sources of sound radiation under free field conditions together with comments on their merits and shortcomings.

Active noise control – how it works in practice: H G Leventhall, Technofirst

Geoff Leventhall presented active control as a successful method of noise or vibration control in a wide range of applications including the areas of hearing protection, noise from air conditioning systems (HVAC), transportation and industry. He explained the basic principle of active control whereby a system produces a sound wave which is an inverse, or mirror image, of the noise. This cancellation sound wave, which is of equal amplitude and frequency but of opposite phase, destructively interferes with the noise without physically blocking the sound path. Environmental problems from industrial sources often include lower frequency tones where active noise control works best. Attenuations of 25 dB or more are achievable on tones whilst broadband attenuation may be about 15–20 dB.

Health and Safety Legislation – where now?: Keith Broughton, Health and Safety Executive

Keith Broughton summarised the history of legislation to control noise in the work place starting with the Wilson Report in 1963, through The Health and Safety at Work Act of 1974, the Woodworking Machines Regulations also in 1974, the Social Security Act (Occupational Deafness) in 1975 to The Noise at Work Regulations in 1989. He then dealt with the Machinery Directive and Regulations 1992 which imposed specific duties on manufacturers with regard to noise and the declaration of emission values, and the proposed Physical Agents Directive which deals with the protection of workers from exposure to Physical Agents, of which noise is one.

He concluded an interesting survey of the subject by expressing the hope that with the further training of HSE general inspectors on the specific risks facing the work force from high levels of noise, together with cooperation from employers and employees, the incidence of noise induced hearing loss can be reduced significantly in the very near future.

Practical experience in the modelling of factory sound fields: David Lewis, Unilever Research

David Lewis then followed Keith's paper by exemplifying the efforts being made by industry to play their part in reducing hearing damage to workers by outlining the work done at Unilever in using computer models to predict noise levels in their factories. Computer simulation of noise levels in packing halls was first considered by the company in 1978 when Unilever was planning to build a new food production/packing facility in Italy. Since then the techniques have been developed and applied in around 20 projects both at the design stage of new facilities and to evaluate alternative noise control strategies in existing factories.

An engineering approach for the acoustic characterisation of aperture devices: B Petersson, J L Horner and R Lyons, University of Loughborough

In this paper, given by Bjorn Petersson, the apertures referred to in the title are the openings allowing the transfer of a fluid from one spatial domain to another, for example the movement of air in a ventilation system from one space to another, or the cooling of machinery or plants such as in transportation vessels and chemical or energy plants. Common to all applications is that some kind of device separates two fluid domains, the device having several different objectives. Among such objectives sound reduction is frequently prominent. The speaker outlined the practical and theoretical approaches to an attempt to provide a unified, generic treatment of the associated acoustic effects.

Measurement and Instrumentation

Chairman: Richard Tyler

A new acoustic measurement probe: the Microflow: E Druyvesteyn, H DeBree and M Elwenspoek, University of Twente, The Netherlands

This session opened with a paper presented by Professor Eric Druyvesteyn describing the Microflow, a new acoustical measurement probe that measures particle

velocity. The probe can be used on its own or in combination with a pressure microphone to realise measurement devices in single or multi-channel configurations.

Development of measurement microphones for harsh environments: G Rasmussen, GRAS Sound and Vibration, Denmark

Gunnar Rasmussen described the problems encountered in measuring in outdoor conditions, high temperatures, high pressure, high air speed and other harsh conditions. He outlined developments in the design and use of measurement microphones to resist the effect of these conditions.

Development of a measurement system for very low sound pressure levels: O H Bjor and G Bernhard Ese, Norsonic AS, Norway

Gustav Bernhard Ese presented a novel system for the measurement of very low sound pressure levels using two microphones in a face-to-face configuration. The signals from the microphones are multiplexed so that the uncorrelated components of system noise are removed, yielding a reduction of at least 10 dB in the lowest A-weighted level that can be measured.

From sound level meter to sound meter: P Darlington and P J Duncan, University of Salford

The processing power available in modern instruments allows them to extract information describing the sound or the sound's source. Philip Duncan illustrated the potential with example applications that use artificial neural networks to determine loudness and reverberation time and to perform source identification.

The VAS: a new non-contact sensor for measuring surface vibration: F J Fahy, ISVR, University of Southampton and P Godano, Rieter Automotive Management, AG Switzerland

Frank Fahy described the development of a new contact sensor for measuring surface vibration at frequencies up to 400 Hz. The final version employs 16 pressure difference microphones embedded in a perforated plate to realise a practical device whose sensitivity, linearity, dynamic range and immunity from noise have been determined.

Musical Acoustics

Chairman: Murray Campbell

Some observations of the output and distribution of organ sound: P Comerford and L Comerford, University of Bradford

Lucy Comerford presented measurements of the sound output and distribution of radiation for a small portable pipe organ. This work is part of a European-funded programme aimed at improving the design of pipeless (electronic) organs, and is being carried out at the Microcomputer Music Research Unit at the University of Bradford. Peter Comerford, who is also involved in the project, commented on some of the practical problems.

Pragmatism, noise risks and orchestras: A Wright-Reid, Consultant

Alison Wright-Read gave an interim report on a project commissioned by the Association of British Orchestras to assess and control risks to the hearing of orchestral

players. It seems clear that it is very difficult for orchestras to comply strictly with the Noise at Work Regulations, but many professional players report that worrying about hearing loss is a major stress factor in their jobs. This project is attempting a comprehensive survey of the problem, and an extensive menu of possible control measures has been drawn up, including the use of screens and personal hearing protection.

Modelling the friction of rosin: J Woodhouse and J H Smith, University of Cambridge

Jim Woodhouse has for some years been working on the interaction between the string of a violin and the hair of the violin bow, and he presented results of an investigation of the frictional properties of the rosin applied to the bow hair. This work was carried out with J H Smith at the Department of Engineering at Cambridge University. It appears that the bow string friction is determined not primarily by the relative velocity, as has been previously assumed, but by the temperature of the rosin. A new constitutive model was proposed and the preliminary tests discussed.

Acoustical parameters for stringed musical instruments: B Richardson, University of Cardiff

Bernard Richardson reviewed the current understanding of guitar acoustics. One of the most fascinating aspects of the acoustics of stringed musical instruments is understanding how, and to what extent, the maker can control the playing and tone qualities of the completed instrument by active choice of design and selection of materials during construction. The vibrating strings couple to the structural and air-cavity modes of the body. These in turn interact with the surrounding air thus enhancing the radiation of energy from the string to the listener. The modal properties of the instrument are thus of central importance in determining its sound quality, but it is unclear what is the relative importance of each mode and how they can be controlled by the maker. This paper draws together the experiences of acousticians and makers and presents a simple physical model, which, combined with psychoacoustical listening tests, has helped to demonstrate the important acoustical parameters governing the instrument's tone quality.

Measurement of musical wind instruments using acoustic pulse reflectometry: D Sharp, Open University and J Buick, University of Edinburgh

David Sharp, now with the Department of Environmental and Mechanical Energy at the Open University, reviewed recent work on the technique of acoustic pulse reflectometry, carried out in collaboration with Jim Buick at the University of Edinburgh. He showed that reconstructions of the internal bore profiles of brass instruments could be obtained with good accuracy, and discussed some of the problems involved in extending the accuracy of the method.

Speech and Hearing

Chairman: Stephen Cox

In the morning keynote session, Professor Roger Moore of DERA had pointed out that speech research is multidisciplinary and the Speech Group had originally been

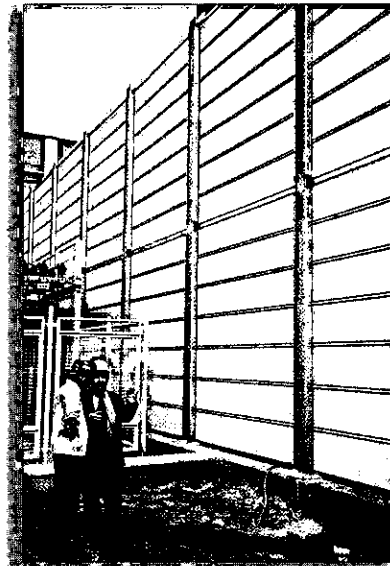


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The staff from the Institute's office: from the left Linda Canty, Joanne Steadman, Sue Omasta, Ann Hogg and Lukman Miah

formed with the aim of bringing together workers in fields such as linguistics, engineering, psychology, computer science etc.

The afternoon session reflected this motivation, with papers on the two major areas of speech technology – speech synthesis and speech recognition – which drew on ideas from these disciplines.

Some issues in synthesising natural speech: M A A Tatham of the University of Essex

This paper showed the importance of linguistic knowledge and insight in the problem of synthesising natural sounding speech using concatenation of waveforms. Professor Tatham described the philosophy underlying the development of the SPRUCE system, which relies on the definition of different levels of linguistic description of speech units. He demonstrated the importance of these distinctions (which are not used in current speech synthesis systems) by playing some examples of synthesis and going on to show how the principles could be applied to manipulating the recorded database in concatenated waveform synthesis to provide an effective increase in its size.

Making speech recognition more robust to different voices: S Cox of the University of East Anglia

This paper showed how ideas from acoustic phonetics (vocal-tract length normalisation), psycho-linguistics (prediction of sounds) and linguistics (detection of accent) have been used in adapting speech recognisers to the voices of new speakers to make them more robust.

The session ended with a panel discussion on the future of speech technology. Dr Cox began by presenting some ideas on how speech technology might be used in the future: it would be one of a number of possible user interfaces and would need to work much more robustly and naturally to gain widespread acceptance by users. The challenge now was to integrate it into applications that are beginning to emerge and that make use of the

mobile communications and Internet technology. The ensuing discussion was wide ranging, with contributions from the floor on such topics as the use of speech technology in vehicles, the nature of the technology used to automate automatic telephone services, the engineering of personality etc.

Underwater Acoustics

Chairman: David Weston

Modelling the performance of sonar arrays in complex, range dependent environments: R J Brind, DERA Winfrith

The shift in emphasis in the sonar research field since the end of the Cold War, from open ocean scenarios involving nuclear-powered submarines towards operations in littoral waters against small and quiet conventional

submarines, has increased interest in expendable underwater acoustic surveillance systems that can be deployed rapidly and at short notice to new areas of operation. Richard Brind explained that the fixed nature of these systems introduces the possibility of complex array configurations, including vertical line arrays, large aperture horizontal line arrays which exploit the arrival angle structure of the acoustic field.

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He described the models that have been developed to predict the acoustic response of such arrays in shallow and deep water environments and gave examples of the results obtained. The talk, which was well received, brought out the complex nature of the problems.

Synthetic aperture sonar: H Griffiths, University College London

Hugh Griffiths talking on synthetic aperture sonar had a much smaller canvas which allowed him to delve much deeper into the interesting questions which arise.

Sidescan sonars are now a widely accepted and important tool of ocean technology. Broadly they fall into one of two classes, the short range high resolution systems working at relatively high frequencies (about 100 kHz) and the long range low resolution systems working at 10 kHz or less. The former have a wide range of applications in surveying of oil wells, pipelines and shipwrecks, as well as in defence in mine hunting. The longer range systems have contributed significantly to the study of the deep ocean floor. The techniques of aperture synthesis have their origins in radioastronomy and sideways looking radar and it was in the 1970s that engineers began to consider the application of the principles to sonar systems. The paper provided a review of the principles of synthetic aperture sonar, highlighted some recent results and considered what might be possible in the future.

Finite element modelling of underwater acoustic transducers: J Dunn, University of Birmingham

James Dunn's paper on the finite element modelling of

acoustic transducers brought out well what an important part these techniques have played in the design of transducers, replacing a lot of practical trial and error in modifying designs which would otherwise have been developed initially by very approximate analytical methods. Additionally, they have aided understanding of why apparently simple designs may not work in the way expected.

Celebration Luncheon and Presentation to Frank Shaw

An excellent lunch was provided by the Barbican staff which enabled delegates to relax and prepare for the following technical sessions. The opportunity was taken to make a presentation to Frank Shaw.

Citation

The IOA's Engineering Division was first set up in 1988 by Peter Lord, working closely with the membership department of the Institution of Mechanical Engineers, under whose auspices our candidates for Chartered Engineer were proposed.

Frank Shaw, who is a long-serving member of the IMechE Membership Committee, has taken part in all our CEng interviews over the past ten years. He has then acted as the advocate of our candidates when their applications were considered by the Mechanicals.

Frank has worked tirelessly over many years for the engineering profession, and in particular for the IOA, hosting, for several years before we had our own HQ premises, our CEng interviews at the Sir Henry Royce Memorial Foundation in Towcester, of which he is Chairman.

Frank had celebrated his 83rd birthday a few days before the conference but he shows no sign of cutting down his work for IMechE or the IOA.

The Institute welcomed the opportunity to mark Frank Shaw's contribution to the IOA by presenting him with the gift of a camera (his choice!) – the latest APS type with auto everything; thus nothing for an engineer to fiddle with!

Annual General Meeting and President's Reception

After the main business of the conference the Annual General Meeting of the Institute was held in one of the two cinemas at the Barbican.

The attendance was markedly higher than is normal for this important part of the Institute's year; this may have been due to its location – it was difficult, without showing some interest in the AGM, to get to the final event of the day; the President's champagne reception, which was also well attended, gave delegates time to discuss the events of the day and wind down before facing the journey home.

Thus ended a unique, enjoyable and it is hoped useful, event in the Institute of Acoustics calendar for 1999; which taken together with the other conferences has made the year one to remember during the first 24 years of the next 1000!



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ENGINEERING COUNCIL QUARTERLY REPORT: March 1999

Malcolm Shirley CEng

The approaching millennium is acting as a trigger for many organisations to appraise their direction, and for the engineering profession the countdown coincides with a period of reflection on the role and direction of the Engineering Council.

It is now more than three years since the Council was reformed to provide leadership and to serve as the voice of the profession. The shaping of the Council, and its role has been an evolutionary process that many feel has reached a landmark stage. Are we serving the profession, and above all the professional engineers and technicians that are its lifeblood, as effectively as we could? What can we do to further improve our relationships with Government, the wider engineering community, academia and the general public?

For this reason a review of our activities, *A Way Forward*, has been undertaken to resolve key issues and provide markers for a set of new policies and practices. This review is complementary to the long term strategy document – *Engineering 2005* – which is currently being refined having been developed in consultation with the profession.

The thinking going into the strategy initiative is to create a clearer and more productive relationship between the Council and the Institutions focussed on the optimum use of the profession's shared resources to best meet the needs of registered engineers and technicians.

No organisation is any longer immune and isolated from the process of continual change experienced by the competitive world of the industrial and business community. We ignore change at our peril – more than ever our policies must be focussed on being responsive to the expectations of our customers – principally Registered engineers, the Institutions, and industry and business that will provide careers for the bright young people we need to encourage into the profession.

In short, the Council must be more flexible and dynamic if our ambitions are to be realised, which means that our unique role as the voice of the whole engineering profession and as an engine of change in matters affecting engineering must continue to be developed. It was to achieve this flexibility, and to reflect the continually changing environment within which the profession operates, that we embarked on our Activity Review.

The Engineering Council's current commitments allow us little scope at present to take on board new tasks and initiatives, and mechanisms need to be devised to be as flexible as the commercial world around us. Economies have already been achieved and

I am convinced that working to make the Council into a leaner operation will result in us being able to focus better on bringing more benefits to our registrants. With the help of the Institutions an implementation programme is now in hand.

This strategy will enable the Council to deliver its commitment to arresting increases in the registration fees, and I personally have already committed the Council to no increase in fees for the year 2000.

Already, though, the Engineering Council's role and effectiveness have developed in the comparatively short period since it was established in its present form. One of the most successful areas of our strategy has been the raising of the profession's credibility and influence among those in Government and in Whitehall.

We have taken – and been offered – numerous opportunities to state to the Government the profession's views on a wide range of issues. It is a demonstration of the effectiveness of the profession's partnership arrangements that Institutions, on the Council's behalf, co-

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ordinated responses during 1998 to more than 40 consultation exercises originating from Government departments or agencies.

Again, these exercises would not be possible if it were not for the expertise within the Institutions to respond authoritatively on topics as diverse as the National Curriculum and issues of sustainability. In turn, these responses have contributed to the closer rapport we have with Ministers, their civil servants, and MPs, facilitating dialogue on the profession's key issues.

A core mission of the Council is to promote engineering as a career for the brightest and most talented young people, and this is the main aim of the National Marketing Campaign, which we are conducting with the EEF and EMTA, with the backing of Government. Integral with this, of course, is the task of ensuring that the UK has an educational framework able to adequately prepare them for the requirements of engineering further or higher education.

We have been concerned that the commitment at secondary level to the relevant subjects, mainly science and design and technology, is inconsistent and vulnerable to downgrading in the amount of resource. Particular concern over the future of National Curriculum design and technology for 14-16 year olds led us to make a representation directly to David Blunkett, the Secretary of State for Education and Employment.

These subjects form the foundations of building a technologically literate society. Technology increasingly

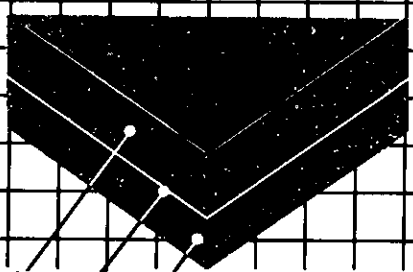
influences how we lead our lives – from the sophistication of home entertainment to the influences of information technology on working practices, and business processes and systems. Better understanding is vital. And, of course, experiences at school, particularly among students at the formative 14-16 age group, can generate interest in the 'how and why' of mechanisms, systems and processes and enthuse them into becoming the engineering professionals of tomorrow.

With this high level of activity, the Council is progressing into the next phase of its development under the leadership of Dr Bob Hawley, who was elected as Chairman of the Senate in February. He brings to the Council the accumulated benefit of his extensive background as an eminent engineer, an industry and business leader and as someone with an unrivalled knowledge of the profession and the issues it faces.

Bob Hawley succeeded Alan Rudge, who piloted the Council through the challenging three years since the Council's relaunch. Alan's contribution as one of the leading architects of the current high standing of the Council and the profession will be missed – not only for his visible role but for the incalculable hours of his personal time that he devoted to profession activity. It is up to all of us to build the standards and unity of the profession on this firm foundation.

Malcolm Shirley CEng is the Director General of the Engineering Council ♦

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<http://www.brad.ac.uk/acad/civeng/acoustics/main.html>



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Hansard

22 March 1999

Road Noise Mitigation

Mr Shaw: To ask the Secretary of State for the Environment, Transport and the Regions what progress he has made on the proposals for noise mitigation on existing trunk roads announced in *A New Deal for Trunk Roads in England*.

Ms Glenda Jackson: My noble Friend the Under-Secretary of State announced today that we have established criteria and a budget to deal with some of the most serious and pressing cases of traffic noise on existing trunk roads as promised in *A New Deal for Trunk Roads in England*.

The Government recognises that excessive traffic noise is an important issue for many people. Noise mitigation was not required on roads built before 1969, and in many cases the mitigation provided on roads built between 1969 and 1988 (when the approach to assessing traffic noise was changed) was based on unrealistically low predicted noise levels. This means there has been inequity in the treatment of residents living close to certain trunk roads built before 1988. To help us identify the most serious and pressing cases we are today establishing criteria which will be used in an initial sift. Cases satisfying these sift criteria will be studied in greater depth to determine whether practicable and cost effective mitigation can be provided. An annual ring-fenced budget of £5 million has been set aside to deal with the most serious of these trunk road cases in England.

Our new sift criteria for noise mitigation will be

(a) trunk roads must have been opened before June 1989, but priority for attention is to be given to locations affected by roads which have remained unaltered since October 1969 (the qualifying date for the first noise mitigation measures);

(b) current (ie 1998) noise levels immediately adjacent to the road to be at least 80 dB(A); and

(c) in the case of roads opened or altered after October 1969 the current noise levels must be at least 3 dB(A) greater than predicted for the designated year.

As far as Wales and Scotland are concerned, this will be a matter for the Welsh Assembly and Scottish Parliament who, after devolution will be responsible for trunk roads in Wales and Scotland.

24 March 1999

Noise Levels (Work)

Mr Michael Clapham (Barnsley, West and Penistone): I am pleased to have secured the debate because, although this may not be the sexiest of subjects, tens of thousands of workers are exposed to excessive noise levels every day. I am also pleased that the Under-Secretary of State for the Environment, Transport and the Regions, my hon Friend the Member for Mansfield (Mr Meale), is to respond. I know that before becoming a Member of Parliament he worked in industry and that at one point he

was a workers safety representative. He would have been appointed under the Safety Representatives and Safety Committees Regulations 1977, which were introduced by a Labour Government. In the ensuing years the safety of British workers improved, but evidence suggests that in the late 1980s and 1990s the working environment deteriorated in many establishments.

According to the current Health and Safety Executive estimates, 13 million workers are exposed to noise levels in excess of 85 decibels. That is the threshold and increases will affect hearing. The connection between noise and hearing loss is well documented. According to an earlier HSE study of self-reported working conditions, 170,000 workers suffered from some form of deafness such as dullness of hearing or tinnitus – ringing in the ears.

I think that anyone would find those figures alarming and they prompted the Royal National Institute for the Deaf and the Trades Union Congress to act. They concluded that there had been insufficient compliance with the regulations, and also that the regulations had not been applied properly, perhaps because of a lack of awareness among employers. The guidance accompanying the Noise at Work Regulations 1989 make it clear that all hearing loss caused by exposure to noise is preventable.

When the all-party parliamentary occupational safety and health group, which I chair, met on 16 March, it heard evidence from manufacturers of personal protection equipment, and some interesting statistics were given. For instance, 300 million earplugs are used each year in the European Union. In Germany the figure is 85 million, and in the UK it is 65 million. Interestingly, although Sweden has a much smaller population, it uses 2.5 times as many earplugs as the UK. The man who made the presentation said that he thought that was due to an increasing awareness resulting from teaching in Swedish schools which motivated young people to protect their hearing with earplugs and similar equipment rather than merely complying with the law.

The RNID and the TUC decided to join forces and conduct a survey of UK industry. They issued 6,000 questionnaires, and the replies resulted in a report entitled *Indecent Exposure*. The findings confirmed the worst fears of both bodies. Nearly a quarter of respondents reported listening to uncomfortably loud sounds for more than four hours a day. Nearly one in five construction workers, more than one in 10 manufacturing workers, and a number of oil rig workers said that they were exposed to such sounds for more than eight hours a day. A third of respondents said that their tasks left them with dull hearing, and 16 per cent of those said that the dullness of hearing continued after work. Twenty per cent of respondents reported that their tasks left them with ringing or rushing noises in their ears or heads for at least five minutes. I hope that my hon Friend the Minister will take those findings seriously.

The survey also found that new workers, as well as those in the traditional industries, risked hearing loss. That confirmed earlier research – which my hon Friend may well have seen – done by the Labour Research Department, which found that workers in call centres, couriers and

workers in restaurants were at risk. The police are also at risk, as they now use phonac devices that fit into the ear canal and pipe noise directly into the ear. The noise to which those newer workers are exposed comes from a different source: it is not the ambient noise with which the 1989 regulations were intended to deal.

Alarming, the RNID and the TUC found that people working in call centres were given no advice about the risk to their hearing, and that none had been given any hearing tests – although, as things stand, tens of thousands of people are likely to become deaf in their 20s.

Indecent Exposure is not just about statistics. Its aim was to show the impact that deafness has on people's lives, and to that end a number of case studies were conducted. I shall refer to a couple of those, but the Minister and his officials can examine them at their leisure. One is the case of a young woman working in a call centre... She does a 40-hour week at a centre, working eight hours per day... She talked of being subjected to a high-pitched bleep through her headphones whenever new calls came in, it told her that someone was in the stack waiting to be put through. There was much background noise: 80 to 100 people were working in the call centre. Consequently the sound coming through the headphones needed to be turned up, so that she could understand the message.

After a while, that lady began to notice that she had hearing loss. She went for a hearing test and it was diagnosed that she had a 10 decibels hearing loss. She went back to work and, within five years, she found that her hearing was deteriorating further and that she was having trouble understanding some of the messages. So she went to her medical adviser for further diagnosis and was found to have a 20 decibels hearing loss. That young lady is 29 years old and has been told that she will have to wear a hearing aid.

The name of the person involved in the other case is in the study *Indecent Exposure*. She is a 48 year-old retired police officer. She had to retire because of hearing loss that was later ascertained to have been caused by the phonac device that she used in her ear. Although it was agreed that she was incapacitated to work in the police force, she had to fight in the courts to establish that her incapacity was the result of an injury at work. When the phonac device was tested for the court case, it was found to emit noise levels of 100 decibels.

One theme runs throughout all the case studies: people were afraid to raise the matter with their employer. That says a lot about the need for robust fairness at work legislation. People were afraid for their jobs and afraid to raise the fact that they were working in conditions that were endangering their hearing.

What can be done? I ask my hon Friend the Minister to bear in mind five points. First, the 1989 regulations, which deal with ambient noise, but are nevertheless important, need to be enforced. We need to ensure that the Health and Safety Executive takes on board the need to enforce them. Secondly, will my hon Friend request that the Health and Safety Executive provides guidance on the use of earphones and other devices that pipe noise directly into the ear?

Thirdly, will the Minister call for more research to find out the ways in which noise that is piped directly into the ear affects hearing loss? I think that if noise is piped directly into the ear, hearing loss occurs more quickly. Fourthly, such research could uncover an engineering solution to the problem. It is an issue that needs to be looked at. If he asks the Health and Safety Executive to undertake research, will he ask it to look particularly for an engineering solution to the problem?

Finally, the disease is prescribed, but the prescription is not wide enough to cover new industries. It needs widening. We need to involve the Industrial Injuries Advisory Council. I realise that that is not within the Minister's remit, but I hope that he will bring the matter to the attention of his colleagues in the Department of Social Security because there is a need to look at that aspect.

Although much of traditional industry has disappeared or radically changed, as shown by the figures that were produced by the Health and Safety Executive, and particularly by the findings of the report *Indecent Exposure*, noise at work is still a big problem. Thousands of call centre workers in their 20s could lose their hearing, as could many police officers and couriers, another group of workers that use earphones. They were also referred to in the report.

The message that needs to come from the debate is that employers should comply with their duties to protect their staff, that the Health and Safety Executive needs to enforce the Noise at Work Regulations 1989 and that it needs to undertake more research into the matter.

The Parliamentary Under-Secretary of State for the Environment, Transport and the Regions (Mr Alan Meale): I congratulate my hon Friend the Member for Barnsley, West and Penistone (Mr Clapham) on securing the debate, which is aimed at raising awareness of the risks associated with exposure to loud noise at work. He has campaigned on health and safety matters since the first day he was in this place. It is always a pleasure to listen to him. Before coming here, he spent most of his working life doing exactly the same. His is a voice worth listening to in every respect.

It is timely to discuss health and safety issues such as noise at work, particularly as we approach the 25th anniversary of the Health and Safety Executive, which was established following the Robens report. I am familiar with the RNID-TUC report entitled *Indecent Exposure*. It contains much with which I agree, so I add my support to the report and to the RNID campaign on noise at work. I am sure that many other hon Members will support the report, including my hon Friend the Member for Peterborough (Mrs Brinton), who is also deeply involved in investigating noise issues. I apologise sincerely for not being able to attend a recent event – I think that it was last week – to highlight all the problems concerning deafness and to launch the report. That was because of a prior engagement.

Hearing loss is a terrible thing. Deafness or partial hearing has a major effect on the quality of life of those affected by it. Some people lose their hearing as they grow older, but the hearing of far too many people

becomes impaired due to a working environment that is plainly too noisy.

Many people do not understand how big the problem is, but last night, yet again, I experienced the problems that are caused by deafness. Not many people in this place know that my hearing is below 50 per cent in both ears. I go through life with people around me becoming slightly amused because I do not seem to have heard, or noted something that they have said. That is a dilemma. It is a problem that many people experience. Having said that, in my profession such an ailment can sometimes be an advantage. It is probably the only profession where that is so.

Noise-induced hearing loss that is caused at work is a serious and significant occupational health problem. Although many cases result from exposure before current legal controls were in place, too many people at work are still potentially at risk. Exposure levels for many workers remain considerable. Research by the Health and Safety Executive in *Self-reported work-related illness in 1995: results of a household survey*, which was published in 1998, suggest that as many as 170,000 people in Great Britain consider that they suffer from a hearing or ear problem that is caused or made worse by their work.

The Health and Safety Executive estimates that about 1.3 million people, in 88,000 workplaces, continue to be exposed to damaging noise levels. The 2 m rule is simple – if people less than 2 m away find it difficult to hear one speaking, there may be a noise problem. Exposure to loud noise at work is covered by legal controls and guidance. I believe that there is no excuse for anyone's hearing to be impaired because of loud noise at work. A range of legislation deals with noise at work and with making noisy machinery quieter.

As my hon Friend said, the Noise at Work Regulations 1989 are the mainstay in tackling noise problems at work. The regulations implement a European Union directive, so that legal controls on noise are common across the European Union. The regulations require employers to reduce noise risk to the lowest reasonable and practical level, and to take specific actions at certain noise levels. The actions include reducing noise, conducting noise assessments, providing information and training for employees, and providing personal ear protection when appropriate. The action levels have been determined on the basis of dealing with practical risk and cost.

The regulations apply also to all people at work in Great Britain who are exposed to loud noise, except on ships at sea and on aircraft that are taxiing or in flight. Last year, the regulations were extended to cover the offshore industry. Therefore, the regulations cover all the industries that we associate with noise, such as foundries or engineering businesses. Unfortunately, as yet they do not cover this place or places like it, although such places are covered by other protection.

The regulations also cover the noisiest workplace such as call centres and those in the leisure industry. Employees in those industries are protected by the legislation, and it is the job of employers in those industries to ensure that the legislation is properly applied. There are legal duties also

on manufacturers & suppliers of noisy equipment to reduce noise levels and to provide the information to buyers.

The Supply of Machinery (Safety) Regulations specifically require manufacturers to take action to reduce noise from new machinery and to provide noise data. Such action is important, as one of the main ways – undoubtedly the best way – of reducing exposure to noise is to reduce the noise at source. As one might expect, design safety is good safety. I take note of my hon Friend's point that engineering solutions to noise are the best way forward. I shall inquire into whether work should be done on the matters that he mentioned.

Rest breaks from noisy areas are, as my hon Friend said, an important part of dealing with noise. The Health and Safety Executive recommends rest breaks, which can be good in helping employees to recuperate and providing a rest from wearing ear protection.

Noise levels have to be averaged over an eight-hour period. The longer people have to work, the lower the levels of noise to which they are allowed to be exposed. The legal requirements, if followed, would substantially reduce the risk of hearing loss. I reiterate that it is up to employers to apply the regulations, and that the Health and Safety Executive will take appropriate action to ensure that they do just that.

We all, however, have a responsibility to recognise noisy workplaces and to work together to protect people's hearing. We have to be aware particularly of people with hearing difficulties, who may be more vulnerable in the workplace and have to be managed with additional care. My hon Friend will know that, shortly after this Government took office, we asked the Health and Safety Commission to re-examine the issue of occupational deafness and to devise new ways of minimising the incidence of hearing loss. I tell my hon Friend that the Health and Safety Executive will continue to target noise at work as one of its priorities and that it has developed a long-term strategy to tackle the problem. The Government supports that strategy – which is to increase awareness of the risks to health, to ensure compliance with current requirements, and to prosecute when appropriate, to offer practical advice on ways of reducing noise levels, and control exposure at the place of work.

The Health and Safety Executive has been pursuing strategy since 1995, as part of its *Good Health is Good Business* campaign. The campaign now has renewed impetus, aided by the significant new resources that Government have invested in the Health and Safety Executive. I assure my hon Friend that noise continues to be highlighted in the planned next phase of the campaign.

My hon Friend also mentioned health and safety guidance. HSE guidance on noise includes revised guidance on legislation, entitled *Reducing Noise at Work*, which was published last year. A Health and Safety Executive book, entitled *Sound Solutions* includes 60 case studies of real examples from industry of how successful noise-reduction methods have been introduced. A range of free leaflets on noise, for both employers and employees, is available.

Securing compliance with the law is crucial. HSE's long-term strategy aims to improve the quality of risk assess-

ment of noise by employers. Risk assessment will be stressed by inspectors. As my hon Friend will know, the Government have made more resources available to the Health and Safety Executive – so that there will be more inspectors to enforce health and safety law, such as that on noise, and so these inspectors will promote more effective control of exposure to noise by encouraging the introduction of quieter machines or processes and by improving compliance with the supply-side legislation. Inspectors will also promote the effective use of purchasing policies and application of control measures. The correct use of ear protection is vital. Employees, too, have responsibilities to protect themselves by complying with notices and wearing ear protectors.

The aim of my reply to the debate has been to reassure the House of the Government's commitment to tackle noise at work. I hope that I have given my hon Friend some comfort on the concerns that he expressed. Three specific matters seemed to trouble him – in what he has described as the new sectors of the economy – and I should like to say a little about each of them.

First, the *Indecent Exposure* report which my hon Friend mentioned rightly emphasises the worries of those who are employed in call centres about the risk to their hearing. A study is in hand to identify the health and safety aspects including noise hazards of working in call centres. The results of the study will inform decisions by the Health and Safety Executive on what action has to be taken.

Secondly, the problems encountered by motorcycle couriers are similar to those of people working in call centres, as both jobs involve using communication headsets or ear pieces. Previous Health and Safety Executive research has drawn attention to the problem, and there is, in its *Reducing Noise at Work* guidance, general advice on measuring noise exposure to workers wearing headsets or ear pieces. There is also the prospect of a new international standard on such exposure.

My hon Friend's third concern was on the effect of excessive noise on employees working in pubs and clubs. He will be aware that I take a personal interest in the issue, particularly as it affects those working in areas in which large numbers of people gather. The Health and Safety Executive has completed some research on the matter, and plans are well advanced for a study of the leisure industry to discover more about real noise levels for those working in pubs and clubs. That research, too, will inform the executive on what action has to be taken to combat the problem. Such initiatives are important.

I make it clear that the Government are not complacent about noisy workplaces. There is legislation to tackle the problem of noise at work, and there will be more inspectors to enforce health and safety law. The Government and the Health and Safety Executive will do all that we can to reduce noise-induced hearing loss, and we intend to work closely with the RNID and the TUC to that end.

I give my hon Friend the assurance that he asked for on the three or four matters on which he asked for further information and research.

14 April 1999

Noise Exposure

Mr Clapham: To ask the Secretary of State for Social Security what representations he has received about the need to extend to new industries arrangements for monitoring for noise exposure.

Mr Meale: I have been asked to reply. *The Noise at Work Regulations 1989*, which require employers to make arrangements to assess their employees' exposure to loud noise at work, apply to all industries, including new industries, with the exception of ships at sea and aircraft taxiing or in flight.

15 April 1999

City Noise Maps

Mr Laurence Robertson: To ask the Secretary of State for the Environment, Transport and the Regions what progress he has made on the introduction of city noise maps; what estimate he has made of the costs of such maps; who will be responsible for meeting such costs; and if he will make a statement.

Mr Meale: My Department has been working with Birmingham City Council, which is mapping the City of Birmingham, to evaluate the usefulness and effectiveness of noise mapping as a tool in action. We expect the report of this work, which will assist in estimating the costs of such maps, to be published this summer. The work carried out in Birmingham will help to inform the European Commission's future proposals on ways in which to tackle noise.

15 April 1999

Noise at Work

Lord Ashley of Stoke asked Her Majesty's Government: What action they are taking to minimise the risk to hearing from noise at work.

The Parliamentary Under Secretary of State, Department of the Environment, Transport and the Regions (Lord Whitty): My Lords, there is substantial legislation in place requiring employers and others to take action to reduce the risk to hearing from noise at work. The Health and Safety Executive and other enforcing authorities are continually working to increase awareness of the risks to health from noise, to ensure compliance with the legislation, to offer practical advice and guidance on ways to reduce noise levels and to control exposure to noise at work.

Lord Ashley of Stoke: My Lords, I declare an unpaid interest as president of the RNID. Is my noble friend aware that although I welcome the constructive nature of his Answer, the evidence points to the fact that the Health and Safety Executive is failing because many employers are unaware of their obligations under the Act and do not comply with the regulations and because many workers are unaware of the dangers to their hearing from noise at work. Does my noble friend on behalf of the Government agree that the next step is for the Government to monitor more closely the work of the Health and Safety Executive and to do what they can to help it to

achieve a really significant change to prevent thousands of British workers suffering hearing loss?

Lord Whitty: My Lords, there are still areas of British industry, particularly the newer ones, which are not fully aware of the regulations and which are not fully enforcing them. Nevertheless, the Health and Safety Executive has made substantial efforts to provide information to employers and others. Its leaflets on reducing noise at work and *Sound Solutions* have received very widespread circulation. Bearing in mind my noble friend's declared interest, I am aware of the report by the TUC and the RNID pointing to some of the problems in getting across the message, which I and my colleague Michael Meacher very much welcome. As to giving greater emphasis to the Health and Safety Executive, we are doing better than monitoring, we are very substantially increasing the resources that are available to the HSE.

Lord Janner of Braunstone: My Lords, perhaps I may be permitted to express my deep admiration for the courage and persistence of my noble friend Lord Ashley in this matter. Can the Minister inform the House whether the Health and Safety Executive is focusing more on this issue? How many prosecutions have taken place? What have been the results, and what precise steps is the executive taking to enforce the many regulations to which he has rightly referred? Is it correct that the risk from noise is growing all the time and that my noble friend is right to express very deep concern about the way this matter is being handled?

Lord Whitty: My Lords, my noble friend is correct. A substantial number of people are exposed to potential noise problems. The HSE estimates that at least 1.3 million people are exposed to noise levels that may result in damage to hearing and that about 170,000 people say that they are suffering from noise at work. I am not in a position to give information on the precise number of prosecutions, but I can say that a very substantial proportion of the additional resources to be allocated to the Health and Safety Executive as a result of the Comprehensive Spending Review will be directed at inspection and the enforcement of the regulations to which my noble friend refers.

Lord Marlesford: My Lords, does the Minister recognise that at present there is inadequate legislation with regard to aircraft noise? Will the Government consider whether on this small and crowded island the time has come to restrict the use of helicopters to the military and emergency services?

Lord Whitty: My Lords, there are substantial regulations relating to helicopters in highly residential areas. I do not believe that it would be appropriate to restrict their use entirely to military and emergency purposes. They can play a very useful role in commercial activities. However, I accept that there are some concerns about both the noise and nuisance value which need to be addressed.

Lord Annan: My Lords, how often is the flight path over central London to Heathrow changed?

Lord Whitty: My Lords, I shall write to the noble Lord on that matter. If the noble Lord is referring to the general flight path, there are a limited number of routes. Helicopters are an entirely different matter.

Baroness Fookes: My Lords, can the Minister refer to the danger from noise to the hearing of those at play? I refer to the noise from discotheques, which the young seem to enjoy, and which very often is at a dangerous level?

Lord Whitty: My Lords, the noble Baroness is correct. The Health and Safety Executive has issued guidance on the level of noise and, in the context of its responsibility for workers in discotheques and other places, attempts to enforce those standards. There is a problem and it is being addressed.

The Countess of Mar: My Lords, does the noble Lord agree that there is a perception that work is usually carried out inside buildings and that some people may have the misconception that because they are engaged in agriculture and work out of doors noisy machinery will not affect them and they therefore do not need to wear ear defenders? Does the Minister agree that an enormous amount of social isolation is incurred as a result of deafness and that many young men who operate machines such as chainsaws are in danger of impairing their hearing? What is being done to inform them of the dangers?

Lord Whitty: My Lords, I agree with the noble Countess that there are dangers in working in the open air with certain machinery and that the same awareness of the risks does not appear to be present. Information is provided by employers in the agricultural and construction industries on the same basis in other work situations. By and large the same regulations apply, but I accept that there is a greater difficulty with enforcement in those areas.

The Earl of Carlisle: My Lords, can the Minister inform the House what discussions the Health and Safety Executive has had with the Ministry of Defence about the hearing of servicemen which is often degraded by high decibel levels of noise emitted by both equipment and weapons systems?

Lord Whitty: My Lords, I had better write to the noble Earl with reference to current servicemen. I am not aware of specific discussions. However, I know that the Ministry of Defence is concerned about the matter. As regards service pensioners, noble Lords may be aware that my noble friend Lady Hollis has conducted two independent inquiries since the advent of this Government. Those experts concur with the previous position: that the hearing loss incurred during service life is not worse for elderly people than it would otherwise have been. My noble colleagues are keeping the matter under review.

Lord Swinfen: My Lords, what safeguards are in place to protect those in properties adjoining the premises in which the noise is generated from damage to their hearing rather than the hearing of those working in the building itself?

Lord Whitty: My Lords, both the environmental health Acts and the law of nuisance would apply in such circumstances. It would not, however, be the direct responsibility of the Health and Safety Executive.

Earl Attlee: My Lords, what progress is being made with regard to the noise emissions from heavy commercial vehicles?

Lord Whitty: My Lords, the manufacturers of new heavy commercial vehicles are engaged in improving standards relating to the creation of noise. As regards roadside noise, the noble Earl will know that there is a substantial programme by the Vehicle Inspectorate to check the noise levels of all HGVs. Spot checks are carried out.

Extracts provided Rupert Taylor FIOA.

BSI News

BS EN Publications

BS EN 583: Non destructive testing – Ultrasonic examination.

BS EN 583-1:1999 General principles. No current standard is superseded.

BS EN ISO 5135:1999 Acoustics – Determination of sound power levels of noise from air-terminal devices, air-terminal units, dampers and valves by measurement in a reverberation room. Supersedes BS 4773-2:1989.

British Standard Implementations

BS ISO 6393:1998 Acoustics – Measurement of exterior noise emitted by earth-moving machinery – Stationary test conditions. Supersedes BS 6812-1:1987.

BS ISO 6394:1998 Acoustics – Measurement at the operator's position of noise emitted by earthmoving machinery – Stationary test conditions. Supersedes BS 6812-2:1987.

Amendments to British Standards

BS 5228: Noise and vibration control on construction and open sites.

BS 5228-1:1997 Code of practice for basic information and procedures for noise and vibration control AMENDMENT No1 AMD 10394. Updated standard.

Updated British Standards

BS 3539:1986 Specification for sound level meters for the measurement of noise emitted by motor vehicles AMENDMENT No 1. Updated standard.

BS 7580: Specification for the verification of sound level meters.

BS 7580-1:1997 Comprehensive procedure AMENDMENT No 1. Updated standard.

BS 7580-2:1997 Shortened procedure for type 2 sound level meters AMENDMENT No 1. Updated standard.

British Standards Proposed for Confirmation

BS 3383:1988 Specification for normal equal-loudness level contours for pure tones under free-field listening conditions.

BS 4196: Sound power levels of noise sources.

BS 4196-5:1981 Precision methods for determination of sound power levels for sources in anechoic and semi-anechoic rooms.

BS 5727:1979 Method for describing aircraft noise heard on the ground.

British Standards Withdrawn

BS 6812: Airborne noise emitted by earthmoving machinery.

BS 6812-1:1987 Method of measurement of exterior noise in a stationary test condition. Superseded by BS ISO 6393:1998.

BS 6812-2:1987 Method of measurement at the operator's position in a stationary test condition. Superseded by BS ISO 6394:1998.

New Work Started – Europe

EN 1915 Aircraft ground support equipment: General requirements.

EN 1915-3 Vibration test methods.

Drafts for Public Comment

99/120535 DC prEN ISO 9902-1 Textile machinery – Determination of noise emission – Part 1: Common requirements (ISO 99021:1999).

99/120536 DC prEN ISO 9902-2 Textile machinery – Determination of noise emission – Part 2: Spinning preparatory and spinning machines (ISO/DIS 9902-2:1999).

99/120537 DC EN ISO 9902-3 Textile machinery – Determination of noise emission – Part 3: Nonwoven machines (ISO/DIS 9902-3:1999).

99/120538 DC prEN ISO 9902-4 Textile machinery – Determination of noise emission – Part 4: Yarn processing, cordage and rope manufacturing machines (ISO/DIS 9902-4:1999).

99/120539 DC prEN ISO 9902-5 Textile machinery – Determination of noise emission – Part 5: Preparatory machinery to weaving and knitting (ISO/DIS 9902-5:1999).

99/120540 DC prEN ISO 9902-6 Textile machinery – Determination of noise emission – Part 6: Fabric manufacturing machines (ISO/DIS 9902-6:1999).

99/120541 DC prEN ISO 9902-7 Textile machinery – Determination of noise emission – Part 7: Dyeing and finishing machines (ISO/DIS 9902-7:1999).

99/200960 DC prEN 501332-1 Sound system equipment – Headphones and earphones associated with portable audio equipment – Maximum sound pressure level measurement methodology and limit considerations – Part 1: General method for 'one package equipment', (Possible new British Standard).

99/701097 DC prEN 10307 Non-destructive testing – Ultrasonic testing of austenitic and austenitic-ferritic stainless steels flat products of thickness equal to or greater than 6 mm (reflection method).

99/702262 DC ISO/DIS 14964 Mechanical vibration of stationary structures – Specific requirements for quality management in measurement and evaluation of vibration (No British standard will be affected).

99/704509 DC prEN 13490 Mechanical vibration – Industrial trucks – Laboratory evaluation of operator seat vibration.

CENELEC Publications

EN 166101: February 1999 Blank detail specification – Surface Acoustic Wave (SAW) filters – Capability approval.

Other ETSI Publications

EG 201 050: February 1999 (Version 1.2.2) Speech Processing, Transmission and Quality Aspects (STQ); Overall Transmission Plan Aspects for Telephony in a Private Network.

EG 202 086: February 1999 (Version 1.1.1) Speech Processing, Transmission and Quality Aspects (STQ); Objectives and principles for the transmission performance of multiple interconnected networks that aim to provide 'traditional quality' telephony services.

IEC Publications

IEC 61373: January 1999 Railway applications – Rolling stock equipment – Shock and vibration tests.

ISO Standards

ISO 31: Quantities and Units

ISO 31-7: (Edition 2) Acoustics Amendment 1:1998 to ISO 31-7:1992. ISO 31 is dual numbered with BS 5775 in the UK. The amendments to the above parts of ISO 31 will be implemented and amendments will be issued to the relevant parts of BS 5775.

This information was announced in the March and April 1999 issues of BSI Update, copies of which are kept in the Institute library.

Law Report

Serving Noise Nuisance Notice

Budd v Colchester Borough Council

Before Lord Justice Swinton Thomas, Lord Justice Auld and Lord Justice Thorpe [Judgment March 3]

A local authority was entitled under section 80(1) of the Environmental Protection Act 1990 to serve a notice simply requiring the recipient to abate the nuisance created by barking dogs without specifying the manner of abatement or the level of barking either which constituted the nuisance or which would be acceptable.

The Court of Appeal so held, dismissing the appeal of David Budd against the dismissal by the Queen's Bench Divisional Court of his appeal by case stated against the dismissal by Judge Rice at Chelmsford Crown Court of his appeal against the dismissal by Colchester Justices to dismiss his appeal against an abatement notice served on him by Colchester Borough Council on March 31, 1994.

Mr Gregory Stone, QC and Mr Jonathan Tod for Mr Budd; Mr David Holborn for the council.

Lord Justice Swinton Thomas said that the notice identified the nuisance as 'dog barking' and required him to abate the nuisance within 21 days.

Mr Budd kept six greyhounds. There were many complaints from the neighbours about the dogs barking, particularly in the early hours of the morning.

Section 80(1) of the 1990 Act provided the local authority with a choice. The local authority was required to serve a notice 'imposing all or any of the following requirements', namely 'requiring the abatement of the nuisance' or 'requiring other steps as may be necessary'.

Depending on the circumstances, it was open to the local authority to take one or other course when serving the notice.

It was not difficult to envisage facts where it would be wholly unreasonable for a local authority to serve a notice merely requiring the recipient to abate the nuisance without stating the works or steps which the local authority required to be taken for that purpose, or where it was clear on the face of the notice that the notice itself required such works or steps to be taken.

Kirklees Metropolitan Borough Council v Field ((1997) 96 LGR 151) was such a case. A rock face and a wall were in imminent danger of collapse on to some cottages and the notice merely required the owners of the rock face and wall 'to abate the statutory nuisance'.

It was clear from the notice itself that the only way the nuisance could be abated was by carrying out very extensive works of shoring up the wall and securing the rock face.

In those circumstances, Mr Justice Owen stated that the notice plainly required the execution of works and, accordingly, the works had to be stated in the notice.

In the ordinary way a local authority was entitled under section 80(1) to serve a notice simply requiring the recipient to abate the nuisance. It was a wholly appropriate course for the council to take in this case.

The barking of the greyhounds was a nuisance by noise to Mr Budd's neighbours. There were many ways in which he might abate the nuisance.

The most extreme would be to get rid of all six greyhounds, but that might well be an unreasonable requirement. A reduction in the number of dogs might abate the nuisance. Insulation of part of the house might be sufficient.

It might be possible to send the dogs to an animal training centre to cure the problem. However, it might well not be reasonable for the local authority to require Mr Budd to take that course, because he might not be able to afford to do so.

It was quite sufficient for the local authority to require Mr Budd himself to abate the nuisance in a manner which was the least inconvenient or expensive and the most acceptable to him.

Nor was it necessary for the local authority to state the level of barking which constituted nuisance, or the level of barking which would be acceptable. Indeed, it would be impracticable for the local authority to do so.

The local authority was entitled to serve a notice requiring Mr Budd to abate the nuisance which involved reducing the level of barking so that it ceased to be a nuisance by noise.

Lord Justice Auld and Lord Justice Thorpe agreed.

Solicitors: Tilbrooks, Ongar; Mr John Cobley, Colchester.

Branch News

Southwest Branch

The first meeting of the New Year was a joint venture with the Western Branch of CIBSE. The venue was Nuairé Ltd, Caerphilly and the topic, unsurprisingly, was fan noise. The meeting started with a tour of the acoustic testing facilities and the methodologies for measuring the acoustic and dynamic performance of fans to the AMCA standards.

Following this Neil Jones gave a presentation entitled *Reasons why fan performance is not achieved on site* which was a comprehensive review of what not to do illustrated by case studies of inappropriate fan selection or problems with the installation.

The evening was rounded off with an open discussion with members relating their own experiences with fan noise.

Stan Simpson MIOA

Midlands Branch

The Midlands Branch held its first evening meeting of the year on 30 March 1999 at the University of Derby who also sponsored the meeting. The main event of the evening was a presentation by Ian Flindell of ISVR at Southampton University, which was given the title *EU – A new noise indicator?* Ian, who co-chairs the EC's Working Group on Noise Indicators (WG1) talked about the group draft position paper and their finalised Executive Summary of this paper.

Ian's presentation provoked a lively and stimulating debate amongst the forty-plus audience, not only on indicators, but also on the entire EC initiative on environmental noise.

Also at the Branch Meeting, Sue Bird presented the ANC's 'Best Student Project of the Year Award (1997)'



Sue Bird, ANC Chairman, presents the ANC prize to Craig Hicken.

to Craig Hicken of Coventry City Council. Craig's project concerned the Noise Act and was carried out for his IOA Diploma which he undertook at Derby University under the expert guidance of Mike Fillery.

John Hinton MIOA

North-west Branch

On Thursday 20 May we started the evening 'baffled by barriers'.

David Hothersall of the University of Bradford's Department of Civil and Environmental Engineering gave an informative and solid talk on environmental noise barriers.

He commenced with an introduction to the physical principles, illustrating the effects of wavelength on diffraction, the use of path difference, and linking wavelength and path difference by the Fresnel number. Simple methods of calculating barrier insertion loss were then covered, such as that of Professor Maekawa of Kobe University.

From there the talk progressed to the standard prediction methods for the UK. These included one taken from *Sound Control for Homes*, an excellent publication by BRE/CIRIA, ISO 9613, probably the best overall method at present, and the familiar *Calculation of Road Traffic Noise*, *Calculation of Rail Noise*, and BS5228.

Less standard methods covered involved experimental modelling, practical measurement, and mathematical modelling by ray and by the numerical solution of wave equations. Fortunately David spared us too much mind-numbing mathematics.

Practical applications and performance were discussed, position of barrier, effect of barrier insertion on soft ground attenuation, and likely actual figures that would be achieved. Problems due to reflections were considered, and the use of absorption and special barrier profiles to overcome them. Meteorological effects such as wind direction and temperature inversions were noted. Some of the work at the Transport Research Laboratory was mentioned.

General design considerations covered included the site conditions, any planning restrictions, visual considerations, cost (compared with insulation), engineering requirements, and acoustic efficiency. In relation to protecting residential amenity it was pointed out that barriers protected the outside, such as gardens, whereas insulation could only protect the inside.

Practical barriers were then illustrated and discussed, with examples being taken from around the world. The talk concluded with a short question and answer session, and we were left feeling considerably less baffled than at the start.

Our thanks to David for his excellent talk, and to BDP for providing the venue.

Paul Michel MIOA

Eastern Branch

A well attended evening meeting was enjoyed by a varied professional audience at South Cambridge District Council Offices when Richard Greer of ARUP Acoustics delivered a very competent lecture on the Use of Section 61 (prior consent) of the Control of Pollution Act in Construction Noise.

Within this communication framework system the essential requirements of all parties, including the public, the developer and the local authority, are highlighted. This provides a route for the minimisation of noise, minimisation of nuisance and the minimisation of construction delay to develop from the early mutual understanding of any noise (and vibration) issues and other areas of concern.

M P Alston MIOA

The Branch held their 2nd meeting of 1999 at the Colchester Institute on 24 March. Some 30 members attended a presentation given by Gregory Stone QC on The Role of the Expert Witness. The following notes give some of the points made in a very interesting and informative address.

The talk was structured around the headings of a) the different types of tribunals involved, b) the qualities of an ideal expert witness and c) practical tips when acting as an expert witness.

The expert witness can be involved in many different situations, from planning and parliamentary enquiries, to civil and criminal court proceedings. Emphasis was placed on the need to pitch the evidence at the right level, summed up as that for the intelligent lay person.

The expert witness ideally needs:

- to be master of his/her subject, able to communicate easily with everyone, and not to 'bamboozle' with
- specialised language and concepts
- to have human skills to diffuse the aggressive, and charm the charmer
- a streak of obstinacy, not agreeing with everything

Position Sought

Vladimir Magdenkov,
41 years of age,
Russian,
BSc,
noise & vibration reduction researcher,

seeks position in the UK.

email address:
[www.lister22.freemove.co.uk/
Magdenkov.HTM](http://www.lister22.freemove.co.uk/Magdenkov.HTM)

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- to prepare proofs of evidence on time; aim for quality not length, including extensive appendices as necessary
- to give an opinion as a professional in a particular subject, but has a duty not to mislead
- to have a good overview of the whole case; read other proofs and hear other evidence, so appreciating the context of his/her own contribution
- stamina, persistence and determination

Practical tips include:

- prepare carefully; points of substance with council; help him/her to develop the required level of understanding
- do not rush your evidence
- take a small amount of summary papers into witness box, not whole proofs of evidence
- listen carefully to questions
- you should answer a question directly, but then follow up or qualify with a 'but' or 'and' to make your point; 'but seen in this context' etc (yes but, trick)
- have a good 'eye' on where you are going, and be aware if the case is slipping away
- if a good point is made against you, mention it and then argue against it for best impact
- do not be too deferential to council but be flexible
- be ready for the moment when it is proposed to take the evidence as read, and use the 'but' to make certain points (limited number), especially if you feel the case is slipping away
- avoid straying on to the concerns of others eg the determination of general nuisance by a judge etc
- beware of the fraudulent nod
- keep your eye on the pen; if the judge/magistrate/inspector stops writing they may be losing interest
- summarise main points and 'counter attack' as necessary

David Bull FIOA

Group News

Industrial Noise Group

The Group was officially revived at a meeting on 25 February 1999, after a spell of inactivity despite being the third largest group in the Institute. The new committee is a lively group which is keen to bring the group back to a level of activity deserving of the size of its membership.

We have provided input to the Institute's 25th Anniversary Conference and plans are afoot for a substantial conference of our own in the autumn to mark the 10th anniversary of the Noise at Work Regulations. Lots of creative ideas have been put forward about what the group's aims and activities should be and we look forward to contributions of ideas from members of the group.

So, we would ask existing group members to keep faith and support us where you can, non-members and especially lapsed members, forget the rest we're the best.

Andrew Raymond (Chairman)

Bulletin Management Board

This board critically reviews each issue of the Bulletin after it is published from the point of view of content, style and presentation.

When reviewing the March / April 1999 issue, the Board decided that the Editorial column would be discontinued with immediate effect. It was also decided that the *Points from Council and Standing Committee Minutes* would be replaced by reports on the work of Council, individual committees and working parties in rotation. It is intended that these will commence in the July / August issue. ♦

Institute of Acoustics

BUYERS' GUIDE 2000: MILLENNIUM EDITION

Acoustic Instrumentation, Products and Services

The Millennium Edition of the Buyers' Guide for Acoustic Instrumentation, Products and Services will be published in November 1999 and will be even more comprehensive than its predecessor with additional categories and sub-categories.

This time, for a modest additional fee, text of up to 100 words describing a company's products and services may be included in Section 3 beneath the address of the company. This will considerably increase the information available to potential purchasers.

The entry fee remains £100 plus VAT for each company or branch office address with a further fee of £50 plus VAT for companies inserting the additional text. Application forms will be available shortly.

For further information, please contact: Keith Rose RIBA FIOA, Associate Editor, Brook Cottage, Royston Lane, Comberton, Cambridge, CB3 7EE Tel: 01223 263800 Fax: 01223 264827

New Products

CIRRUS RESEARCH plc

A Permanent Noise Monitor

The CR:243/1 Noise Monitoring Terminal is a purpose-designed unit for unattended measurement of environmental and industrial noise. It has the ability to measure and store information over long durations and perform automatic remote calibration when used with a suitable outdoor microphone.

Noise monitoring systems can be built around the CR:243/1 using simple software and suitable communications to download the data collected. More comprehensive software allows systems to be expanded when needed. Systems can be designed and installed that support weather measurement as well as noise.

The CR:243/1 can be used in many situations where reliable, installed noise measurement in all conditions is required. Examples of sites where the CR:243/1 is currently used include international airports, motor racing circuits, power stations, construction sites and urban environmental noise monitoring projects.

The CR:243/1 is a proven instrument in use worldwide, with full type approval and calibration. A full range of associated equipment and accessories is available to allow turnkey systems, as well as purpose designed applications, to be covered quickly and easily.

For further details, contact James Tingay at Cirrus Research plc, Acoustic House, Bridlington Road, Hunmanby, North Yorkshire YO14 0PH Tel: 01723 891655 Fax: 01723 891742 Email: sales@cirrusresearch.co.uk

Cirrus Research is a Key Sponsor of the Institute.

THE NUMERICAL ALGORITHMS GROUP LTD

NAG Fortran Library

The Numerical Algorithms Group (NAG) has released the NAG Fortran 77 Library, NAG f190 (the Fortran 90 library) and NAG FL90plus

for Windows 95/98/NT using the Lahey/Fujitsu Fortran 95 (LF95). These products extend the range of numerical and statistical libraries for PC users.

The NAG Fortran 77 Library, now at Mark 18, contains over 1000 user-callable routines for mathematical and statistical computation. NAG f190 is the world's first numerical procedure library written in Fortran 90/95. The current release (Release 3) contains over 210 generic user-callable procedures. NAG FL90plus combines both the NAG Fortran 77 and f190 libraries. This provides a convenient mechanism for migration of existing Fortran 77 programmes to the current standard, Fortran 95.

Further details can be found at the NAG website <http://www.nag.co.uk/numeric.html> or from NAG Ltd, Wilkinson House, Jordan Hill Road, Oxford OX2 8DR Tel: 01865 511245 Fax: 01865 310139.

CASTLE GROUP LTD

dBdata4W Windows Software

At the touch of a button, Castle's dBdata4W Windows software enables easy and efficient analysis of data that has been captured by any compatible Castle sound level meter, providing the information that you need in a form that you can use as it is, or in any other PC package.

Once created on screen, the data can be copied and pasted into any other software package either as a table, graph or picture simply with a couple of mouse clicks. Octave band analysis information can also be displayed and this can be compared with in-built Hearing Protection Attenuation Data.

dBdata4W is a Windows 95 package that also works with Windows 98 and Windows NT. Other packages are available for Windows 3.1X and DOS users.

Castle GA1001 Excalibur

Audiometer

The GA1001 Excalibur audiometer makes light work of the testing process by using the speed of a computer to efficiently test employees' hearing. The data management of the Excalibur system enhances this testing process. This means that data

can be stored and then analysed when convenient. Connecting directly to a PC or laptop (Windows 3.1, '95 or '98) provides prompts on the PC screen that guide the examiner through the testing process.

The Excalibur's state of the art features include the ability to compare new data with previous test results for more meaningful analysis, and can even generate letters that recall patients for testing. Whole 'batches' of test data can then easily be analysed to give management statistics.

For further information contact: Richard Norton or Miss Kelly Buncher Tel: 01723 584250 Fax: 01723 583728 Email: sales@castlegroup.co.uk. Castle Group Ltd, Salter Road, Scarborough, North Yorkshire YO11 3UZ.

Castle Group Ltd is a Sponsor Member of the Institute

NES ACOUSTIC & ENVIRONMENTAL CONSULTANTS

INSUL Sound Insulation Prediction Software Ver 4 .4

INSUL is a program for predicting the sound insulation of walls, floors, ceilings and windows. It is based on simple theoretical models that require only minimal construction information. The program can make reasonable estimates of the Transmission Loss (TL) and Weighted Sound Reduction Index (R_w) for use in sound transfer calculations. INSUL can be used to quickly evaluate new materials and systems, or to investigate the effects of changes to existing designs. It models materials using the simple mass law and coincidence frequency approach and models more complex partitions using work by Sharp, Cremer and others.

It is claimed that INSUL will greatly enhance the ability of acoustic consultants and product manufacturers to quickly and confidently specify constructions in order to achieve a desired airborne sound insulation performance.

For further information contact Ian Etchells at NES Acoustic and Environmental Consultants in the UK Tel:

0161 474 7202 email: nes.int@dial.pipex.com. Or contact Jon Farren at NES in Dublin, Tel: +353 (0)1 450 4922 email: nes@iol.ie. National Environmental Sciences, Kylemore Road, Dublin 12.

ACSOFT LTD

A New Signal Acquisition and Analysis System

With its introduction into the UK of the SigLab signal acquisition and analysis system from DSP Technology, AcSoft offers new power and flexibility for analysis of dynamic signals and systems.

SigLab can combine many instruments in a single multipurpose tool and match the performance of dedicated instrumentation. SigLab collects measurements such as time histories and power spectra, and performs advanced dynamic system analyses with no user programming.

SigLab features a mouse-driven graphical interface for controlling data acquisition and viewing data. Optionally SigLab can be integrated with The Mathworks' MATLAB, the premier program for numeric computation and visualisation. With SigLab it is easy to take advantage of MATLAB's power, even with no knowledge of MATLAB syntax. MATLAB toolboxes available at the click of a mouse include oscilloscope, spectrum analyser, transient recorder, network analyser, swept sine analyser, and frequency response analyser for control systems.

All the instruments are written as MATLAB M-files which the user can access and modify to solve unique measurement problems.

SigLab features include sigma-delta data conversion technology and three high performance DSP chips to achieve high real-time bandwidth with a 90 dB spurious free dynamic range. The system provides full anti-alias protection for all bandwidths. Standard features include advanced real-time functions such as zoom.

Versions of SigLab with two or four input channels can be daisy chained for fully synchronised multi-channel capability using the high speed SCSI interface. Users can replace the standard signal conditioning cards with their own to address specialised requirements such as accelerometer powering. Sampling rate is up to 128 kHz per channel, and with up to 32 Mbytes of memory available for transient capture, SigLab makes the DAT recorder superfluous in many applications.

SigLab also offers two outputs controlled by a full-function signal generator.

Rugged and lightweight, SigLab is equally at home in the laboratory or field, with a form factor which fits well with a notebook computer.

For further information contact: John Shelton, AcSoft Ltd, 6 Church Lane, Cheddington, Leighton Buzzard LU7 0RU Tel: 01296 662852 Fax: 01296 661400

AcSoft Ltd is a Sponsor Member of the Institute.

EUROFORM PRODUCTS

Viroc Acoustic Systems

Viroc is a high density, high impact, fire-rated, multipurpose panel which will add mass to acoustic constructions.

For flooring systems, performance figures claimed (to Document E of the Building Regulations) are airborne 53 dB and impact 61 dB with a system thickness of 29 mm. For wall systems, partition systems are available providing up to 55 dB on standard single layer wall constructions.

Also acoustic and fire performance curtain walling, rainscreen and external cladding. For soffit systems panel constructions provide U values of 0.45 W/m²K and acoustic performances in excess of 45 dB.

Euroform roofing system designs are available providing an R_w in excess of 51 dB.

For product literature and technical information please contact Euroform Products Ltd, The Heliport, Lyncastle Road, Appleton, Warrington WA4 4SN Tel: 01925 860999 Fax: 01925 860066 email: Euroform@sales90freeserve.uk

News

BSi Panel GME/21/6/4 – Human Exposure to Vibration and Shock in Buildings

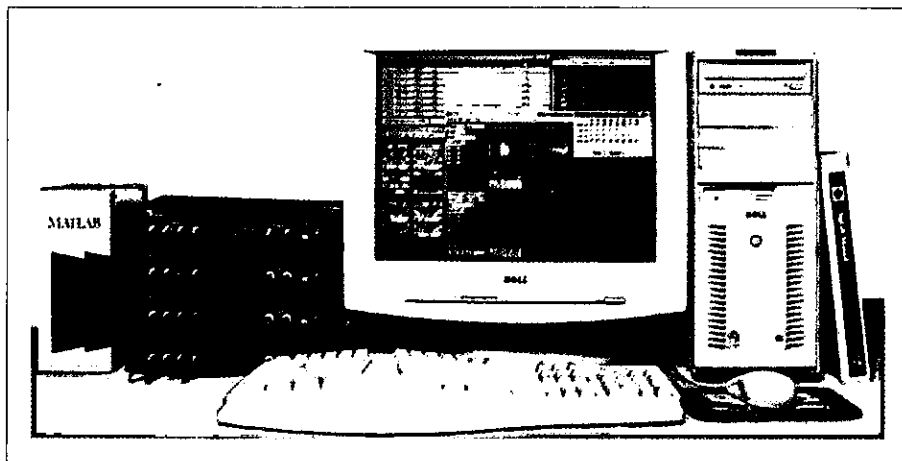
British Standards panel GME/21/6/4 (Chairman Colin Stanworth), is undertaking a review of BS 6472 (1992) Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz).

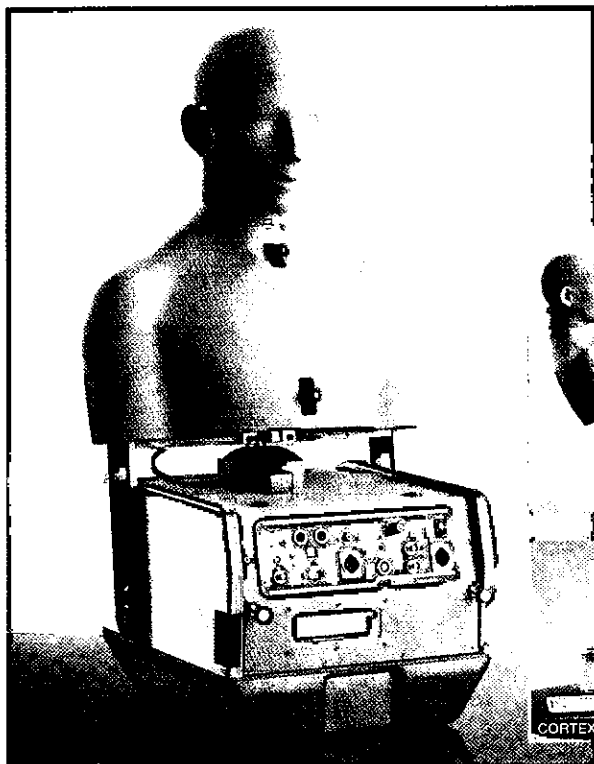
To facilitate this review, it invites comments from practitioners in industry on any aspect of its interpretation, application and in particular any comments concerning its merits or shortcomings.

Any information concerning instances where the application of the standard has led to a satisfactory or unsatisfactory result would be most valuable.

Information provided will be treated in strict confidence, within the working group, and will not be disclosed to third parties.

Any queries in respect of this request can be forwarded to: Secretariat of GME/21/6/4 at BSi, 389 Chiswick High Road, London W4 4AL, or to Ather Sharif MIOA on Tel: 0181 647 1908 email: ced.co@virgin.net.





Sound quality analysis Noise analysis Binaural recording

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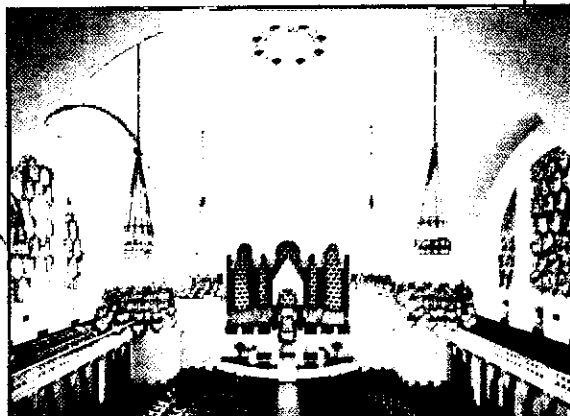
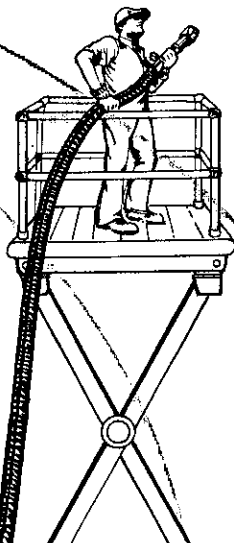
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BRÜEL & KJÆR

Go Surfing with Brüel & Kjær

Brüel & Kjær have further underlined their commitment to customer support by introducing a comprehensive website where both existing and future customers can read or download details of the wide range of acoustic and vibration measurement instruments and systems currently available from the company.

Simply accessed by keying <http://www.bk.dk>, the WebPages provide a complete catalogue of product datasheets, new product releases together with the location of their 90 offices and distributors in 55 countries throughout the world.

Download a complete demonstration of the new Brüel & Kjær Pulse analyser system or checkout Year2000 product compliance from the comprehensive list included in the pages. The site also allows access to the latest technical reviews and application releases together with back copies of the Brüel & Kjær Magazine.

Start surfing today and find out more about the world of sound and vibration!

Brüel & Kjær in the UK can be emailed on info@bkgb.co.uk or contacted on Tel: 0181 954 2366 Fax: 0181 954 9504

Brüel & Kjær is a Key Sponsor of the Institute.

CEL INSTRUMENTS LTD

Detecting Dome Decibels

The Millennium Dome project is close to completion but throughout its construction noise levels have been constantly monitored by an all-weather sound measurement system to minimise any nuisance to neighbouring residential areas.

Commissioned by the New Millennium Experience Company and installed by Symonds, the overall acoustic consultancy for the Dome, the system includes a CEL-480.C Logging Sound Level Meter linked to an all weather microphone unit.

The equipment, from CEL Instruments, a Casella group company is located on a site office rooftop 200 metres from the Dome and is operational for 24 hours a day.

Continuous 15 minute L_{Aeq} measurements are stored in the instrument's memory and each week the New Millennium Experience Company downloads the data to a PC, using CEL's dB21 software package, to produce a report that shows the levels throughout the working period.

The same data is also used to produce a graph of the weekly emissions and this is submitted to the local authority, Greenwich Council, to demonstrate the site's compliance with noise limitation measures.

Exported from dB21 as an ASCII file, data can also be used in both spreadsheets and word processing packages.

The noise emission target set for the project was stringent, requiring the noise within the site not to exceed the overall background level and this has generally been achieved. The continual logging facility of the system, however, means that any exceedance of the limit is quickly identified enabling immediate remedial measures to be taken.

Acoustic tests were also carried out in October 1998 within the Millennium Dome by Symonds using a variety of equipment, including other CEL sound level meters, in order to investigate its acoustic qualities.

The CEL480 is one of a series of CEL integrating sound level meters that provide a modular approach to noise measurements as functionality can be added to the basic model in stages to provide a solution to many of the most common noise measurement problems.

Easily upgradeable, the instruments incorporate an icon based keypad and a large graphic screen that, say CEL, makes the instruments uniquely user friendly.

For information on the CEL environmental noise systems contact: CEL Instruments Ltd, Regent House, Wolseley Road, Kempston, Bedford MK42 7JY Tel: 01234 841441 Fax: 01234 844155 Website: <http://www.cel.ltd.uk>

CEL Instruments is a Key Sponsor of the Institute.

HEALTH & SAFETY COMMISSION

Tessa Jowell and Alan Meale launch the healthy workplace initiative

Tessa Jowell, Minister for Public Health, and Alan Meale, Minister with responsibility for Health and Safety, asked businesses to 'Sign Up' to the Healthy Workplace Initiative at its recent launch.

By taking part in the 'Sign Up' programme, employers register their interest in improving health in the workplace as part of the Healthy Workplace Initiative, underlining that 'improving health is everybody's business'. This partnership between the Department of Health and the Health and Safety Commission (HSC) will lead to a joint programme between the Department of Health and the Health and Safety Executive (HSE).

Speaking at the Safety and Health at Work Conference at Earls Court, Ms Jowell said: 'Through this programme we hope to strengthen the belief that 'improving health is everybody's business.' Through the 'Sign Up' campaign, we will be contacting thousands of workplaces of every kind to give them the opportunity to register their interest in the programme. Businesses who reply will be sent regular newsletters updating them on the latest initiatives to help create healthier workplaces and giving them examples of good practice.

Other businesses can 'Sign Up' using the website. Guidance from the Healthy Workplace Initiative will help employers and employees to improve productivity, lower sickness absence rates, prevent accidents and reduce illness. Copies of *Our Healthier Nation* are available from The Stationery Office Tel: 0171 873 9090 (£10.30) ISBN 0-10-138522-6.

For further information contact HSE's Infoline Tel: 0541 545500.

ISVR, UNIVERSITY OF SOUTHAMPTON

'Star in a jar' is a job for Ultra-loo!

The phenomenon of collapsing bubbles, nicknamed 'Star in a Jar', has won an important research grant for

University researchers Dr Tim Leighton (Institute of Sound and Vibration Research - ISVR) and Dr Peter Birkin (Department of Chemistry).

When ultrasound is applied to a bubble of gas within a liquid, it initially expands and then collapses. The gas is compressed, achieving high pressures and temperatures (in some cases exceeding those on the surface of the sun). This is accompanied by a bright flash of light known as sonoluminescence, hence the phrase 'star in a jar'.

Collapsing bubbles are highly erosive, and consequently have many potential uses. Ultrasonically-induced bubble collapse can be used to assist in the removal of kidney stones, which are broken into smaller fragments within the body using ultrasound, without the need for surgery. These fragments can then be passed naturally from the body. Bubble collapse can also be used for sterilization purposes, as it can destroy biological cells, and even erode plaque from teeth during some ultrasonic dental procedures. It also has many commercial applications in material processing.

The university has now received over £100,000 from the Engineering and Physical Sciences Research Council for further investigations of collapsing bubbles.

The temperature, pressure, erosive and chemical effects which take place within the bubble gas are of key importance. The problem is that, until now, there has been no accurate way of directly measuring them and Dr Leighton has invented a novel device, christened 'Ultra-loo' by his students because it functions when a chain attached to a U-bend shaped tube is pulled. The device can make an isolated, conical shaped bubble collapse, and can be fitted with sensors to monitor conditions within the bubble. This, combined with a programme of tests on more conventional, ultrasonically induced bubble collapse (undertaken by Dr Birkin), should help the team to produce recommendations for measuring techniques and scales which could be used by industry to monitor processes exploiting bubble collapse.

Ultrasound researchers make no bones about their work

The future of osteoporosis diagnosis could lie in ultrasound, thanks to a team of Southampton researchers. Their project has been awarded a £146,000 research grant by EPSRC for further development.

Osteoporosis is a common condition in which a decline in bone mass leads to serious fracturing, particularly of the hip, pelvis and spine. It affects one third of adult women and one in 12 men, and is currently diagnosed by X-ray, an expensive technique not widely available because of the size of the equipment needed. The way ultrasound travels through cancellous bone, which is structured like honeycomb and erodes with the onset of osteoporosis, is being studied.

It is hoped to eventually create a portable, safe ultrasound machine which is a far cheaper and more practical method than X-ray to use for initial diagnosis.

For further information contact Tim Leighton MIOA, ISVR, University of Southampton, Tel: 01703 592331, email: t.g.leighton@soton.ac.uk

SONASCAN

3D Sight From Sonic Imaging

A new technique for visualising the three dimensional internal structure of an object will allow engineers to see exactly where cracks and faults have appeared and how well the structure has been built. The technique, being developed by Sonoscan, can provide a high quality 3D view of the internal features and defects of items such as integrated circuit packages, diamond coatings or ceramic discs.

The imaging technique uses computer software that stacks together a series of planar ultrasound images. These images are collected by pulsing ultrasound into an object and collecting the echoes that bounce back from any voids or defects. The resulting 'acoustic solids' reveal all of a part's internal features and can be computer rotated and cross sectioned to allow detailed analysis. The imaging technique can also provide pictures at such a fine resolution that the user

will be able to tell if a supplier has changed the composition of the material used.

This technique can provide a 3D view of the internal features and defects of most polymers, metals, ceramics and composite materials or in objects made up of one or more of these materials. 3D acoustic imaging provides a quick, non-destructive method of imaging and evaluating internal structure without having to physically cut open the part. (source: *Materials World*)

For further information please contact Andrew McLaughlin on Tel: 0171 451 7395 Fax: 0171 839 2289 or email: Andrew_McLaughlin@materials.org.uk

HARRY KENYON MIOA 1925 - 1999

Harry Kenyon recently passed away peacefully in hospital on 26 May. He was a Member of the Institute and a Chartered Mechanical Engineer.

Harry was educated at The Liverpool Institute and then at Leeds University and achieved a BSc (Hons) in Mechanical Engineering in 1945. He then worked in industry for companies such as the Metallastik Division of Dunlop Rubber and Lockheed Automotive Products, until 1973 when he formed Martec Environmental Engineering.

Many of those in the profession who encountered Harry will not readily forget him. He was an energetic and determined man and never more at home than when expressing his opinion in Court, British Standards committees or simply on the phone; although his favourite forum for discussion was probably the Windermere Autumn Conferences. He also supported the work of the Noise Abatement Society, and as a vice-chairman represented its views.

He continued to work until his death. He is survived by his wife, his son Mel, who will continue to run the firm, three daughters, and eleven grand-children.

Items for inclusion in this section should be sent to John Sargent MIOA, Oak Tree House, 26 Stratford Way, Watford WD1 3DJ. ❖

Further on Inaudibility

From Dick Bowdler FIOA

The Editor

Dear Sir

Most of the authors of your letter (S A Williamson and others, March/April 1999) will already know my views on inaudibility since we have debated them from time to time for more than ten years. I am surprised that such an eminent group of members is reduced to so sloppy an argument.

Stripped of its rhetoric, the letter simply puts forward the view that there should be a criterion: nowhere is there justification for inaudibility. You can easily test this. Just replace the word inaudibility throughout the letter with (say) 30 dBA.

The appropriate use of inaudibility to control music has been successful in many Local Authorities.... it has protected the public and allowed developments to take place which would not otherwise have been possible. The only reason any development would not otherwise be possible is because it could not meet the pre-determined criterion – whatever that was. There are many Local Authorities who use other criteria who could use the same argument to justify equal success.

Inaudibility is used, not to inhibit or thwart development but to allow it to take place in circumstances which would otherwise be unacceptable. But they would only be otherwise unacceptable as viewed by the inaudibility criterion. Try this – *30 dBA is used, not to inhibit or thwart development but to allow it to take place in circumstances which would otherwise be unacceptable.* It works just as well.

Music..... is so easily controlled; all music systems being provided with a volume control. Yes, but that volume does not necessarily have to be turned down to inaudibility. It can be turned down to any criterion.

My argument against inaudibility is twofold. In the first place the achievement of inaudibility depends on factors outwith my control as a designer. If I can gain access to a complainant's premises to measure background noise, which is often impossible, I may be able to make music inaudible in a room above a pub. If the owners of the room subsequently install secondary glazing and reduce the background noise the music may become audible.

In the second place I do not believe that the criterion is even-handed. The suggestion that the *criterion is fair to all parties and strikes an appropriate balance between the needs of the community and the rights of individuals to enjoy their property* is clearly just not true. How can a criterion which places no obligation on one party but all the obligations on the other, be called balanced.

Some criterion, or more likely criteria, based on circumstances, is probably needed. I do not object to criteria which vary locally. I am still waiting to hear an argument which demonstrates why inaudibility is better than anything else.

New Acoustics, Clydebank

From S R Peliza MIOA

The Editor

Dear Sir

In the March/April 1999 Letter to the Editor, Mr S A Williamson MIOA and colleagues raised a number of eyebrows in the comments relating to the audibility concept. I would wish to comment on some of these.

In my experience the inaudibility concept has not been used in harmony when related to noise emission from amplified music. The inaudibility concept may be fine in an ideal world. However, it is a subjective criteria which has its application limits in real life because we all have different hearing thresholds and the masking level (from other sounds) will vary over time. It can in certain circumstances be an unreasonable criterion to impose on an operator of premises with amplified music. This concept has resulted in at least one court case where one of my clients successfully appealed against an inaudibility condition in a PEL Appeal.

In the age of the modern sound level-measuring instrumentation we should strive to seek a fairly easy to apply objective criterion. I agree that the broad band approach is not effective when addressing the bass beat. It completely misses the problem issue. In my experience the measurable objective criterion is that the Equivalent Noise Level of the music (representative short term of about 30 seconds) must not exceed the Background Noise Level (fast) with no music at the mid octave bands of 63 and 125 Hz. Obviously this needs to be determined for the most sensitive time of the night. With an octave band real time analyser (with display) one can quite clearly correlate the objective data with the subjective situation.

Currently the Institute is in the process of carrying out a trial study using responses from members which includes both objective and subjective input. It may be that with input from all concerned an acceptable objective standard criteria can be arrived at. However, we will not progress in this respect if we fall back on the totally subjective approach.

Acoustic Consultants Ltd, Bristol

Tenants Beware

If the property is inadequately sound proofed so that the noise of ordinary use next door comes through the wall, landlords are not obliged to improve the insulation. Tenants are entitled to no more than the broad level of peace and quiet prevailing at the time they first take their lease and, even if the noise next door is a nuisance, they have no remedy against the landlord. They cannot rely on their general right to quiet enjoyment of leased property to make their landlords carry out improvements or repairs that are not the landlord's responsibilities under the lease. This role of 'caveat lessee' means that tenants taking over offices or industrial units that form part of a larger building should check the insulation first.

From a recent newsletter published by Messrs Ottaways, Solicitors, of St Peters St, St Albans and reproduced with their permission. Comments would be welcome – Editor.

Acoustics Recruitment Associates
150 Craddocks Avenue Ashted Surrey KT21 1NL UK
Tel: 01372 272 682 Fax: 01372 273 406
e-mail: h.g.leventhall@dial.pipex.com
Technical Adviser: Dr Geoff Leventhall

A premier UK-owned noise and vibration hardware company has created a vacancy for a Manager to work at the highest technical levels within the company and to ultimately assume the responsibilities of the present Technical Director.

Candidates must combine understanding of academic fundamentals with commercial awareness, forward thinking and sound judgement. Responsibilities will include:

Keeping the wide range of company products technically up to date.

Exploring opportunities for new products.

Staying in touch with technical and research developments through reviewing the journals, attending technical meetings and developing personal contacts with leading researchers.

Generally ensuring that the company maintains its leading position, both technically and commercially.

Candidates are likely to have had a successful academic start, possibly including a higher degree in a relevant branch of acoustics, followed by industrial, design or consultancy experience. There should be a demonstrable continuing interest and curiosity in wide aspects of acoustics. It is unlikely that a person aged less than 25-30 years will have acquired the experience and maturity for this post. Older candidates are encouraged to apply. It is intended that this key position will be filled by someone who is able to stay in post for a considerable number of years. If you are interested in this position and, after reflection, believe that you match its requirements, contact Acoustics Recruitment Associates for a preliminary discussion, or send your CV.

ACOUSTICS CONSULTANTS

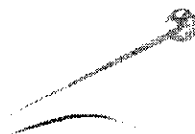
Warrington and Horsham

Hepworth Acoustics is looking for two consultants to play an important role in implementing the next stage of the company's business plan. We have a vacancy at our Warrington head office and one at our recently established Horsham office. You will play an important role in servicing our existing workload for a diverse range of clients.

A degree or similar qualification in a relevant subject, and membership of the Institute of Acoustics is essential. You will need a minimum of two years experience in acoustics consultancy or in the acoustics section of a local authority. In return we offer a competitive salary, fully resourced company car, paid overtime, plus a package of other benefits. To apply for one of these positions please send a detailed CV to Peter Hepworth at the address below.

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