Acoustics BULLETIN

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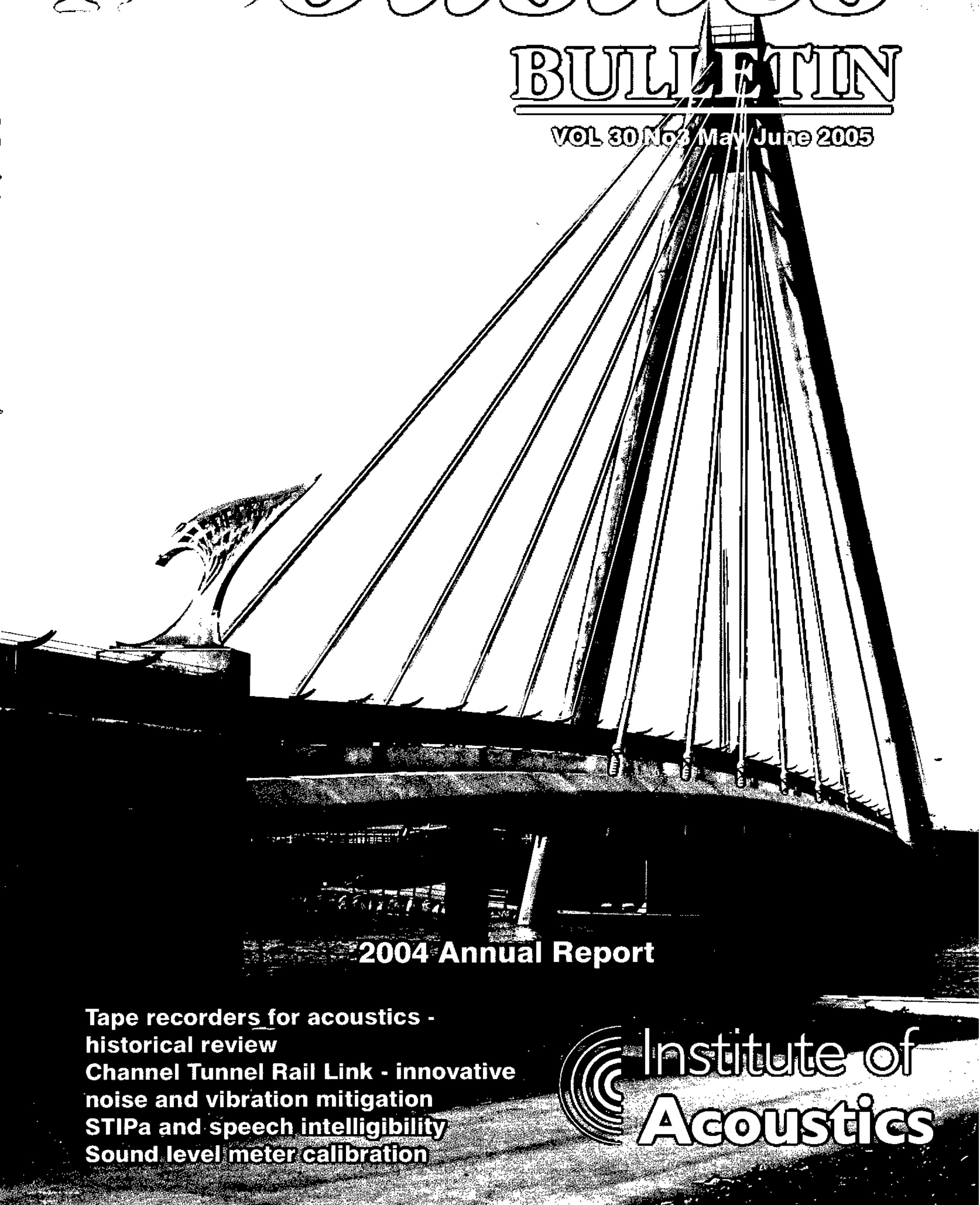

2004 Annual Report

Tape recorders for acoustics - historical review
Channel Tunnel Rail Link - innovative noise and vibration mitigation
STIPa and speech intelligibility
Sound level meter calibration

Institute of Acoustics

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Contents

Institute of Acoustics

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

Dear Members

The 2005 conference year certainly got off to a good start with the Underwater Acoustics Group's conference on sonar transducers and numerical modelling, and the Spring Conference organised by the Building Acoustics Group. These events were noteworthy for both their scientific merit and friendly atmosphere, and will give the organisers of forthcoming meetings something to live up to. With an impressive schedule still to come, including the 21st birthday of Reproduced Sound, I have every confidence that they will respond accordingly!

The Spring Conference Dinner provided the occasion to recognise Geoff Leventhall's distinguished career by making him an Honorary Fellow. Honorary Fellowships are awarded for exceptionally important services to acoustics or to honour service to the Institute. Geoff amply qualifies on both counts and it was a great delight to present this particular award.

The Annual General Meeting was held at the Spring Conference, and the annual report showed that the Institute continues to be energetic both technically and socially at Group and Branch level, as well as nationally. The AGM noted the retirement of Ian Campbell as Vice President for Groups and Branches and also of Bridget Shield as an Ordinary Member of Council. Both have made substantial contributions to the operation of the Institute over many years and I am sure that everyone appreciates their efforts. Their replacements on Council are Stephen Turner as Vice President for Groups and Branches, and Gary Heald as Ordinary Member. Both have proven track records, Stephen as Chair of Meetings Committee and Gary as Chair of the Underwater Acoustics Group, so Council should benefit greatly from their input. Council is also looking forward to the contribution over the next year from our new Young Members' Representative, Anne Carey, who is well known to the London Branch as their Secretary.

The AGM passed two special resolutions relating to service on Council. One enables members receiving remuneration for their educational services not to have to give these up if elected, and the other reduces the maximum allowable period of continuous service for Ordinary Members. These revisions should encourage wider participation of the membership at large in the Council of the Institute of Acoustics.

As well as developing initiatives mentioned in previous letters, Council will soon be considering proposals for a new inter-disciplinary Group aimed specifically at our younger membership and a new Branch covering the geographical area of Bedfordshire, Buckinghamshire and Hertfordshire. Let me have your views on these ideas and your offers of help.

Tony Jones

Tony Jones
President

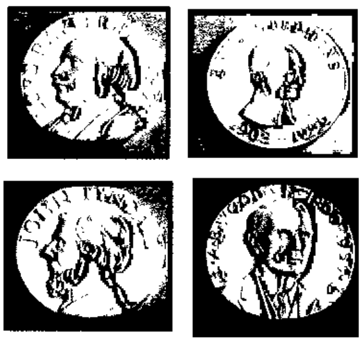
Institute of Acoustics
Annual Report 2004

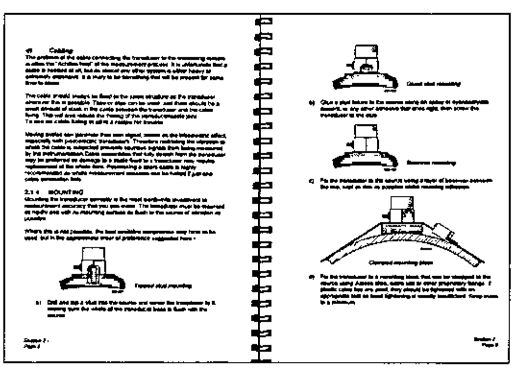
Summary

The Institute has continued to serve the interests of its members through its established programmes in the areas of education, professional development, meetings and publications, and by providing representation in areas such as the Engineering Council and International affairs

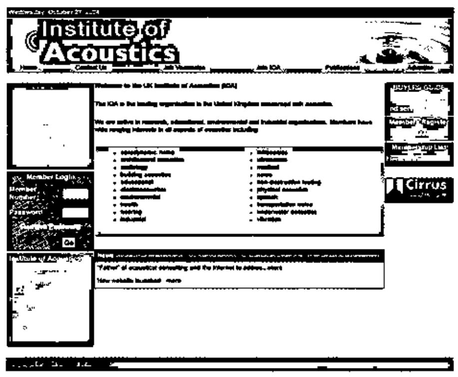
During the year

- An ambitious programme of conferences and technical meetings was undertaken at both national and regional level
- An extremely well-attended series of four Update Workshops on the EU Physical Agents (Noise) Directive and the forthcoming new UK Regulations was held in London, Birmingham, Leeds and Glasgow with the support of the Health and Safety Executive (HSE)
- The Institute's thirtieth anniversary was celebrated at the Autumn Conference
- The Institute's prestigious medals and awards programme was enhanced by the introduction of two new awards. The Young Persons Award for Innovation in Acoustical Engineering (sponsored by Industrial Acoustics Company Ltd) was announced and the Award for Promoting Acoustics to the Public was created. Nominations for both are being sought for the inaugural presentations in 2005
- Demand for the Institute's Diploma in Acoustics and Noise Control, along with the range of short courses, continued to grow
- The Institute's web site was improved and restructured
- A Good Practice Guide on the use of Instrumentation to Measure Vibration affecting People was published
- Arrangements have been made for the Acoustics Archive to be housed at Southampton University's library
- The Institute continued to participate in the consultation process for Government initiatives and British and International Standards
- Liaison with the Engineering and Physical Sciences Research Council (EPSRC) over improved categorisation of research grants concerning Acoustics continued to be an important function and nominations were made to the Research Assessment Exercise
- Following a thorough audit process by the Engineering Council, the Institute was granted a licence to independently award Chartered Engineer and Incorporated Engineer status to qualifying members
- Strategic development of the Institute was considered and various actions are being implemented, including improved communications through the creation of the role of Publicity and Information Manager





Pictured top left: during the year the Institute announced that two new accolades would enhance its existing medals and awards programme; bottom left: a Good Practice Guide on the use of Instrumentation to Measure Vibration Affecting People was published: top centre: Southampton University's Avenue Campus was the venue for the IOA Spring Conference 2004; top right: pictured at the Autumn Conference - IOA President Tony Jones (right) deep in conversation with Dr Leo Beranek, our guest speaker at the Institute's 30th Anniversary Dinner; bottom right: our improved and restructured web site



Standing Committees

The operation of the Institute is guided by Council through Standing Committees concerned with Education, Medals and Awards, Meetings, Membership, Publications, and Research Co-ordination. There is also a Committee of the Engineering Division

Education Committee

Through the continual efforts of the Education Committee, education remains a core component of the Institute's activities. The various educational programmes and courses are a valuable means of bringing the Institute to the attention of many professionals working in acoustics and environmental health. Significant numbers of successful students may then go on to join the Institute.

The management of the *Diploma in Acoustics and Noise Control* has continued to progress. A standardised arrangement for the declaration and assessment of Special Needs has been introduced and will be implemented by all Diploma Centres. The methods for ensuring consistency in marking of coursework between centres have been refined and will continue to be monitored during the coming year.

A major revision of the modular structure of the Diploma is underway for implementation in 2006/2007. The aim of the revision is to produce modular content that reflects the contemporary needs of acoustic professionals. In the coming year the Education Committee will be examining the Higher Education framework for awards and will be working to ensure that the Diploma continues to justify its status as a post-graduate award.

The number of students recruited to the Distance Learning scheme in September 2003 was 140, including 28 in the Distance Learning Scheme, with similar sized groups meeting at St Albans, Bristol and Edinburgh. Of these, all but a few are standard entry qualifications, with an individual assessment for each non-standard entry. Following the success of one Distance Learning student from New Zealand, plans are advanced for a franchising arrangement with Auckland University. A cohort of 12 students in New Zealand is anticipated for 2005/6.

Four one-day 'update' workshops for *Workplace Noise Assessment* certificate holders on the implications of the Physical Agents Directive (Noise), were organised around the country in October/November and these attracted more than 200 delegates. Following the revisions to the Building Regulations Approved Document E, progress has been made for the re-introduction of the Certificate Course in the *Measurement of Sound Transmission within Buildings*. This course is planned for the Spring of 2005. Short courses to support the introduction of anti-social behaviour legislation in Scotland were developed; the first of which was a 1 day workshop for existing holders of the *Certificate of Competence in Environmental Noise Measurement*.

The need for skills training for junior noise consultants had been recognised in 2003, and in 2004 two one-day meetings were held where the 'great and the good' of the acoustics world passed on their experiences to younger members. It is hoped that this initiative will be repeated in future years.

At the end of the year Mike Fillery passed on the baton of Chair of the Education Committee to Dave Saunders. Mike has occupied the Chair for the past six years during which time there have been significant improvements in the management and quality of the Diploma, the introduction of new courses, the appointment of the Education Manager and the consolidation of the Distance Learning programme. All this would not have been possible without the hard work of the Education Manager, the office staff and the members of the Education Committee.

Engineering Division Committee

The Institute's five-yearly Engineering Council 'licence renewal audit' took place in 2004. The visiting panel commended the Institute on the quality of the records, the scoring and assessment system and the guidance given to candidates. A general review of the Division's work and proposals for the future took place and among the topics discussed were the possibility of obtaining third-party accreditation for the Diploma, the possibility of working with an industry sector to develop an NVQ in some aspect of acoustical engineering and the need for a market assessment for growth in IEng and EngTech registration. The Engineering Council has subsequently granted the Institute a full five-year licence in its own right for CEng and IEng, thus ending the requirement for the IMechE Bilateral Agreement.

The Committee met three times during the year. Two internal audits were carried out, with no non-compliances identified. The number of enquiries for registration remains strong but some candidates still defer or fail to complete their applications. The first recipient of the Institute of Acoustics Engineering Medal was named as Rob Harris of Arup Acoustics.

Medals and Awards Committee

The Spring Conference at Southampton University provided an opportunity to catch up with some presentations that had been pending a suitable occasion. On home ground, Prof Tim Leighton was presented with the Tyndall Medal for 2002 and gave his medal lecture *From sea to surgeries, from babbling brooks to baby scans: bubble acoustics at ISVR*. Two A B Wood Medals were also presented, namely for 2002 to Dr Simon Richards and for 2003 to Dr Anthony Lyons. Respectively, their medal lectures were entitled: *Underwater acoustics and sonar performance in turbid environments*; and *High technology and high frequency seafloor acoustics*.

Left: Following presentation of the R W B Stephens Medal 2003, recipient Greg Watts delivers his lecture at the Autumn Conference

Below left: James Angus (right) receives the Peter Barnett Award 2004 from IOA President, Tony Jones

Below right: the Tyndall Medal 2004 was awarded to Prof Trevor Cox

During the Autumn Conference held at The Oxford Hotel, the Rayleigh Medal for 2004 was presented to Prof Alan Cummings who spoke on *Duct wall breakout – friend or foe?* and the R W B Stephens Medal for 2003 was presented to Prof Greg Watts whose lecture was entitled *Reducing traffic noise disturbance*. The announcement of Rob Harris as the recipient of the inaugural IOA Engineering Medal was also made at the conference; Rob will receive his medal at the 2005 Spring Conference.

Reproduced Sound 20, also at The Oxford Hotel, was the

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occasion when the Tyndall Medal for 2004 was presented to Prof Trevor Cox, who addressed the conference on *Acoustic diffusers - The good the bad and the ugly*. Prof James Angus was announced as the recipient of the 2004 Peter Barnett Memorial Award, and Peter Mapp delivered his 2003 Peter Barnett Memorial Award lecture called *Dumb microphones and deaf loudspeakers – the reproduction and measurement of sound*.

Honorary Fellowships were bestowed on Prof Bob White, at the Spring Conference, and on both Dr John Walker and Dr Leo Beranek, at the Autumn Conference. The latter also saw Stephen Chiles and Peter Sacre receive their Awards for Services to the Institute, while the ANC's Best Diploma Project Award was presented to Richard Cookson and the ANC's Best Paper Award to Dr Stuart Colam. The presentation of the Institute's Best Diploma Student Award was made to David Rees at Reproduced Sound 20. Following our decision to extend the A B Wood Medal for even numbered years to include acousticians domiciled in the European Union (rather than being restricted to the UK), the award of the A B Wood Medal 2004 to Dr Eric Pouliquen was announced. The medal presentation will take place at an Underwater Acoustics Group conference early in 2005.

Other notable events during 2004 included the award (jointly with ISVR) of the Professor D W Robinson Prize to Tracey Draper, and notification that Prof Tim Leighton had received an ICA Early Career Award. Towards the end of the year two new Institute awards were announced; these were the Young Persons Award for Innovation in Acoustical Engineering and the Award for Promoting Acoustics to the Public, with the inaugural awards being scheduled for the 2005 Autumn Conference.

TABLE 1 MEETINGS ATTENDANCE IN 2004

Topic, Date and Venue	*Attendance*
Anglo-French Physical Acoustics 14-16 January, Wye College	61
Spring Conference 29-30 March, Southampton	110
The Art of being a Consultant 31 March, Southampton	31
Acoustics and Sustainability – Conflict or Cohesion? 27 April, London	42
Aircraft Noise 13 May, London	68
Developments in Noise Research 26 May, Birmingham	46
The Art of being a Consultant 16 June, Salford	40
Shake Rattle and (the) Role of the Physical Agents (Vibration) Directive in risk assessment 7 July, Derby	54
Sonar Signal Processing 14-15 September, Loughborough	44
Symposium on Bio-Sonar Systems and Bio-Acoustics 16 September, Loughborough	46
Autumn Conference 6-7 October, Oxford	109
Reproduced Sound 20 8-9 October, Oxford	83
Update Workshop on EU Physical Agents (Noise) Directive and the new UK Regulations 20 October, London	70
Update Workshop on EU Physical Agents (Noise) Directive and the new UK Regulations 3 November, Birmingham	74
Update Workshop on EU Physical Agents (Noise) Directive and the new UK Regulations 10 November, Leeds	70
Update Workshop on EU Physical Agents (Noise) Directive and the new UK Regulations 17 November, Glasgow	49
Environmental Vibration 24 November, London	46

Meetings Committee

The year 2004 saw another wide range of meetings being held by the Institute. These included four two-day conferences, various one-day meetings, several workshops and over 25 afternoon and evening meetings arranged by the Institute branches. Of particular interest was the number of meetings held in conjunction with other organisations. In May, to mark Noise Action Day, a one day meeting was held in conjunction with DEFRA which enabled the results of several government supported research contracts to be publicised. Two meetings were held in conjunction with the Association of Noise Consultants aimed at young practitioners on the *Art of being a Consultant*. Towards the end of the year, four workshops were held in conjunction with the HSE on the new regulations in connection with Workplace Noise Assessment.

It is important to recognise that none of these meetings would occur without the hard work of the organisers. To that extent, the work of the various committees of the Specialist Groups and Regional Branches is gratefully acknowledged, along with assistance from members of the Meetings Committee and Head Office staff.

Membership Committee

There were the usual four meetings during the year, and a total of 231 individual applications (all grades) were considered, including potential new members and transfers between grades; 210 (72 corporate, 138 non-corporate) were approved, including 11 reinstatements, but only one new sponsor member was welcomed. There was a net gain in individual membership of 9, compared with 7 in the previous year. The detailed figures are shown in the table. Applications for Technician membership were disappointingly few, but extra publicity is to be aimed at those attending courses for the Certificates of Competence. Versions of all Membership Application Forms are now on the Institute's website.

Clarifying amendments to the Code and Rules of Conduct, concerning matters relevant to members working in academic fields, were approved by Council, to be operative from 1 January 2005. Advice for members on maintaining their continuing professional development has been compiled and is now available on the website, with suggested spreadsheets for members to keep their own informal records. There were no changes in the regular membership of the Committee during the year.

Publications Committee

This has been another busy year for the Publications Committee. A significant number of proceedings from meetings were published together with an excellent set of *Bulletins*, under the editorship of Ian Bennett. Our Advertising Manager Dennis Baylis has also performed well, consolidating and building on his previous year's successes. The major piece of work during the year has been the new web site which was launched in December. A considerable amount of work went into this, for which thanks go to the contractor, Simply Sites, Roy Bratby and the Publications Committee Chairman! The website is an ongoing project and will gradually increase in usefulness and information content. Already it has membership and products and services directories - both of which are major steps forward for information access - and long overdue if the Institute is to maintain its position as the first choice for acoustics information in the UK.

Increasingly, the Publications Committee is becoming a 'Communications Committee' as it reflects the changes in its role and function. As with other Institute committees interest from members (new or old!) is welcomed from those wishing to become involved in its work. This next year will no doubt have some challenges - why not be part of them?

TABLE 2 MEMBERSHIP

Grade	2003	2004
Hon Fellow	18	21
Fellow	197	196
Member	1371	1371
Associate Member	702	714
Affiliate	106	96
Technician Member	5	10
Student	49	49
Totals	2448	2457
Key Sponsor	3	3
Sponsor	30	28
Institutional Subscriber	15	15

TABLE 3 GROUP MEMBERSHIP

Group	2003	2004
Building Acoustics	676	719
Electroacoustics	189	202
Environmental Noise	1047	1075
Noise and Vibration Engineering	639	673
Measurement & Instrumentation	253	273
Musical Acoustics	133	135
Physical Acoustics	94	98
Speech	101	96
Underwater Acoustics	134	131

Breakdown of Institute membership 2004

TABLE 4 BRANCH MEMBERSHIP

Branch	2003	2004
Eastern	235	236
Irish	101	112
London	560	558
Midlands	340	360
North West	269	297
Scottish	120	124
South West	200	205
Southern	418	437
Yorks/Humberside	171	171

TABLE 5 DETAILS OF EMPLOYMENT

Employment Category	2003	2004
Architectural Practice	19	18
Consultancy	838	875
Industry/Commerce	323	329
Education	190	190
Public Authority	538	515
Research & Development	207	195
Other	73	74

Research Co-ordination Committee

The committee met on three occasions in 2004. Liaison with the Engineering and Physical Science Research Council (EPSRC) over categorisation of research grants concerning Acoustics has continued to be an important function. Dr Bateman has been replaced by Dr Angharad Thomas as the EPSRC member on the Committee. Dr Bajram Zeqiri has replaced Roy Preston as a member from NPL. Dr Jo Bray has attended on behalf of DEFRA.

Through Norman Bolton from DTI, who kindly continued to provide a London venue for meetings in 2004, the Institute has the opportunity to devise a proposal for a Foresight programme in acoustics. It is hoped to make this proposal early in 2005. The dialogue with Membership Committee over the Code and Rules of Conduct for members with respect to research activities has resulted finally in an amendment to the Code and Rules of Conduct referring to conduct in respect of research. A continuing concern is the status and format of research papers in Institute conference proceedings.

Specialist Groups

The Institute reflects the broad spectrum of the science and application of acoustics and several Groups exist to foster contacts between members of the various specialisms

Building Acoustics Group

The Building Acoustics Group ran a successful meeting in April with over 40 delegates attending a half day meeting on *Acoustics and sustainability*. This was the third in a series of professional practice meetings following on from successful meetings on *Design and build unplugged* and *Contractual risk and liabilities* held in 2003. The meeting comprised four presentations on the approach to environmental design as well as extensive discussion. The object was to discuss whether different approaches to the design of buildings would conflict with acoustics design. The Committee has been active in preparing for the Spring Conference in 2005.

Electroacoustics Group

The Electroacoustics Group committee membership has remained stable for the year with a full complement, the secretary being Paul Malpas from Arup Acoustics. The Group's sole function and responsibility during 2004 was the arranging and implementation of the RS20 conference which was held at Oxford in November. A report of the conference would appear in the January/February 2005 issue of the *Bulletin*. The conference was widely regarded as a technical and social success. The Electroacoustics Group committee feels a strong sense of ownership and care towards the RS conferences and that major changes to the format would be perilous.

No one-day conferences were organised as no burning issues bubbled to the top of the agenda. The committee keeps its radar on and continues to be ready to organise such events. Thanks are due to the committee membership and their alter-ego, the RS committee, and Head Office staff for the considerable time and effort put into organising the Reproduced Sound 20 conference.

An entertaining evening workshop on microphone placement during RS20: top left: Shelley Katz on grand piano; bottom left: Simon Stephenson on banjo; and top right: Sam Wise on Northumbrian pipes

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Environmental Noise Group

The Environmental Noise Group continued to be active throughout the year. As well as being responsible for the 2004 Autumn Conference, the group was also responsible for the one-day meeting on Developments in Noise Research held in Birmingham. In addition, input was provided to the draft Institute/IEMA Guidelines on Environmental Noise Assessment (which is once again making good progress), and liaison is maintained with internal and external groups to ensure that the Institute keeps up to date with the latest issues in environmental noise.

Measurement and Instrumentation Group

Although a regular programme of meetings for the year had been planned by the Group, a one-day meeting scheduled for March on tape and digital recording, and another later in the year on sound quality, had to be cancelled due to lack of registrations by the cut-off date. This is an increasing problem for meetings organisers. However, a successful and well attended meeting entitled *Shake, rattle and (the) role... of the Physical Agents (Vibration) Directive in risk assessment* was held at the Rolls Royce Learning Centre in Derby in July. This attracted 54 delegates and eight speakers to enlighten the audience on various aspects of measuring vibration, mostly as it affects people. During the meeting the *Good Practice Guide to the use of instrumentation to measure vibration affecting people*, published by the Institute, was launched and all delegates received a free copy as part of the attendance package.

The AGM of the Group was held during the lunch break of the Derby meeting. One committee member, John Shelton, was required to stand down and was duly re-elected unopposed. As this still left one vacancy on the full committee, our longest-standing co-opted member, Mike Swanwick of Rolls Royce, was also elected as a full member of the Committee on his home territory. Thanks go to all members of the Committee for the active roles they take in all aspects of the Group's activities and to Martin Armstrong for his secretarial skills on behalf of the Group. A full programme is well in hand for 2005, which will include the Autumn Conference, so it is hoped that there will be sufficient delegates to warrant the considerable time and effort spent organising and preparing for these events.

The Institute's 30th Anniversary Dinner was held during the Autumn Conference

Musical Acoustics Group

Although the Musical Acoustics Group has been dormant for some time, there was a minor revival during the year. In particular, a performance by the New Violin Octet in Aust, South Gloucestershire, gave members an opportunity to learn about these new instruments which were developed by Carleen Hutchins over the latter part of the 20th century. The pre-concert talk by Peter Dobbins attracted about 30 people, while attendance at the concert was an impressive 101 (a full house).

Additionally, a funding application submitted to EPSRC for a UK Musical Acoustics Research Network under the Culture and Creativity Programme was successful. This was coordinated by Murray Campbell at Edinburgh University and, in the coming year, will support a number of musical acoustics activities, as well as providing an opportunity for the AGM.

A performance using the New Violin Octet was given in Aust, South Gloucestershire
(photo: John Castronovo)

Noise and Vibration Engineering Group

It was a rather quiet year for the Noise and Vibration Engineering Group. A number of committee members were required to attend to their 'day' jobs hence Institute business took a back seat. One edition of the *Industrial Noise Newsletter* was published mid-year. The key activity during committee meetings in 2004 was to explore opportunities to broaden membership of the committee and identify potential areas of interest for future meetings. For 2005 Stephen Walsh, Malcolm Smith, Barry Jobling and Rueben Peckham will be welcomed to the committee, which looks forward to their input and new ideas. During 2005 it is intended to publish three *Newsletters* and a one-day meeting to coincide with European Health and Safety week in October is already being planned.

Joint IOA/IOP Physical Acoustics Group

The highlight of the year was the Anglo-French Physical Acoustics Conference (AFPAC'04). This meeting, which is now held annually on opposite sides of the Channel, was organised jointly with the Groupe Spécialisé d'Acoustique Physique, Sous-marine et Ultra-Sonore of the Société Française d'Acoustique. Some 61 delegates assembled at the Wye Campus of Imperial College in Kent for the meeting in January. The conference covered a wide range of topics in Physical Acoustics with 43 oral papers and three posters being presented. A very strong theme

running throughout was the practical application of ultrasound to measurement problems in NDE and industry, and the need for a thorough understanding of the science underlying such techniques.
In addition a very successful Tutorial Day on Physical Acoustics was held at the Institute of Physics in London during September. This took the form of three extended lectures on very different aspects of physical acoustics and ultrasound and enabled the presenters to provide comprehensive reviews of their topics.
The Group was very saddened by the sudden death in November of a long serving committee member, Prof Bob Chivers, who was instrumental in setting up the Physical Acoustics Group and an enthusiastic member of the Institute of Acoustics and Institute of Physics.

Speech Group

Whilst there has been no activity during the year plans are being made to hold a one-day meeting during 2005. The search for a new Chairman continues.

Underwater Acoustics Group

Over the past year the Underwater Acoustics Group has organised a number of conferences and events. A special session was held at the Institute's Spring Conference on acoustics in liquids and tissues. This allowed researchers from underwater acoustics and medical acoustics to present during the session and give a cross fertilisation of ideas from both disciplines. At the start of the session Prof Tim Leighton presented his Tyndall Medal Lecture and was awarded his medal by the President. The title of the lecture was *From seas to surgeries* and gave an account of Tim's work in both fields. The President also presented medals to two A B Wood Medal recipients. The 2002 recipient was Dr Simon Richards, of QinetiQ and the 2003 US Recipient was Dr Tony Lyons from the Applied Research Laboratory, Penn State, USA. Both gave their lectures during the special session.
During September the Group held two further conferences. These were on Sonar Signal Processing, chaired by Prof Hugh Griffiths, and Bio-acoustics and Bio-sonar, which was chaired by Dr Peter Dobbins and Prof Brian Woodward. It was felt that there were a number of researchers who might be interested in both subjects so the group decided to hold these events consecutively at the same venue, Loughborough University. The Signal Processing conference, held over two days, was followed by the one day Bio-acoustics Symposium. Both were well attended and it was noted that a significant number of people stayed for the two events.
At the start of the Bio-acoustics meeting a special session was held in memory of David Goodson. David's wife attended the event and listened to a tribute to her late husband, given by Prof Woodward, and a memorial lecture given by Whitlow Au, from Hawaii. Before his death David had been one of the organisers of the Bio-acoustics events and was an active member of the Underwater Acoustics Group committee.
The A B Wood Medal recipient for 2004 was announced as Dr Eric Pouliquen who is currently working at the NATO Undersea Research Centre in Italy. This was the first time that the medal had been available to European acousticians, *ie.* extending it beyond the UK. Dr Pouliquen would receive his medal at a conference on transducers and numerical modelling in underwater acoustics being held at the National Physical Laboratory (NPL) in March 2005.

Regional Branches

The Regional Branches of the Institute were established to further the technical and social activities of the Institute at local level

Eastern Branch

During the year the Eastern Branch Committee organised seven technical meetings and one social meeting. These had an average attendance of around 19 members and were organised from four committee meetings. As always, the committee members tried to provide a wide cross-section of topics with venues spread across the Eastern Region as much as possible, although many were held at Colchester Institute.
The first meeting in February saw members visit the test facilities at Sound Research Laboratories in Little Waldingfield near Sudbury, guided by David Clarke. This was closely followed in March by an afternoon presentation at Ipswich, delivered by Richard Scuttle, on *Building Regulations Approved Document E*. In April, Peter Mapp gave an illustrated talk and demonstration at Colchester on aspects of *Speech Intelligibility*. This was followed in May by an illustrated talk at Braintree delivered by Lesley Ormerod, entitled *IPPC Noise Permitting*.
In June the planned social meeting took members back to the sea, with a very enjoyable and interesting Evening Cruise by Thames Barge which included a return voyage from Maldon around the Heybridge Basin and the River Blackwater and a meal onboard when back at the quay. After the summer break, members returned in September to enjoy an afternoon meeting and visit to the wind turbine at Swaffham, where Andrew Toomey delivered a very interesting talk on *Noise from wind turbines*. This was closely followed in October by a meeting at Colchester on *Noise problems for call centre operators*, delivered by Keith Broughton. Finally, the AGM was combined with our meeting in November at Colchester Institute, when Dr Andy Moorhouse delivered a lecture on *Virtual acoustic prototypes - listening to machines before they exist*.

Irish Branch

There were two evening meetings during the year, the first of which was held in January at IEI in Dublin. Keith Broughton,

Geoff Kerry, Immediate Past President, led a discussion on the Acoustics Profession and the IOA's strategic development

Principal Specialist Inspector in Noise and Vibration with the HSE provided an update on the *EU Physical Agents Directives*. Almost 30 people attended this informative evening. We were delighted to welcome Geoff Kerry, the Immediate Past President of the Institute to our AGM in May which was held in the Belfast Institute of Further and Higher Education. Geoff spoke to us regarding the *Acoustics Profession - Past, Present and Future*. The Institute was looking toward its strategic development and an interesting number of ideas were debated.
There were three Committee meetings during the year with two additional committee members joining and one stepping down. In February, the Irish Branch was represented at the 'Groups and Branches' meeting held at St Albans and this proved to be an interesting meeting polling many ideas. The Institute of Acoustics was again included in the *Association of Professional Engineering Institutions Yearbook* for Northern Ireland and this enabled the possibility of engineering partnerships.

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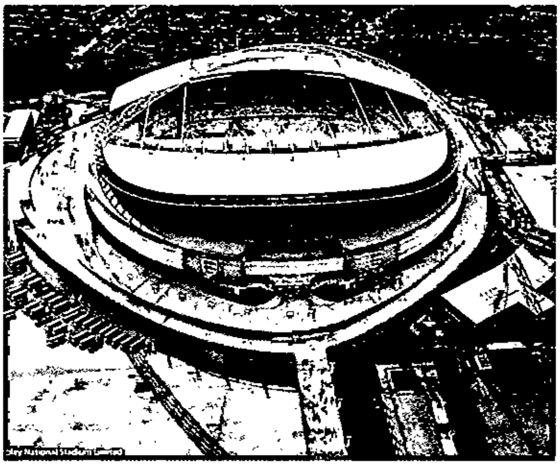
London Branch

A total of eight events were held by the London Branch throughout the year. These consisted of five evening meetings held at the Capita Symonds offices in Holborn, a half day visit to the Wembley Stadium, a one-day conference and the annual dinner. Attendance at the meetings and functions was good with roughly 20 to 40 members per evening meeting.

Some 25 members attended the half day visit, held at the offices of Wembley National Stadium overlooking the new stadium site, where we heard three interesting talks from the construction director, the lead architect, and Maer Davis, an acoustic consultant with Capita Symonds. The one-day conference, on the subject of aircraft noise, was attended by 68 delegates – the room's capacity. There were eight technical papers covering a wide range of issues, including the assessment and control of aircraft noise using the average mode equal energy contours, draft MOD policy on noise compensation, and an update of the UK Aircraft Noise Index study (20 years on).



Acoustics were naturally on the agenda during a visit to the new Wembley National Stadium development site

The annual dinner, held in November at 'The George' in London Bridge, attracted 50 people. The after dinner talk, entitled *Changes at the BBC,* was given by Bob Walker from the Corporation. The food and atmosphere were good and everyone thoroughly enjoyed the event. The remaining evening papers were given by Roger Tompsett from Atkins, on the *Construction of the London noise map*, followed by several rail noise talks by Colin Cobbing, Mark Southwood and John Campbell. The final talk of the year was given by Richard Tyler and had the thought provoking title *Calibration - what do you get for your money?*.

Midlands Branch

The Midlands Branch held four evening meetings during the year. The first was in April at the offices of Atkins Noise and Vibration, where Greg Watts of TRL gave an update on the development of a European harmonised noise prediction model - *Harmonoise*. This presentation outlined the requirements that the model had to fulfil and described the work that has been carried out to date, with emphasis on the contribution of TRL. Data has been collected over an extended period under different meteorological conditions in order to validate the model.

The second meeting took place at the University of Derby in May. Nick Antonio of Arup Acoustics delivered his personal observations on the implications of the changes to Building Regulations Approved Document E. Nick assessed the document from a number of different perspectives, examining the impact upon local authorities, developers and contractors and on the design process. He concluded with a discussion of the current state of play regarding Robust Details and where things will go in the short term. Nick delivered a talk that was informative and entertaining and was warmly received by the audience.

We returned to the University of Derby in September where we repeated the young members' meeting of 2003, when three students on the MSc in Applied Acoustics course at Derby gave presentations. These covered a case history of a landfill site, measurement and assessment of groundborne reradiated noise from railways, and the development of a microphone windshield. The overall standard was excellent and hopefully inspired the 30-plus cohort of new Institute Diploma students who were guests at the meeting.

The final meeting of the year and AGM was held in November at the Birmingham office of Atkins Noise and Vibration. After the formal issues of the AGM were dealt with (Mike Fillery stepped down as Branch Secretary after a decade of sterling service and Paul Shields was elected as the new Branch Secretary; all other members of the existing committee were re-elected) there was a presentation by Prof Deborah Withington of Leeds University on psycho-acoustics, with particular reference to directional audible alarms.

In all, this talk upheld the fine standard of all the presentations in this year's interesting and varied programme. Whilst the evening meetings had been successful, not all was plain sailing, for yet again the half-day visit had to be cancelled. A visit to the Symphony Hall, Birmingham in September had been planned but uncertainties over the arrangements prevented it taking place. The Branch Committee held a planning meeting in December to discuss the programme of branch meetings for 2005. During this meeting Mike Swanwick was elected onto the committee.

North West Branch

Our meetings year began in March with a presentation by Professor Stuart Bradley of Salford University. Stuart provided an interesting insight into the trials and tribulations of acoustical engineering in Antarctica and the unusual use of acoustic radar. By all accounts, the penguins remained undisturbed, but this cannot easily be verified, since Stuart has now returned to his native New Zealand.

In May, a workshop on BB93 was jointly presented by Andy Turnbull of Acoustic & Engineering Consultants Ltd and Thomas Wulfrank of Arup Acoustics. Andy provided an overview to the *Acoustic design of schools*, using his experience on a number of multi-school projects. Thomas concentrated on speech intelligibility in open-plan areas and his experience in demonstrating how to comply with these requirements. The resulting question and answer session seemed to pose significantly more questions than answers. Richard Greer, representing Rail Link Engineering, provided an excellent presentation on the acoustic control measures employed during design and construction of the Channel Tunnel Rail Link. The methods of controlling vibration from the rail were particularly interesting.

The final meeting of the year coincided with the AGM in November. Nick Antonio of Arup Acoustics persuaded Les Fothergill of the Office of the Deputy Prime Minister to head north and give us his experience on Approved Document E and Robust Details. Les provided a summary of the most frequently asked questions and helped respond to an extensive question session, where the primary concern appeared to relate to pre-completion testing and who qualifies to do the testing. Exhaustion was averted by a visit to a nearby hostelry.

During the year, meetings were well attended, and hosted by Ove Arup and BDP who must be congratulated on their smooth running. The committee has made a conscious, or is it unconscious, decision to reduce the number of meetings from those in previous years. All their efforts must be applauded and special thanks are offered to Paul Freeborn for keeping the kettle boiling and providing the committee venue. Despite this the Committee would like to hear from the membership about possible meeting topics.

Scottish Branch

Although it could be argued that the Scottish Branch did not have a large quantity of meetings and visits during the year, those members who did attend would say that the quality was first class. One of the most important meetings the Scottish Branch has ever held was at the Golden Lion Hotel in Stirling in April. It was held under the banner of *IOA Matters* and the principal speaker was Ian Campbell, Vice President, Groups and Branches. Professor Bob Craik was coerced into chairing the meeting which he did in his usual formidable fashion, armed with a series of flip charts and pens.

The attendees were asked to put their ideas forward and voted on how they would like to see the Institute develop. Everybody present thoroughly enjoyed the intellectual and thought-provoking evening and retired to the restaurant to replenish their energy levels. In acoustic staying terms L_{max} was awarded to Bob Craik, Ian Campbell, Lilianne Lauder, Anne Ormston and Alistair Somerville. L_{min} was therefore awarded to the other Institute members who retired gracefully during the evening. All 18 Scottish Branch members who attended contributed to a very lively and entertaining evening, which was enjoyed by all - especially Ian Campbell.

Although the Scottish Branch Committee members had a number of good intentions for meetings and visits during the year it was not possible to arrange a further event until December. With the help of Norman Allan, who was the then Airside and Safety Manager at Edinburgh Airport, a meeting entitled *Come fly with the IOA* was arranged for early December. However, due to a last-minute medical emergency which involved Norman being hospitalised, Fiona Watson kindly agreed to give a presentation on the practical aspects of noise monitoring at a busy airport. Everyone enjoyed her interesting slides, including those of Fiona's holidays which she managed to convince everyone were to do with noise monitoring problems.

To take people's minds off noise and airports, David Mackenzie gave a high flying presentation on his research into noise in hospitals. Those present thoroughly enjoyed the meeting and to keep up with the festive spirit the group retired to the Khukuri Nepalese Restaurant. The Branch was honoured to be joined by Dr Mike Stewart, who has recently taken up a new post with the Health and Safety Executive in Buxton. The Chair and Secretary would like to thank all the Committee members for their hard work and commitment during 2004 and look forward to a full and interesting programme of events in 2005.

Southern Branch

The Branch held its AGM in April, which was followed by a presentation by Nigel Cogger on the new environmental noise standard, BS 9142, attended by 22 members. Roger Tompsett and Liz Williams gave a presentation on the London noise map at the July meeting. The next meeting, to be held in March 2005, would be a presentation by Prof Tim Leighton.

South West Branch

The committee met twice in 2004 and organised two Branch meetings. The first was in February, entitled *Noise and vibration in vehicles - some tricky problems and the art of compromise.* This excellent presentation was given by Andrew Middleton from Anthony Best Dynamics Ltd, a company of noise, vibration and suspension engineers offering a range of products and services to the automotive industry. The meeting, followed by a lively discussion, was attended by 24 delegates from a variety of backgrounds within acoustics. The Branch would again like to thank Stan Simpson and the University of the West of England for hospitality.

The second meeting was a visit to the BBC in Cardiff in September. Leon Ford, Radio Operations Co-ordinator from the BBC conducted an extensive tour of the radio and TV studios and control rooms, incorporating sets for the long-running Welsh soap, 'Pobol y Cwm'. The 20 delegates were most impressed with the facilities and willingness of all BBC staff who withstood a barrage of questions and supplied a wealth of information about reverberation times, operation of equipment, difficulties of producing live TV broadcasts from the Millennium Stadium, co-ordinating 'Children in Need' throughout Wales, and what 'Pobol y Cwm' means (people of the valley). Thanks are due to Leon and his colleagues from the BBC at Cardiff. It is hoped that the Branch can build on this for 2005 and have another successful year.

TABLE 6 INSTITUTE PERSONNEL AT 31 DECEMBER 2004

COUNCIL		
Officers		**Ordinary Members**
President	Dr A J Jones FIOA	Mr N Antonio MIOA
President Elect	Mr C E English FIOA	Prof T J Cox MIOA
Immediate Past President	Mr G Kerry FIOA	Prof R J M Craik FIOA
		Prof B M Gibbs FIOA
Honorary Secretary	Dr R J Orlowski FIOA	Mr C J Grimwood FIOA
Honorary Treasurer	Mr K A Broughton MIOA	Dr G C McCullagh MIOA
Vice Presidents		Prof B M Shield FIOA
Engineering	Dr B McKell MIOA	Mr A W M Somerville MIOA
Groups & Branches	Mr I J Campbell MIOA	Mr S W Turner FIOA
International	Mr B F Berry FIOA	

Committees & Sub Committees	Chairman
Education	Dr M E Fillery FIOA
Diploma in Acoustics and Noise Control, Board of Examiners	Prof K Attenborough FIOA
Certificate of Competence in Environmental Noise Measurement	Mr D Trevor-Jones FIOA
Certificate of Competence in Workplace Noise Assessment	Mr T Ward MIOA
Certificate in Measurement of Sound Transmission in Buildings	Prof R J M Craik FIOA
Certificate in the Management of Occupational Exposure to Hand Arm Vibration	Mr T M South MIOA
Engineering Division	Dr B McKell MIOA
Medals & Awards	Dr A J Jones FIOA
Meetings	Mr S W Turner FIOA
Membership	Mr J R Dunn MIOA
Publications	Dr M K Ling MIOA
Research Co-ordination	Prof K Attenborough FIOA

Specialist Groups	Chairman	Secretary
Building Acoustics	Prof R J M Craik FIOA	Mr P J Rogers MIOA
Electroacoustics	Mr R C Cross FIOA	Vacant
Environmental Noise	Mr K M Collins MIOA	Ms N D Porter MIOA
Noise and Vibration Engineering	Mr M D Hewett MIOA	Mr J Richards MIOA
Measurement & Instrumentation	Mr R G Tyler FIOA	Mr M J Armstrong MIOA
Musical Acoustics	Dr P F Dobbins FIOA	Vacant
Physical Acoustics *(Joint with the Institute of Physics)*	Mr D Cartwright	Dr N Saffari
Speech	Vacant	Vacant
Underwater Acoustics	Dr G J Heald FIOA	Dr P D Thorne FIOA

Regional Branches	Chairman	Secretary
Eastern	Mr M P Alston MIOA	Mr C L Batchelor AMIOA
Irish	Dr G C McCullagh MIOA	Mr S Bell MIOA
London	Mr J E T Griffiths FIOA	Miss A L Carey MIOA
Midlands	Dr M E Fillery FIOA	Mr J F Hinton MIOA
North West	Mr P E Sacre MIOA	Mr P J Michel MIOA
Scottish	Mr D J MacKenzie MIOA	Ms L Lauder MIOA
Southern	Dr N D Cogger FIOA	Dr H Sagoo MIOA
South West	Mr T Clarke MIOA	Mr S Simpson MIOA
Yorks and Humberside	Mr P Horsley MIOA	Dr K V Horoshenkov FIOA

Yorkshire and Humberside Branch

There has been no activity during the year but plans are being prepared for 2005.

Institute of **Acoustics**

Meeting report

Sonar transducers and numerical modelling in underwater acoustics

The most recent in a successful series of conferences run by the Underwater Acoustics Group on sonar transducers was held at the National Physical Laboratory, Teddington on 21 and 22 March 2005. This particular meeting covered a wide range of different transducers and working frequencies, as well as applications of numerical modelling in sonar and transducer design.

An excellent range of papers was presented with 26 contributions in total, including two invited presentations. The conference had a truly international flavour with presentations from Russia (3), China, USA (2), France, Italy and South Africa (2). In total some 80 delegates from 12 countries attended the event. A highlight of the meeting was the presentation of the A B Wood Medal for 2004 to **Dr Eric Pouliquen** for his work on the acoustics of the seabed. His subsequent lecture, *Recent progress in high frequency seafloor acoustics*, highlighted the complex interaction of sound with the seabed.

Sandy Cochran (University of Paisley) gave the meeting an excellent start with his invited paper, *Present and future piezocomposite technology in underwater sonar transducers*. This highlighted the current state of the art and indicated the potential further developments that will result from the use of multiplayer piezocomposites and piezocrystal composites.

The composite theme was continued by **Adrian Hulme** (PCT Ltd) who described how transducers with improved field characteristics could be made by bending composite materials to form curved transducers in his talk, *Various curved 1-3 composite sonar transducers*. A better understanding of the behaviour of composite transducers was provided by **Michael Shatalov** (CSIR, South Africa), in his paper *Analysis of lateral resonances of 1-3 piezocomposites based on membrane theory*.

The final paper before lunch, *Integrated co-fired triply resonant broadband projector and co-polymer hydrophone transducer*, was presented by **Stephen Butler** (NUWC, USA). In his presentation he described how, by introducing additional resonant elements into a piston stack transducer, it was possible to produce a system with three resonant frequencies and a very wide effective bandwidth at low frequencies.

The theme of multiply resonant transducers was taken up after lunch by **Tiejian Xia** (Hangzhou Applied Acoustics Research Institute, China) in his talk, *The design of one kind of folded hybrid transducer*. This explained how the size of a multiple resonance frequency transducer could be reduced by folding the transducer elements back on themselves to produce a compact design.

The *Results of development, numerical modelling and field tests of new low-frequency piezoceramic sources* were presented by **Boris Bogolyubov**, with translation by Victor Farfel, of the Institute of Applied Physics, Russian Academy of Sciences. This demonstrated three different designs of low frequency transducer and highlighted how their performance had been analysed using FE modelling and measurements in the field.

Dorian Richelmi (Thales USL, France) presented a paper on a *New Bi mode transducer technology, modelling and measurements*. This described an alternative, and novel, dual frequency strategy, where one resonance is associated with an acoustic cavity on the transducer face.

In the second Russian contribution of the session, **Lev Nikitin** presented a paper on behalf of his colleagues (I V Gerasimova, R P Pavlov, V I Pozern and O B Stupak) at the Morphyspribor Research Institute, St Petersburg, Russia, on *The bandwidth of piston-type sonar transducers*. This again looked at a number of practical devices with multiple resonances, either produced by using a double head mass or by a double head mass and water filled cavity for extending the operating frequency range of transducers.

IOA President Tony Jones (left) presents the A B Wood Medal 2004 to Dr Eric Pouliquen for his work on seabed acoustics

After tea the second afternoon session started with a paper given by **Alexander and John Butler** (Image Acoustics, USA), describing *A wideband multiple resonant transducer concept* which uses feedback to control the transducer performance and give a flatter transmitting response over a wide frequency band.

Michael Shatalov (CSIR, South Africa) then described *The design of Tonpilz transducers based on the Rayleigh theory of vibrating bars*. This showed how a novel algorithm formulated on the basis of a Lagrange approach could be used to give improved predictions for Tonpilz transducers; these compared favourably with the results with FE predictions.

The design issue then moved on to effects of transducer heating in a paper presented by **John Blottman III** (Naval Undersea Warfare Center, USA). His paper *Thermal design of high-power active transducers with the ATILA finite element code* showed how FE vibration and thermal codes could be combined to predict the temperature rises produced in transducers under high drive levels.

The final two papers of the session then considered the current transducer requirements and future possibilities. In the first, *Transducers: the military requirement* **Ian Shepherd** (MARCOM Defence, UK)

The National Physics Laboratory's Teddington premises provided a contemporary backdrop for the conference proceedings

Some 80 delegates from 12 countries gave the event a truly international flavour

described the current requirements for a wide range of applications ranging from low frequency active devices to very high frequency classification sonars.
This was followed by **Simon Tanner** (QinetiQ) describing the wide range of research going on in *Sonar Sensors for the 21st Century*. He covered a very wide range of technologies, from injection moulded composites and fibre optic hydrophones to vector hydrophones and low frequency active devices based on free flooding rings.
The delegates then sat back to hear the A. B. Wood medal lecture given by **Eric Pouliquen** on *Recent progress in high frequency seafloor acoustics*. This entertaining and visual presentation formed an excellent end to the day's lectures; suitably stimulated the delegates retired to the Park Lodge Hotel for a drinks reception and the conference dinner.
An invited lecture by **David Hardie** (QinetiQ) on *Modelling: ideas and challenges for the future,* set the second day's scene. This provided an excellent overview of the use of different techniques for modelling transducers and in particular approaches to modelling the infinite fluid problem, such as the use of wave envelope elements and boundary elements.
The *Exploitation of cyclic symmetry in sonar transducer array analysis* was described by **Patrick Macey** (PACSYS Ltd). This showed how it was possible to calculate the performance of a cylindrical array of piston transducers in a relatively short time by exploiting the cyclic symmetry.
The next paper, *Distributed computing for sonar transducer analysis*, was also presented by **Patrick Macey** in conjunction with **Trevor Esward** of NPL. This described how the power of 200 PCs distributed across the NPL site had been used to run a FE sensitivity analysis on a particular transducer problem with a speed-up factor of more than 100. The advantages of this approach that simply utilises spare PC time are clearly very significant.
After coffee, **Pierre Gélat** (NPL) continued the FE transducer modelling theme with a paper *Prediction of the acoustic field produced by a foetal heart monitoring transducer using the FE and BE methods*. This highlighted the problem of inadequate knowledge of material parameters when transducer modelling; this was partially overcome by using an initial sensitivity analysis of the impedance of the PZT disk to obtain better estimates of some of the important parameters.
Unfortunately **Paul Yeatman** (Ultra Electronics, Canada) was unable to present the next paper, *Constructive use of acoustic interactions in a multi-element projector array,* due to illness on the day, so the next paper was *Improved modal modelling coupled to acoustic boundary elements for sonar transducer analysis*, which was also given by **Patrick Macey** (PACSYS Ltd). This considered how a modified modal approach can be used to improve significantly the accuracy of the standard modal approach.
As a contrast to the FE modelling talks, **Andrew Hurrell** (Precision Acoustics Ltd) described the use of a finite difference model in his paper, *A comprehensive finite difference model and its applications in underwater acoustic materials characterisation*. This showed how the FD model could be used to predict the response of systems and visualise the interaction of the wave field with a structure, permitting a better understanding of the physics of the problem.
After lunch, **Victor Humphrey** (ISVR, University of Southampton) described the *Finite element modelling of scattering by partially fluid-filled cylindrical shells.* He highlighted how the use of two different FE models, and comparison with experimental measurements, had enabled a number of issues that limited the accuracy of the modelling results to be identified.
The use of FE models to model structures and radiation was also considered by **Peter Brazier-Smith** (Thales Underwater Systems). His paper, *A finite element model 'FELINE' for the response of a submerged shell structure to forcing/insonification*, discussed how shell structures could be analysed as a system of truncated cones with fluid loading accounted for by assembling the acoustic field from virtual sources inside the structure.
Judith Bell (Heriot-Watt University) returned to the scattering theme with her paper *Analysis of target scattering using a finite difference time domain model.* Once again, this illustrated the use of an FD approach to produce images of the (scattered) wave field; in this case she demonstrated how partial burial of a target in sediment affected the scattered field.
A model for the acoustic response of a fluid-loaded cylinder with variable internal stiffeners was presented by Christopher Walker (Thales Underwater Systems). This demonstrated the use of the model to predict the performance of a system by considering the radiated noise and self noise induced by mechanical excitation.
The final afternoon session started with **Yan Pailhas** (Heriot-Watt University) presenting his paper, *Modelling for obstacle avoidance sonar design.* This considered the design of a sonar system for Autonomous Underwater Vehicles (AUVs) to enable them to avoid obstacles, and in particular nets.
The final paper, *PALLADA: diver detection sonar*, was presented by **Lev Nikitin** on behalf of his colleagues (S A Smirnov and Y Y Kokorin) at the Morphyspribor Research Institute, St Petersburg, Russia. This discussed a system that is used to detect free swimming divers and utilises image and signal processing to distinguish slowly moving swimmers and reject signals from large fish.

Ample opportunity for informal discussion during the coffee break

The conference appeared to be enjoyed by all who attended, with many favourable comments received. Many thanks go to Stephen Robinson of NPL for bearing the brunt of the local organisation, and his co-organisers Victor Humphrey and David Hardie. The meeting was part sponsored by the DTI under the NMS Acoustical Metrology Programme.

Victor Humphrey

Editor's Notes

Ian F Bennett BSc CEng MIOA

As spring is now properly under way, and the Spring Conference has come and gone, it's time to look forward to longer evenings and warmer night-time noise surveys. I was musing recently during one such survey, one balmy evening in the middle of nowhere, that over the years I have earned a crust as an acoustical engineer, public awareness of noise issues has steadily increased. The forthcoming Noise Action Week (23 to 27 May) is a case in point. Until this year, it was a Noise Action Day, so either the five-fold increase is the result of a snowball effect, or there is suddenly even more need for noise awareness and general consideration among the public.

I suspect that most people (I narrowly avoided calling them 'the silent majority') know perfectly well that making loud noises at the dead of night is not the most sociable behaviour, but as we all know, there are those to whom creating (or at least, reproducing) such a noise is the latest evolutionary step in a simian proboscis-measuring competition. I wish the NSCA well in its efforts to raise awareness, but I suspect that more radical steps are required to rid the streets of those small cars with large wheels, whose amplifier power exceeds that of the engine. I fully expect future occupational noise deafness claims to be thrown out on the grounds that the claimant's car hi-fi was responsible for the threshold shift, but that doesn't stop my windows rattling.

The cover photograph of *Acoustics Bulletin* is usually intended to link in with some prominent feature in the issue. I know from conversations with several members at meetings up and down the country that the 'full page' cover is popular, and that most find it pleasing to the eye. This month, however, you will search in vain for a connection between cover and content. We have simply taken the opportunity to satisfy one member's request that an outdoor shot should have some blue sky in it. And as anyone who knows me can confirm, I tend to take lots of photographs of bridges. So there you are! Copy for July/August 2005 should reach me by 6 June.

Ian Bennett
Editor

Reproduced Sound 21

Feedback to the Future

4-5 November 2005

Mark Bailey, Chairman of the conference committee, promises an appetising mix

So, here we are, roughly mid-way between RS20 and RS21 and, therefore, in a great position to look back - and forward, Feeding back (indeed) to the future!

RS20 was an enjoyable and enriching event; in fact, one (or, at very least I) could liken it to a superb gastronomic experience. Please indulge me a little here - this may seem a strange analogy, but I think in many ways it works very well. The entrées were the organisation and the session chairmen; the main courses were the exceptional papers; and the dessert, the evening sessions, banter, networking and conversation. No matter what your favourite part of the meal, I am sure you were not disappointed!

If you wish to reminisce further about RS20, we are compiling pictures on the website (www.reproducedsound.co.uk). Also, for those of you that missed it, there is a chance to see again John Tyler's coverage of the event. Please take a look, and if you have any comments, feel free to email them to Linda Canty at the IOA: you can be sure we will be listening.

Looking forward to RS21, a very special conference is in the making. Already we have many of the key ingredients, with submissions confirmed from regular contributors - and some newer ones also. For the evenings, we plan an *Audio Antiques Roadshow* and a *University Challenge* as part of the entertainment. If you have any older audio equipment you would be happy to loan or show for the weekend *Roadshow*, please let us know. Peter Mapp and I will be leading the RS committee in authoring the questions and chairing the *University Challenge* evening, so you can be sure your wits will be stretched!

This year, we have a milestone event to host - the twenty-first holding of the longest-standing Institute of Acoustics conference. We can expect a menu of impeccably served papers from the world's leading academics, consultants, suppliers and manufacturers in our field. I hope to have whetted your appetite and to see you there. This exceptional experience is one not to be missed.

Submissions for Audio Antiques Roadshow: please email equipment description and availability to linda.canty@ioa.org.uk
Keep up to date on RS21 at www.reproducedsound.co.uk
Comments on the web site can be sent to linda.canty@ioa.org.uk

NEW MEMBERS

At Council on 10 March 2005 the following were elected to the membership grades shown

Fellow
Bird P C
Bird S M

Member
Ball D M
Davies R
Deuchars A M
Ellis P
French S A
Hales C M
Huntley J L
Johnson M
Kelly D J
Lawson S J
Lewis R J
Loven M M
Mansfield N J
Mansfield R E R
Mellor S K
Miller J L
Pennell R
Pugsley A N
Rooney R W
Sherlock I D
Stait R E W
Street T A
Weller S I
White S
Wu T
Yates I J

Associate Member
Aliberti G
Bassett J M
Bevan J L
Brown R A
Bushell P
Collingwood V A
Cooke M R
Craven M T
Davies P A
Gilbert M P
Girdziusz E
Harrison M E
Hayes A
Hayes J S
Hesnan D T
Jackett R J
Kennedy C L
Mackenzie R K
Matharu S
McGrath P A
McLoughlin M
O'Driscoll L A
Oldfield A R
Orton J G
Pickering N
Prowse R
Sharma S K
Stroud P J
Taylor S J
Thompson D L
Thorne K A
Tomaz R C A
Ural O
Wallis C
Watson S J

Affiliate
Bangue S
Reed J
Turney T D

Technician
Batten D R
Carr I D
Gray M R
Howell J M
Reynolds J M
Taylor P J
Templeman B J

Student
Bremner J D
Consetta R A
Finfer D C
Gibb A
Sanavi A
Terry D M
Yu C J

Sponsor Member
Industrial Commercial & Technical Consultants

Institutional Subscriber
Southend-on-Sea Borough Council

Branch meeting reports

Comparing room acoustic measurement techniques

Our topic for the London Branch meeting held on 16 March 2005 at Capita Symonds, Holborn, was *Results of the NPL study into comparative room acoustic measurement.* Adrian James (Adrian James Acoustics) began by presenting some of the findings to come out of the *Deep study into standards for architectural, room and building acoustics,* which he was commissioned to carry out in 2000 by NPL, as a scoping study for the National Measurement System acoustical metrology programme.

The deep study involved getting in touch with researchers and consultants who worked in architectural, room and building acoustics to obtain their views on the standards in this area and find out how they carry out measurements on a day-to-day basis. It also involved a review of standards and technological developments in measurement techniques, and an assessment of the economic implications of current standards for UK industry.

The study identified a number of problems with the current standard (ISO 3382) and inconsistencies between it and ITU standards. It found that the ISO standard was too prescriptive, introduced unnecessary restrictions and was widely ignored by many reputable acousticians. The study concluded that a comparative measurement exercise was needed to provide data that would be useful in the review process for ISO 3382.

A one-day workshop for comparative measurement was held at Surrey University in July 2002. Ten measurement teams took part in the exercise. Two rooms were selected, one large and bright, one small and dead, and each team carried out room acoustic measurements using their own measurement systems, sources and receivers.

Measurement positions were restricted in an attempt to cut down on variables.

The participants processed results outside the measurement rooms and then handed all the data over to Adrian so he could carry out statistical analysis on the differences among them. With nine different teams, eight methods, seven sources, four receiver types and three microphone positions in the large room alone, the process took quite a long time. However, Adrian did manage to wade through all the data, and he came up with some interesting results.

The effects of the different loudspeakers, microphones, measurement systems and positions on measurement parameters T_{20}, T_{30}, EDT and D_{50} were presented, along with some very interesting comments on the pitfalls of room acoustic measurement.

Adrian's presentation concluded with a discussion of the standardisation process and procedure. The general view was that the people who have to use the standards every day should be more active in creating them.

The talk wound up with a few more questions and answers and then a trip to the pub.

Thanks are due to Adrian James for giving up his time and coming along to present his work, to Capita Symonds for their hospitality, and to more than 30 members of the London Branch who made the meeting a success.

Anne Carey
Secretary, London Branch

Ventilation System Design

On 16 April 2005, Iain Kinghorn BSc Hons, CEng, MIMechE (Flakt/Woods) welcomed Eastern Branch members for a visit and presentation on *Ventilation system design*. During his talk Iain addressed the process of selecting and achieving acceptable ventilation within set acoustical boundaries for restaurants and commercial premises offering fast food take-aways. This was followed by a tour of the company's fan and acoustic product manufacturing facilities.

The presentation briefly discussed the ventilation needs, system design principles and fan selection to meet the requirements for DW171 & DW172 - Standard for kitchen ventilation systems. Having established these requirements, the noise characteristics of various fans were considered, along with their methods of noise reduction in the ventilation system. Finally a brief look at fan noise generation mechanisms and designs for low noise completed the lecture.

Michael Alston
Eastern Branch Chairman

Where did the 10dB go?

An historical review of the use of tape recorders for acoustic measurements

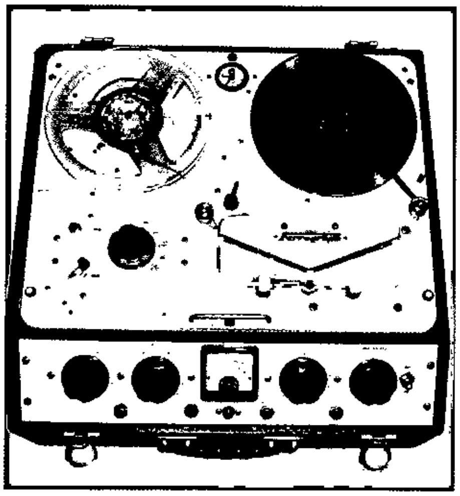
Geoff Kerry and Mark Avis

The first patent for a tape recorder was filed in 1897 by Vladamar Poulson. It used a steel wire moving past a magno-meter head at seven feet/second. Although a company was formed to manufacture a commercial product, it failed after a few years. There was little further development of note until just before the Second World War, when BASF developed the first usable magnetic recording tape: strips of cellulose-acetylene covered in magnetic steel particles. In conjunction with AEG, a plastic tape recorder was developed known as the 'magnetophon' which was then brought into use for broadcasting applications.

By the end of the war, the Germans had advanced tape recorder design sufficiently to interest the Allies. A number of American and British firms took advantage of the technology and produced various devices, initially for broadcasting, and eventually data recording for field trials work. The domestic market was exploited by the likes of Grundig and Phillips, and the keen amateur and semi-professional market by Ferrograph, and eventually companies such as Revox.

The advantages of making a replayable record to a person engaged in measuring acoustic signals, especially those of a transient nature, appear obvious. With a tape recorder it is possible to freeze in time a signal or series of signals that can span the audio frequency range. On replay, a search can readily be made, by either ear or instrumentation, to identify particular parts of the signal. In addition, and this was especially advantageous before the development of parallel analysers, the ability to replay the same record through sets of contiguous filters enabled octave band analysis over the same section of original signal. To assist with this work the tape recorder also provided a means of time compression or expansion, allowing frequency domain transfers into the operating range of the filters.

However, this convenience came at a price. Early engineering of both tape and recorders was good but not brilliant, and mechanical inaccuracies could result in tapes being replayed at slightly different speeds, causing unwanted frequency changes. Tape irregularities or drop outs caused spurious signals. High quality records had to be kept of events, amplifier gain settings and tape footage, all of which were prone to error. There can hardly be an acoustician that has not had to question the validity of at least some of his taped records. An unrecorded change of input gain after a calibration level had been put on tape invariably led to a hunt for the missing 10dB! The adoption of a policy of putting a calibration tone onto tape at the beginning and at the end of each reel or section of work was not just 'good practice' but common sense.



Early Ferrograph professional tape recorder

Advances in electronics, miniaturisation, standardisation, mechanical precision and magnetic tape technology have, over the years, resulted in very significant improvements in dynamic range and frequency response and ease of operation. From the early 1960s, when acoustic 'noise' and its measurement and control became important in society, through to the turn of the 21st century the tape recorder has played a vital role in handling and storing data for acoustic analysis. However, despite the advances and the introduction of digital techniques, the days of the tape recorder are now numbered. Solid state recording, which is not prone to the major weakness of the tape recorder - moving mechanical parts - is taking over.

The authors' careers in acoustics have spanned the four decades during which tape recorders have been the acoustician's essential accessory. This article illustrates the advances that have been made and the problems that have been overcome by the use of tape recorders over a working lifetime.

PARAMETERS IN TAPE RECORDING

Basic recording process

Tape recorders consist of two distinct parts. The first is the tape recorder itself with a motor-driven tape transport, a recording and a replay head and a set of amplifiers and signal conditioning electronics. These process the electrical signal prior to recording and decode the information back to an electrical signal on replay. The second is a long tape with an oxide coating and the means to store it.

The basic principle involved in tape recording is that a fluctuating AC signal is applied to a coil wrapped around a circular electromagnet. The electromagnet has a narrow gap in it and this is bridged by an induced magnetic flux. As the tape is drawn across the gap, the magnetic flux magnetises the oxide on the tape. When the tape is replayed, it produces a varying magnetic field across the replay head gap, which in turn creates a varying magnetic field in the core of the electromagnet, resulting in an electrical signal across the replay coil. The ability to reproduce faithfully the signal originally applied depends on a number of factors, but principally on the precision of the tape recorder's mechanical transport.

Important parameters

There are several methods of coding the signal to improve or extend the range of the tape recorder (1). Outlined above is a basic record process that suffers from a number of defects to be described later. The simplest functional method is known as the direct recording (DR) process, which involves the application of a bias to the signal before recording. The second method to be described is the frequency modulation (FM) process where the signal modulates a high frequency carrier signal. The third method is an early digital recording process,

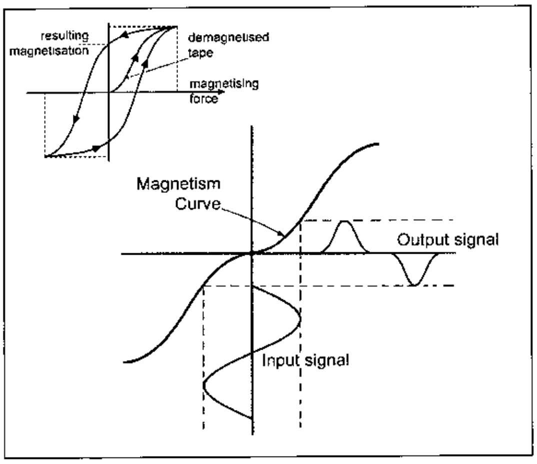


Figure 1: Non-linearity due to hysteresis

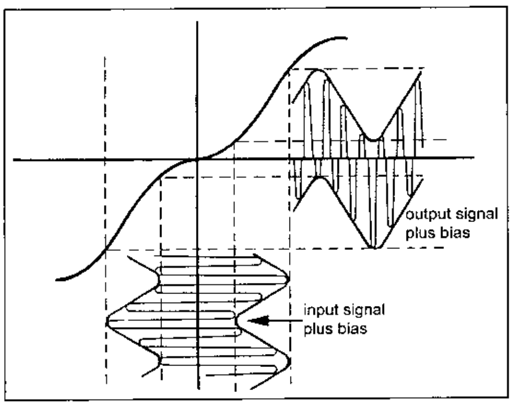


Figure 2: Application of high-frequency bias

which uses a pulse duration modulation (PDM) process and the fourth method is the current pulse code modulation (PCM) digital process that employs a sampling and binary coding technique.

Full explanations of each process and the influence of various parameters on quality and performance are given in reference (1) and the suggested bibliography. An overview of the recording methods is given below.

Direct recording

In this process, the amplified input signal is mixed with a high frequency bias before being applied to the recording head. This technique overcomes the inherent non-linear relationships that exist between the state of magnetisation induced in magnetic materials and the magnetising force applied to obtain that state. This non-linearity is due to hysteresis effects and is illustrated in *Figure 1*. If a high frequency bias is applied, it is possible to operate the recording process over the linear section of the recording characteristic as illustrated in *Figure 2*

The high frequency bias signal is applied with an amplitude several times greater than the input signal, and the two are mixed with a linear mixing amplifier: no amplitude modulation processes are therefore involved. Because a high bias frequency is used, the wavelengths are too small to be resolved by the replay head. In the recording process, the tape (with fine particles of magnetic oxide on its surface) effectively shunts the gap of the recording head. This completes the magnetic path and maintains the gap in a permanent state of magnetisation.

At the instant an element of the tape leaves the head, the strength of its magnetisation is proportional to the flux

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flowing through the head (which in turn is proportional to the recording current). The actual recording effectively takes place at the trailing edge of the head gap. The intensity of magnetisation along the tape will vary depending on the applied input signal and will effectively be proportional to its time variation, as long as the tape passes the head at a uniform speed. A sinusoidal signal will produce a sinusoidal varying magnetisation intensity and the wavelength will be directly proportional to the tape speed. Thus if the tape speed is changed on replay, the frequency of the replay signal will change.

The reverse process takes place on replay with the tape again completing the bridging of the head gap allowing the magnetic flux to flow through the head and induce a current in the replay coil. However, the voltage generated across the coil will be proportional to the rate of change of flux. Thus if the flux is proportional to the recording current for a constant input current signal the output voltage will vary in direct proportion to frequency.

To obtain a flat frequency response (very desirable for any sound recording and essential for acoustic measurements) it is necessary to have a replay amplifier with an inverse characteristic known as playback equalisation *(Figure 3)*. At the lower frequencies, however, the output voltage from the replay head approaches the inherent noise floor of the system and cannot be faithfully reproduced, resulting in an inherent

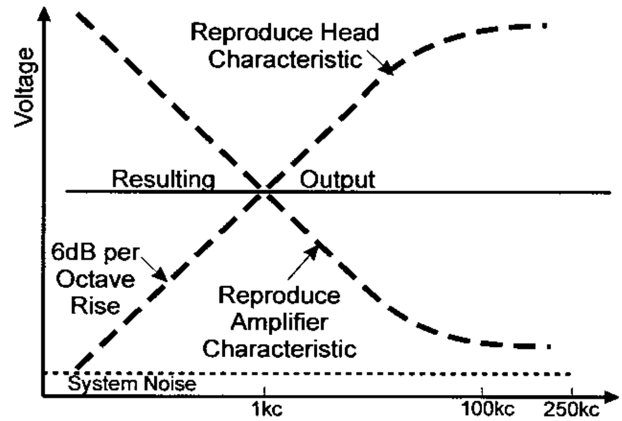


Figure 3: Playback equalisation to give a flat frequency response

lower frequency limit.

There is also an upper frequency limit set by the width of the record head gap. If the frequency of the record signal is very high, the resultant wavelength of the induced magnetic signal will be shorter than the dimension of that gap. This would effectively mean that the average magnetisation in the gap would be zero and subsequently any replayed tape output would be zero. As the input frequency increases and the induced wavelength approaches the gap dimension, the resultant output signal falls off. The effect of this restriction can be mitigated by either reducing the size of the gap or increasing the tape speed.

However, there are limitations on both processes. A narrower gap results in a lower output from the replay head with a resultant deterioration in signal-to-noise ratio. With greater tape speed, head and tape wear will be increased, and of course the recording time will be decreased. Typical values for direct recording frequency ranges are shown in *Table 1.* Noise on playback is produced by the random distribution of magnetic particles. It is inversely proportional to tape speed and to track width. Therefore, a doubling of tape speed or a doubling of track width results in an increase in signal-to-noise of 3dB.

A further limitation of the direct recording process is caused by the quality of the recording tape. If the oxide layer is not uniform, it can cause changes in the output signal, which if significant are known as dropouts. These can be caused by nodules or clusters of oxide or even accumulated foreign dirt particles lifting the tape away from the head. The effect is most noticeable at wavelengths associated with the size of the particles.

Frequency modulation (FM) recording

In this method, a carrier signal is frequency modulated by the record signal and the recording occurs in the frequency domain eliminating the effect of amplitude instabilities. The recording process takes place around a centre frequency and the input signal will vary that frequency either up or down depending upon its phase, the amount of variation being dependent on the signal amplitude. A DC signal will change the carrier frequency one way or the other depending on polarity.

On replay the signal is demodulated and passed through a low pass filter, which removes not only the modulation frequency but also any extraneous high frequencies generated during the process. However, the fundamental use of a 'frequency' carrier means that the tape transport has to be very precise because any speed variation will effectively cause a change in signal characteristic. Speed variations are referred to as 'wow' and 'flutter' and their effects on the signal are dependent on the depth of frequency modulation used in the FM process.

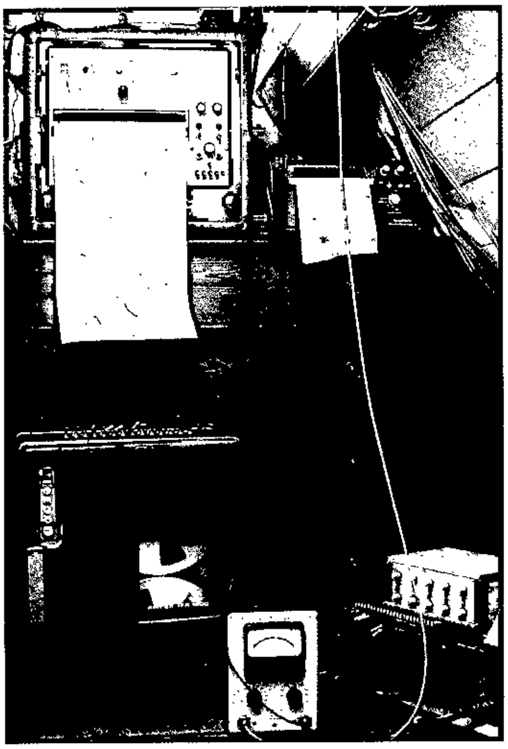
The FM process can be used in two ways. The first method is frequency division multiplexing where several individual signals are modulated by their own carrier frequency signal. The signals are then mixed linearly and the result recorded using the direct record process. The wide bandwidth and linearity allows the simultaneous recording of several channels of information on one tape track.

In order to 'fit' the individual signals into the DR bandwidth each one is limited to a maximum frequency deviation, which is a fixed percentage of the centre frequency of the carrier. The actual deviation depends on the number of channels to be accommodated and, clearly, since the final amplitude of the recorded signal depends upon its frequency range, in general, the more channels the less the signal-to-noise ratio.

The second method is a wide deviation FM system where only one channel of signal is recorded per track, allowing

Tape Speed	1 7/8 ips	3 1/4 ips	7 1/2 ips	15 ips	30 ips
DR	100Hz-9.5kHz	100Hz-19kHz	100Hz-37.5kHz	100Hz-75kHz	200Hz-150kHz
FM	0-625Hz	0-1.25kHz	0-2.5kHz	0-5kHz	0-10kHz

Table 1: Typical Direct Record (DR) and Frequency Modulated (FM) bandwidths (IRIG – intermediate band)



FM recording system in use

a much wider frequency deviation with a wider dynamic range and improved accuracy. Typical frequency ranges are also given in *Table 1*. If high frequency information is not required, then (usually, but depending upon the precision of the transport) a lower tape speed can be used without loss of quality. With the centre frequency scaled to the tape speed, it is possible to record at one speed and replay at another to facilitate time compression or expansion of the original signal.

Digital recording process

Early digital recording techniques employed a sampling process known as pulse duration modulation (PDM). Here the signal is sampled and the resultant varying amplitude pulses converted into pulses of constant amplitude but of varying pulse width. The information presented to the recording head is not a rectangular pulse but a positive going spike at the beginning of the pulse and a negative going spike at the end. The fidelity is still dependent on maintaining accurate tape speed but it is less prone to wow and flutter.

Because of the inherent replay characteristic the output pulses are differentiated but the replay electronics are simply triggered by the zero crossings to produce the original varying width pulses which can then be converted into the original signal. In some versions of this technique several channels are processed by a switching technique incorporating a time delay and the pulses recorded sequentially on the tape, taking up the available space. On replay, they are then separated again into individual signals.

In the early digital recording process, a PDM type sampling technique is used with binary coding of the information. Advantage is taken of this feature because it is only necessary to have two states to represent a binary signal and this can be achieved by positive or negative magnetic saturation of the tape. There are several ways in which the coding is accomplished in practice but the most common one is known as the non-return-to-zero system.

In digital recording there are no restraints on tape dynamic range or on linearity, nor are signal-to-noise problems encountered. However, limits are set by accompanying electronics and the ability to record and play back pulses. The higher the frequency range or the greater the number of channels to be recorded, the greater will be the number of bits to be processed. With a finite length of tape passing the head every second, it is necessary to use a very high sampling frequency for optimum performance.

Tape dropouts are a major source of error in digital recording and it has been necessary to employ both mechanical and electronic means to minimise the problems. Better head-to-tape contact has been achieved by the use of smoother tapes, better oxide deposition and precision engineered heads, as well as mechanical systems that maintain adequate tape tension. Electronic mechanisms include redundancy, the simultaneous recording of a second track, or a parity check achieved by recording a series of pulses derived from the original on an additional track for cross checking on replay. Other problems arise from tape skew where varying tape azimuth at either the record or replay head causes bit reading errors.

Early digital recorders were limited in terms of the sampling frequency because of head gap and tape speed restrictions. Digital sampling techniques, error detection and correction and associated electronics were significantly improved during the 1970s, culminating in the introduction of the compact disc.

To apply the technology to tape recording it was necessary to adopt the technique developed in video recording, which requires high frequency signal modulation. Here a rotating head is used to decrease the recorded wavelength and increase the frequency response and hence the sampling frequency. Increases in tape performance also complemented the process and more recently for multi-track digital recording the DASH (digital audio stationary head) system has been introduced by Sony which again has tape passing a fixed head at relatively high speed ($0.76ms^{-1}$). Precision engineering in transport and head manufacture is essential; making these systems too costly for anything other than professional studio use.

The first Pulse Code Modulation (PCM) recorders used standard video recorders as the audio recording medium providing full audio frequency spectrum capability (20Hz to 20kHz) on two channels. Subsequent miniaturisation led to the development of the Digital Audio Tape (DAT) recorder and the demands of the acoustics industry led to the modification of low frequency capability to well below 1Hz, and indeed effectively to DC recording.

More recently, internet audio delivery and a demand for physically compact magnetic data storage have led to the development of perceptual coding systems. These reduce the binary word-length of recorded digital samples, facilitating a decrease in the size of the recorded files at the expense of an increase in noise floor. Perceptual models aim to ensure that this noise is masked by signal content which usually implies an approach based on filtering the signal into a number of sub-bands related to audio critical bandwidths.

For steady state signals, the 'artefacts' introduced by this data compression are usually well masked and 'noise-like'. It might be argued that in such situations a format such as mini-disk or mp3 might allow long duration data logging with little influence on measured levels and spectra. However, most systems are regarded with caution where impulsive signals are concerned and because of the 'lossy' nature of compression, they have not been regarded by the acoustics community as useful for instrumentation purposes.

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Comparisons between recording techniques

Direct recording process

i. widest frequency spectrum (50Hz to 250,000 Hz)
ii. wide dynamic range
iii. handles moderate overloads without sudden changes in distortion level
iv. relatively simple record/replay electronics

Frequency modulation recording process

i. will record down to DC
ii. resistant to tape drop-out problems
iii. excellent phase shift *versus* frequency characteristics
iv. limited bandwidth per tape speed
v. complex record/replay electronics
vi. precision engineered tape transport

Pulse duration recording process

i. ability to record large number of channels simultaneously
ii. high accuracy when using self calibration facility
iii. inherently high SNR
iv. limited frequency response per channel
v. complex electronics

Digital recording process

i. inherent capability of high accuracy
ii. insensitive to speed instabilities
iii. relatively simple record/reproduce electronics (but A-D and D-A converters are also required)
iv. Output can be fed directly to digital computers
v. Requires high sampling frequency and fast tape or rotating heads
vi. Suffers from drop-outs requiring error correction circuitry

PRACTICAL EXPERIENCES

Early direct record systems

The author's initial contact with a tape recorder occurred around 1960 before he started his career in acoustics. In fact, it could be said that using what was not only new but high quality technology probably assisted with his eventual career choice. The device was a Ferrograph tape recorder, probably an early full track system, and it was used to record and replay a variety of sound effects for stage productions.

The author's initial contact with a tape recorder being used in an instrumentation context for acoustic measurements occurred when he was employed as a student apprentice in the aircraft industry. There an EMI 'midget recorder' developed for the broadcasting industry **(2)** was being used to record cabin noise in flight in a newly developed twin-prop passenger aircraft. The high performance turbo driven propellers and the jet engines themselves created quite high noise levels in the cabin.

The aircraft was offered to operators in a variety of internal 'trim' layouts and it was frequently necessary to check internal noise levels. This was achieved by comparing octave band noise levels obtained at various points in the cabin and the only realistic way to do it, during the relatively short time the aircraft flew at normal cruising conditions when flying development or acceptance flights, was by tape recording for later analysis using a spectrum analyser in the laboratory. The recorder had been modified and it had input and associated electronics for a standard Bruel & Kjaer preamplifier and half inch microphone, all battery driven. However, another modification allowed the recorder itself to be powered from a 12v lead acid battery, necessary to maintain the supply when flying in a partly trimmed and extremely cold aircraft fuselage.

The EMI 'midget' weighed about 8kg with the microphone modification and the battery was a standard car battery located 'safely' in a wooden box. A long lead allowed freedom of movement around the cabin. The recorder only had a mechanical rewind and was not suitable for replay tasks so this was achieved in the laboratory on an EMI transcription deck. Field calibration, before, during and after flight was carried out using a pistonphone. However, frequency response and linearity checks, to ensure that record and replay machines were properly lined up, were carried out on a regular monthly basis leading to the author demanding a synchronised Bruel & Kjaer level recorder/oscillator combination to speed up the work.

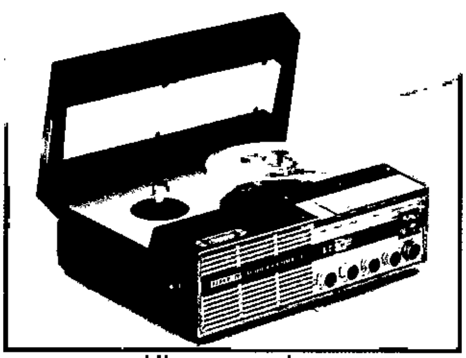
Life was made a little easier with the acquisition of a Bruel & Kjaer 2203 sound level meter but it was used as a 'front' end to a pure EMI midget (*ie.* with the modified microphone circuitry removed). It was still necessary to parallel-process the octave band data because changing engine conditions led to inconsistent results if the sound level meter's sequential octave band filter (type 1613) was used in flight.

This was very much the technique in use when the author moved to the University of Salford. A B&K 2203/1613 combination was in use for many jobs but it was backed up with recordings on another EMI midget recorder. The recordings were essential if transient data was to be analysed, especially using narrow band analysers or even one third octave analysers which were not portable devices at that time. The use of the B&K 2203 with a recorder invariably led to the perennial question 'what happened to the 10dB?'. Fastidious written records were required to ensure that the attenuator settings on the sound level meter were properly related to the pistonphone reference signal and the recording level. Again, the task was made easier in less noisy environments with the introduction of the first sound level calibrators (B&K 4230).

The EMI midget was not ideal, especially when used with the internal rechargeable batteries of the day and the 7.5ips tape speed limited recordings to fifteen minutes' duration. Again, life became easier with the purchase of a Uher Report 4000 recorder and this became the standard field recording medium for conventional noise work during the 1970s.

Early instrumentation recorders

Early instrumentation recorders were often FM based and invariably multi-track, and were used mainly by the military or by the aircraft industry. Although they were used to record low frequency vibration signals and slowly varying DC signals from such devices as thermocouples, strain gauges *etc.*, limited use was made of them in main-stream acoustic

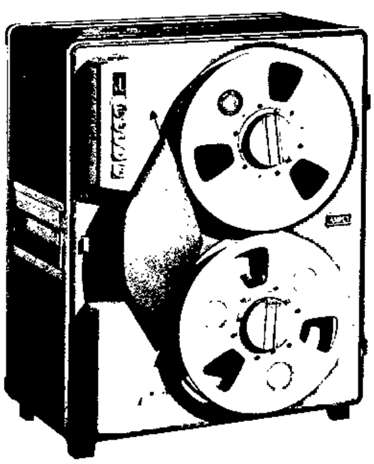


Uher recorder

measurement work. This was possibly because of their size and weight, multiplicity of channels and the fact that they had to be run at high speeds if any useful high frequency data was to be obtained. Flight data recorders were relatively small but the record electronics were often contained in a separate case and they invariably ran off a 28v supply.

However, the author was involved in a number of projects that used such recorders and one particular one used seven channels of data, four noise and three pressure, during an investigation into aircraft boundary layer noise. The replay of data from several tracks, recorded simultaneously, was tedious and could only be achieved with multi-pen chart recorders or UV galvanometer recorders. These devices restricted the overall measurement bandwidth to relatively low frequencies.

During the 1960s, significant advances were made in multi-track tape recorder developments. The author used a fourteen-track FM recorder using one-inch wide magnetic tape in 1970 when Concorde first flew supersonic development trials down the west coast of the UK. However, although two channels provided acoustic information, the essence of the trial was to look at vibration induced by sonic boom in buildings and thus we concentrated on low frequency data.


Ampex 14 track instrumentation recorder

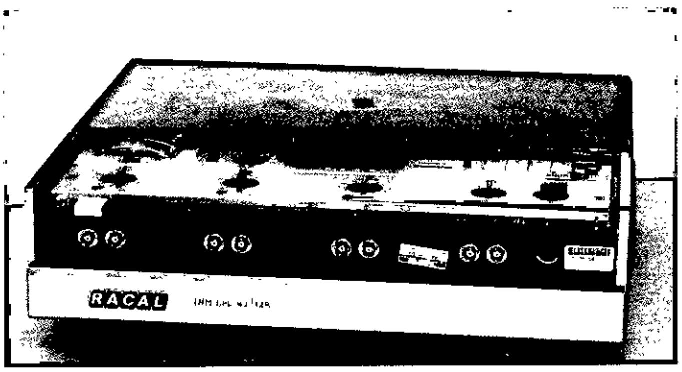
The need for a relatively portable tape recorder to gather vibration data resulted in several companies producing high quality four-channel instruments. Some designs had a dual capability in that they had switchable or interchangeable electronics allowing operation in either FM or DR mode. With the latter in operation, there was adequate bandwidth for wide frequency acoustic measurements. Other variants had options on FM or PDM channels, the latter providing relatively simple storage for slowly-sampled ancillary data such as temperature.

However to the acoustician it was the low frequency capability for vibration that was attractive, and many four channel instruments were used for simultaneous tri-axial vibration measurements with one DR channel reserved for 'noise'. Several of these recorders were put to use both in a follow-on sonic boom exercise and for long term monitoring of quarry blast and building vibrations. Accepting a low frequency bandwidth allowed slow tape speeds to be used and it was possible to record several events per day over a number of days by use of a timer or other remote control mechanism.

Several companies - such as Elliotts - provided standard high quality DR recorders with a modification that would allow optional conversion to FM channels and there was at least one 'do it yourself' version provided in the technical press (3).

From hi-fi to professional recorders for the acoustician

As already noted, the ubiquitous Uher had become the portable tape recorder of choice for many acousticians. It was relatively inexpensive, lightweight and reliable and could offer a range of tape speeds allowing flexibility in the selection of recording time and bandwidth. The two major faults were a tendency for operators to select the wrong speed, or for the instrument to re-select the wrong speed (despite the control lock!), and for operators to leave the machine switched on



Racal Store 4 instrumentation recorder

after use. This last problem usually resulted in damage either to the case or to the battery box terminals, eaten away by chemicals exuded by the flattened batteries.

Towards the end of the 1960s high quality professional, portable audio recorders developed primarily for the film industry, such as those manufactured by Nagra and Stellavox, began to be used for acoustic measurements. A major problem when operating such recorders (and many others) lies in ensuring that the input potentiometer is locked at a suitable position to allow measurements to be monitored on the sound level meter and to obtain maximum dynamic range, without overloading the tape recorder, especially for high crest factor signals.

Most tape recorders are fitted with variable input potentiometers, which are set as necessary, and the input monitored on a vu-meter or modulometer, or a simple record level indicator. In the early 1970s, Nagra Kudelski released their IV series on the market and in particular one model, the IVSJ, was revolutionary because although essentially a twin-track

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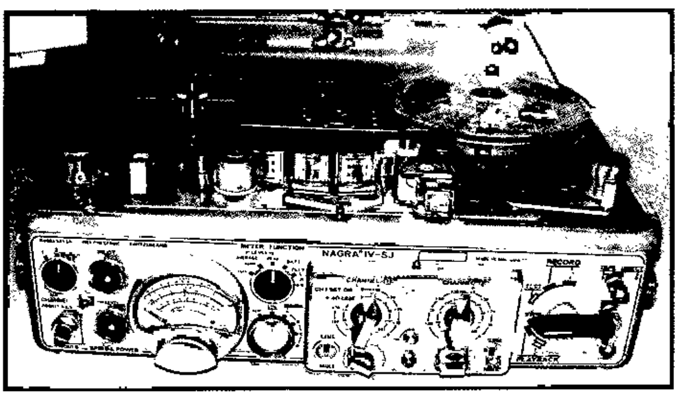
audio recorder it also had two sound level meters built in. There were connections for a range of precision measuring microphones and the power for these and their associated pre-amplifiers was built in.

The recording meter was switchable from a VU meter to sound level meter setting and on each channel there were switchable weighting networks and precision potentiometers with 10dB and 1dB fixed steps. In addition, a third track was added, operating in FM mode, that went down to DC but was limited to a 3.5kHz upper frequency (-2dB). This proved extremely useful for single channel vibration measurements and low frequency noise measurements. For some applications, this track and one of the standard tracks were linked to provide a very wide band recording system from 0 to 35kHz (-2dB at 15ips).

At about the same time, Bruel and Kjaer released its type 7003 and 7004 tape recorders onto the market. The former used an FM technique and had four channels. Operating at 15ips the bandwidth was from DC to an upper frequency limit above 10kHz (±1dB) and the dynamic range 44dB thus making it extremely versatile for both acoustic and vibration measurements. The type 7004 was a twin track DR machine with an extended frequency response from 25Hz to above 50KHz (±3dB at 15ips) in 'direct mode'. A second tape speed at 1.5ips made this and the 7003 ideal for frequency transformations.

The 7004 also had an 'audio' mode with reduced frequency response but extended dynamic range. This model replaced an earlier twin track FM tape recorder that had four tape speeds allowing frequency transformations of 2.5, 4, 10 and 40 times. This was useful for bringing low frequency data up and high frequency data down into the range of (then) conventional audio analysers and graphic pen recorders. The 10:1 scaling was used particularly to simplify measurements using acoustic models of concert halls and theatres.

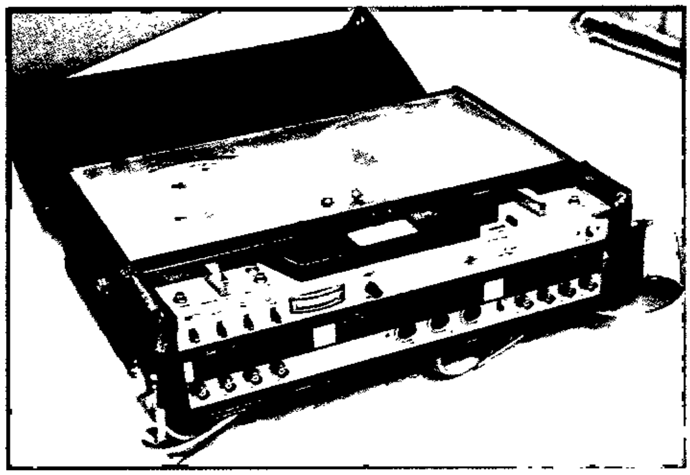
The B&K recorders had a 'voice' channel, usually operated by a purpose-made AVC microphone for recording identification. Endless tape loop adapters were also available to allow the use of sequential band pass filter sets on the same section of taped data. Needless to say, all these purpose-made professional instrumentation recorders had



Nagra professional tape recorder

very low values of wow and flutter.

Improvements in the precision of tape transports and record and replay heads coupled with the miniaturisation of electronic components led to the development of a generation of four track (and seven track, on half-inch tape) tape recorders. These were multi-speed (including 60ips), met standard and wide band recording standards (4) with interchangeable DR and FM electronics, and although rather large for transporting in a shoulder bag, were nevertheless readily usable in field applications.



Bruel & Kjaer 7003 recorder

From professional recorders back to hi-fi

Even though by the late 1970s the professional recorders were extremely reliable and quite capable of operating in difficult field conditions, they were generally expensive. There was a need for a simple recorder to back up standard sound level meter measurements and to provide records for laboratory analysis for the identification of specific frequency or time dependent events. Not unnaturally, some people turned to cassette recorders but invariably found that the tape transport mechanisms were not robust enough either within the recorder or within the cassette.

There were also a myriad of potential problems associated with the noise reduction electronic signal processing systems (such as Dolby) and in bias selection for tapes. Nevertheless, some of these recorders found a use and the particularly robust and pocket sized Sony 'Professional Walkman' was built into several instrumentation arrangements, which were developed to identify noise events.

...and into the digital world

As stated earlier the fledgling compact disc industry had become established by the early 1980s and there was growing awareness that digital techniques had some advantages, especially with improvements in signal-to-noise ratio and accessibility to data located in the centre of the storage medium. The search was on for a suitable method of recording and replaying data in digital format. The PWM system could not carry enough pulses even at fast tape speeds. An audio signal not only requires sampling at a sufficient rate (over twice the upper frequency of interest) but each sample has to have its amplitude coded as well. A 16-bit encoded digital audio signal recorded with a sampling rate of 44.1kHz requires 7056 megabits to be recorded each second. If stereo or two-channel audio is required and error correction and control is added, the bit rate becomes in excess of 43,128Mbits per second. The then state-of-the-art magnetic recording media could only handle 20Mbits.

However, the demands of the broadcasting industry

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had led during the late 1950s to the development of video tape recorders. Television signals are of much wider bandwidth than radio, and video signals have to be modulated at a high frequency in order to reduce the bandwidth to something workable. This resulted in a carrier frequency that is much too high for standard tape recorder technology. A recorder was developed that used rotating heads to put tracks transversely on a linear moving tape, thus effectively increasing considerably the speed of the magnetisation process and consequently the upper frequency limit. The two technologies were married together to produce the first true digital, portable and relatively inexpensive recording system. It comprised an A to D converter with an output modulated at TV frequencies and a standard video recorder.

A system produced by Sony combining their PCM F1 unit and a battery operated 'Betamax' video recorder was used by a colleague for a series of UK-wide lectures on audio. So impressed were we by its performance that we decided to purchase one of our own, which we promptly modified by changing the coupling capacitors to give it an extended (2Hz) lower frequency performance. This was subsequently lowered to about 0.5Hz by the addition of an external box carrying some large capacitors.

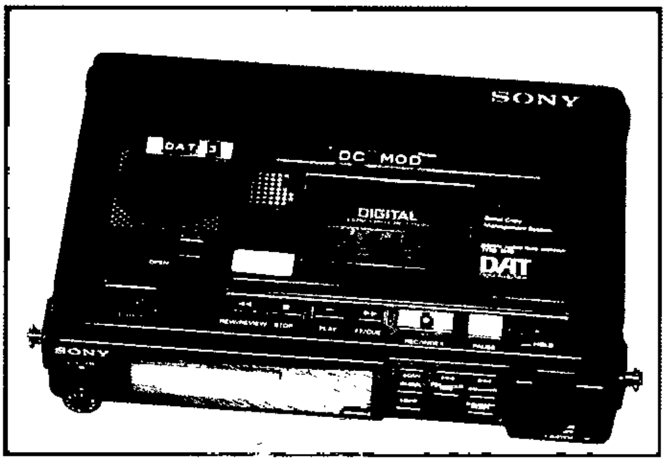
Eventually, despite the protestations of Sony who promised impending doom, we short-circuited the coupling capacitors and had a direct-coupled input (5). As a portable recorder the units were a little cumbersome, taking up most of the space in a small suitcase and requiring a 4 ampere hour lead acid battery to obtain any useful recording duration. Nevertheless, the 94dB dynamic range and wide 0.5Hz to 20kHz bandwidth were ideal for the type of work to which the system was put, recording a wide range of explosions and gunfire.

The same system (but with the Betamax recorder replaced by a standard videocassette recorder) formed the basis for a range of remote blast monitors (RMUs). In these the PCM unit and recorder were housed in the same case as a microphone power supply which supplied a standard Bruel & Kjaer type 2639 preamplifier fitted with a type 4147 sealed low frequency microphone operating at 28v polarisation. This provided a dynamic range from 70dB to over 160dB with a bandwidth (-3dB) from 0.5Hz to 20kHz.

Fitted with an in-built calibration signal and an automatic start sequence the RMU was operated by radio signal. It was housed in a waterproof case that held some large lead acid batteries which were recharged by solar cells and a small wind generator. The units were left unattended at property on and around firing ranges, often for weeks at a time, depending on the firing programme. Afterwards the tape was returned to the laboratory for analysis and a new one fitted.

These were transportable but hardly portable devices, and although one version was fitted in a shoulder bag, and they were eventually replaced at least for standard manned fieldwork by DAT (Digital Audio Tape) recorders. The DAT recorder uses exactly the same format as the CD system and incorporates digitized PCM electronics and a small rotating head cassette recorder in one unit. It is possible to 'mark' events on the tape using a sub code, which is written independently of the PCM signal, and then use these markers in high-speed searches. The current date and time are also written automatically to tape.

The first units to be purchased for field use were Sony D10 DAT recorders. They had rechargeable batteries and tape cassettes that could last for two hours. The recorders were modified by the agent to give them a low frequency capability. Being small, lightweight and with integral rechargeable batteries they were used to record either



Sony D10 digital recorder

directly from a sound level meter or through a microphone twin channel power supply unit with built-in stepped gain controls to optimise range. The D10s were twin channel units and these were augmented by two Sony 4 channel DAT recorders which had two switchable bandwidths. More recently the Sony TCD-D8 DAT 'Walkman' has come into widespread use. It is small and lightweight, and operates from standard alkaline cells.

Solid state digital recording

As early as 1972 Bruel & Kjaer exploited emerging digital technology and solid state memory in the introduction of the type 7502 digital event recorder. Their manual (6) acknowledged the shortcomings of tape recorders, such as wow and flutter, poor tape economy and tape wear, when applied to the capture and replay of transient and single event phenomena. Their solution was a fast (up to 100kS/sec) sampling A to D converter with 8bit capability and solid state memory of up to 10k per instrument. It was possible to link several instruments together to increase sweep time or dynamic range.

The instrument was quite large and weighed 17kg, and being mains operated was not readily suited to fieldwork. However, in the laboratory it provided a ready means of handling transient data previously recorded in the field on tape. Once on the event recorder, the transferred signals could be replayed repeatedly for contiguous frequency analysis or frequency transformed upwards or downwards as required, without the inherent problems normally introduced by tape loops.

Many manufacturers introduced digital technology into their acoustic analysers but the memory limitations prevented their use for storing several events or for long duration events unless the data could be downloaded to a computer. Even then, capacity was limited. Many ancillary devices were produced or adapted to overcome the storage limitations and these included digital data recorders which used magnetic tape as the medium. It was, however, necessary to pre-process the signal in an analyser before recording. The devices were designed for use primarily in the laboratory. A typical example was the B&K 7400 digital cassette recorder.

During the 1990s several companies developed digitally based data acquisition and processing software specifically for the acoustics and vibration market. Thanks to significant advances in electronic component miniaturisation, memory size and component cost reductions, signal handling and digital processing units were produced which were housed in cases no larger than the sound level meters of the day. These units relied upon conventional laptop computers, not only for storage but also for control and post processing of the data. The combination made a versatile package that could be used in the field, driven by re-chargeable batteries, and which was able to produce results almost instantaneously in whatever format was required for reporting. The digitised data was also stored, like a DAT recorder but in solid state medium, and could be subsequently re-analysed if necessary.

The most recent developments in recording technology for the acoustician are to be found in new generation sound level meters or portable sound analysers. These have self-contained true audio digital recorders which can be programmed to work alongside the measured and frequency analysis functions with the input signal. The digitised data is stored either internally or in transportable storage media such as standard PC slot memory cards.

The design objective of one example, the Norsonics NOR121, was to meet the full type '0' sound level meter specification. To achieve this a sample speed of 48kHz is required and to meet the amplitude linearity a word length of 24 effective bits is required. At a data rate of $144kBs^{-1}$, a 1 Gbyte memory card will allow two hours of recording and the internal memory will double this. There is provision to limit the bandwidth and extend the recording time and to switch the system to '.wav' format so that the records can be analysed on other equipment. If replayed into the NOR121 '.wav' files are limited to a dynamic range of 80dB.

CONCLUDING REMARKS

It is apparent that, with a few notable exceptions, the manufacturers of acoustic measuring equipment have not been particularly willing to embrace the use of the tape recorder as a means of storing data for later analysis. They appear to have preferred to concentrate on the production of direct reading devices providing instantaneous results. This can be attributed to a number of reasons but the complexity and the precision of the mechanical design and its subsequent maintenance must be one of the foremost ones. The difficulty of meeting the relatively stringent sound level meter design standards throughout the whole measurement chain, including the complex record/replay phase, provides another reason why acoustic equipment manufacturers have been somewhat tardy in their acceptance of tape recorders.

Rather surprisingly, again with few exceptions, little was done to interface acoustic measuring equipment with tape recorders produced by other manufacturers. Often there was only the option of an AC output socket to connect a recorder, and this generated a number of operational problems that had to be overcome. However, several manufacturers saw the advantage that DAT recorders brought to the measuring chain, especially for unattended recording sessions. 'Front end units' which incorporate standard capacitor pre-amplifier power supplies and several fixed gain steps, are now available. Both alkaline battery- powered and lightweight, when coupled with the small DAT recorders they provide a versatile portable instrumentation package.

With the introduction of solid state recording electronics most of the interface difficulties have been left far behind. Many of the new generation of sound level meters have the optional capability of recording measured data over a wide dynamic range and bandwidth with more than adequate precision. Acousticians who have struggled for some 50 years to use a device that brings so many advantages to handling acoustic data, especially in the field, can now put their energies into understanding the data rather than into capturing it successfully.

The days of the 'lost 10dB' are over. Nevertheless the magnetic tape recorder, and magnetic tape as a storage medium, are likely to be with us for some time yet. Recent advances in 'intelligent tape technology' have resulted in the development of multi-channel recorders with the capability of recording wideband analogue and digital channels together with the simultaneous recording of video signals, and this leads to new and exciting analysis possibilities.

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Is STIPa a robust measure of speech intelligibility performance?

Peter Mapp

This article has its origins in a paper presented at Reproduced Sound 20 in October 2004. The material has been updated to take account of recent developments in this fast-moving topic. The measurements and reported results were correct as at 7 April 2005, although discussions with all the manufacturers were still in progress. Another update will be presented at Reproduced Sound 21 in November 2005

STIPa (Speech Transmission Index for Public Address systems) is rapidly becoming a popular method of assessing speech intelligibility. Although only introduced in 2001 (1) and ratified in IEC 268-16 in 2003, at least four manufacturers are already producing test equipment apparently capable of measuring STIPa. Although STIPa has been introduced as a simple way to make accurate STI measurements, extensive testing and measurement research by the author on early versions of the meters suggested that, in practice, measurement results could be highly variable and often erroneous.

Although the accuracy of the meters has generally improved, there are still a number of discrepancies that can give rise to inconsistent results and discrepancies between meter readings. A number of practical measurement error mechanisms have been found by the author. These include the nature and generation of the test stimulus as well as its introduction into the system under test. The current accuracy of field STIPa measurements is therefore questioned, and the implications for Public Address (PA) and Voice Alarm (VA) system auditing and assessment are highlighted.

STIPa and STI

Although STI was conceived in the early 1970s **(2)** it was not until two decades later in the early to mid 1990s that it had much practical impact in terms of sound system assessment. There were two primary reasons for this. First, until the 1990s the measurement of STI was a complex and time-consuming process with each measurement taking around 15 minutes. In 1985, the introduction of RaSTI **(3)** dramatically reduced the measurement time and a dedicated instrument became available.

RaSTI was slowly introduced into a number of standards as an approved method of measuring sound system performance. The two standards having the most impact were CAA Spec 15 and IEC 849/BS 7443 **(4, 5)**. For the first time, the intelligibility performance of PA and VA systems was being specified and policed. Whereas STI was conceived to use a modulated signal, Schroeder showed that it could also be derived from an impulse response. Thus, during the 1990s two measurement techniques were available: the modulated RaSTI signal and an impulse derived method.

Towards the end of the 1990s the accuracy of RaSTI as a predictor of sound system performance (or indeed as an accurate predictor of sound system STI) was being questioned, for example **(6,7)**, although as early as 1991 Mapp had shown that ambiguous and invalid readings could be obtained **(8)**. Indeed the accuracy of STI in general, as a predictor of sound system performance, was in question **(9,10,11)**.

One of the advantages of STIPa is that it again uses a speech-like modulated signal and so should excite a sound system in a similar manner to normal speech. In addition, the test signal already has a speech-shaped spectrum, so negating the need for additional filtering, a process omitted by many test operators. Matching test signal to system speech levels is also simplified, which should enable more accurate levels to be set and hence potentially improve the accuracy of measurements. Another great advantage of STIPa is that it uses a reduced modulation set and so enables the complex processing to be carried out in a portable instrument using standard on-board digital signal processing.

Work carried out by TNO showed that STIPa closely tracked STI over a range of reverberation and noise conditions **(1)**. It would therefore appear that STIPa, unlike RaSTI, should be a better predictor of STI for situations exhibiting either a narrow bandwidth or poor frequency response, although a detailed study specifically for sound systems has not as yet been carried out. *Figure 1* shows a typical STIPa waveform and spectrum.

Since the introduction of the first commercial meter in 2002, the author has taken an active interest in the progress of STIPa. Currently, he now owns examples of all four commercially available STIPa meters as well as most of the commercial measurement platforms offering an STI calculation facility. Last year saw the introduction of three new STIPa meters, and immediately a number of discrepancies were noticed: therein lay the conception of

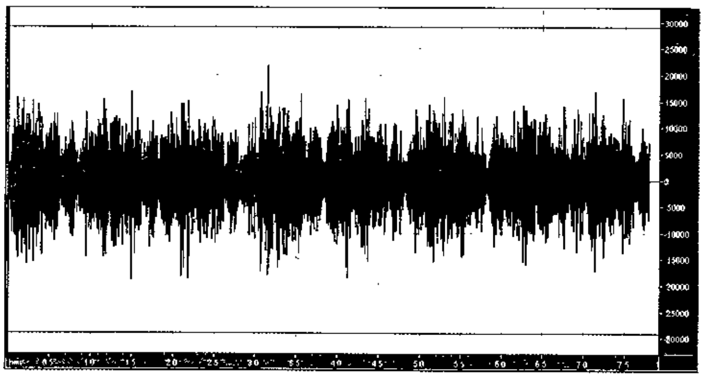

Fig 1(a) STIPa waveform

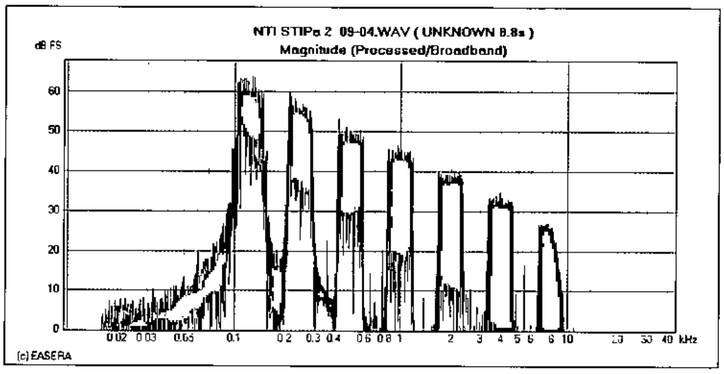

Fig 1(b) STIPa spectrum

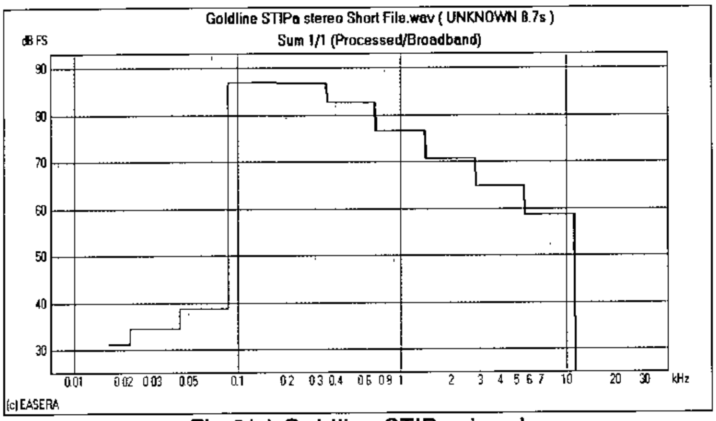

Fig 2(a) Goldline STIPa signal

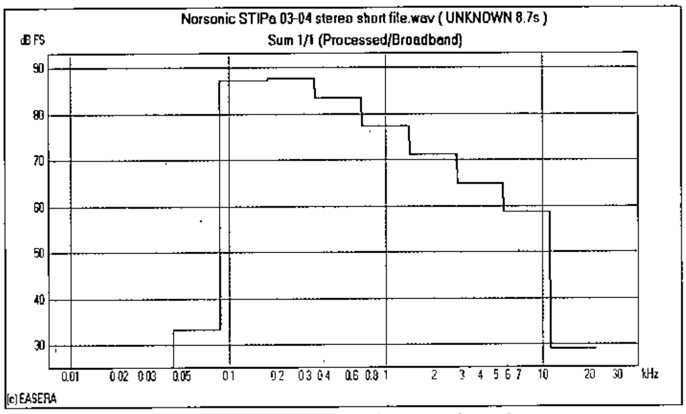

Fig 2(b) Norsonic STIPa signal

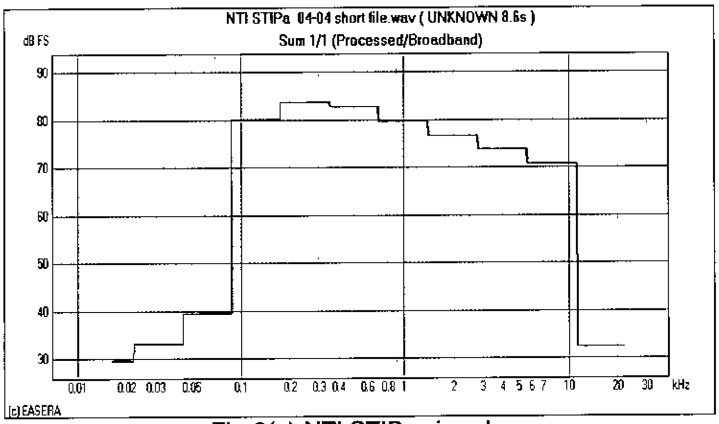

Fig 2(c) NTI STIPa signal

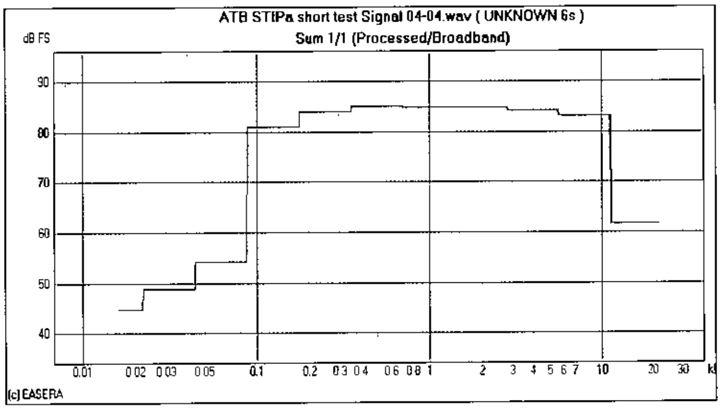

Fig 2(d) ATB STIPa signal

this article. The meters tested were: Audio Tool Box ATB2, Goldline DSP2, NTI Acoustilyser and Norsonic 118 sound level meter/analyser.

STIPa measurement variations

As mentioned above, the STIPa test signal is a modulated signal with a standard speech spectrum. The requirements are set out in IEC 60268-16 (2003). It was therefore surprising to find that the test signals from the various instruments of differing manufacture were significantly different. *Figure 2* shows a spectral analysis of the signals as found in October 2004.

The variation in spectral content was one obvious cause of the discrepancies found. The problem was pointed out to the manufacturers and the test signals were revised and re-issued. They are now very similar and their spectral content is now no longer cause for concern.

Because the STIPa test signal is pseudorandom in nature, inevitably there will be some variation between consecutive readings, requiring at least three readings to be taken and averaged at each test position. *Table 1* below shows a typical set of readings, made under ideal, stable conditions.

Table 1: Typical STIPa readings

run	1	2	3	4	5
STIPa	0.50	0.53	0.53	0.55	0.53

Meter 'round robin' test

A comparison test on three of the meters carried out in October 2004 showed a very significant variation in the measurement results, as indicated clearly by *Figure 3* Variations of up to 0.1 STI were found between the meters when measured under identical test conditions. Such a variation is not acceptable, particularly when it is realised that contractually, variations of 0.03 or less can be significant in a particular project!

Two of the meters have since undergone hardware or firmware changes, so the test was repeated in March 2005. An average of four readings per measurement condition were taken. Interestingly, the variations between consecutive readings were noted as being lower than previously observed, with a general variation of just ±0.01 - a 0.02 spread within the results for a given meter.

Figure 4 shows that although the various meter readings now agree much more closely, an interesting discrepancy occurs, at both low and high sound pressure levels. However, over the range 50 to 80 dB(A) the variation among the meters for the particular test condition shown (reverberation-induced loss of intelligibility) is only 0.01 STI when each meter uses its individual, dedicated test signal. This is a very encouraging result.

A divergence in the readings can, however, be seen above 80dB(A), particularly between the Goldline meter on the one hand, and the NTI and Norsonic meters on the other. At 90dB(A) (not an unusual level for a sound system) the discrepancy is 0.05 STI, whilst at 100 and 110 dB(A) it increases to 0.06 and 0.07 respectively. At

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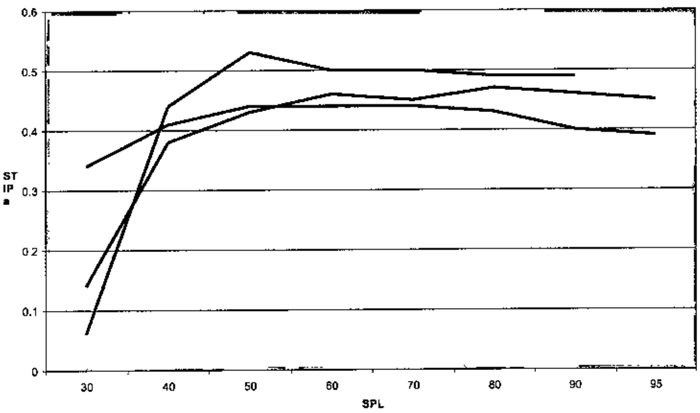

Fig 3 Comparison of three STIPa meters 10-04

Is STIPa a robust measure of speech intelligibility performance?

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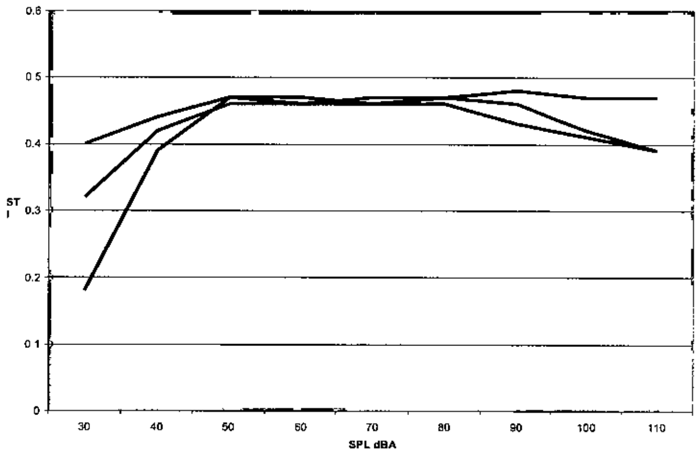

Fig 4 STIPa comparison test March 2005

40dB(A), the variation is 0.05 STI. Levels below this may well have been affected by the noise floor of the instruments and in any case are of little practical use.

The primary reason for the discrepancy is that the Goldline does not implement the sound level dependency characteristics of intelligibility, which are mimicked within STI and STIPa. This is a serious omission which could have some interesting contractual implications.

Listening to the various STIPa test signals it is very hard to tell them apart, and in practice it would seem likely that simultaneous measurements may need to be made but with different instrumentation, *eg*. consultant and contractor witness tests in parallel might be necessary. An experiment was therefore carried out whereby each meter was used to measure the test setup using its own and also the other three test signals. The results of the test are shown in *Figure 5*.

Each group of bar graphs along the x-axis represents one of the test signals, whereas the individual bar graphs each represent a particular meter. With the exception of the Audio Toolbox, very close agreement was found between the meters and test signals: the test was carried out at 80 dB(A). The maximum variation between the GL, NTI and Norsonic meters/discs was just 0.02 STI. The Audio Toolbox signal, although being reliably read by the other meters, gave rise to an inflated value of around 0.60 instead of 0.46. The cause of this is still under investigation.

The results of the above test are very encouraging and suggest that the various meters and test signals are compatible, at least over the range 50 to 80 dB(A).

A further comparison test was carried out whereby both noise and reverberation distortions were introduced into the test set-up. The reverberation condition remained constant throughout but the signal-to-noise ratio was carefully adjusted to give a spread of results. Three SNR values initially evaluated were : 40dB, 10dB and 6dB. The distrurbing background noise signal employed was speech-shaped noise. *Figure 6* presents the results. The bar graphs show the STIs obtained by each of the three STIPa meters and a reference MIssa system. The agreement was extremely good with a variation among the four measurement platforms of just 0.01 STI for any of the three conditions tested, over an average four runs per measurement.

As a final test of meter compatibility and accuracy, a comparison was made using several computer-based measurement platforms. The results are plotted in *Figure 7*. Agreement for this particular test condition was very good, with a maximum discrepancy of just 0.02 STI.

Whereas the above tests were not exhaustive, they are considered varied enough to show up any major flaws within the various meters now on the market, and the discrepancies among them. The results are encouraging, though caution is obviously required when carrying out tests at high or low sound pressure levels.

Test stimulus and its introduction into the system under test

Currently all the STIPa measurement systems provide a CD with the test stimulus on it. The CD is then played on a system player or other portable unit. It is assumed that the CD medium is transparent and of sufficiently high quality not to affect the test. However, in the author's experience this is not always the case. *Table 2* shows examples of the results from measurements carried out on a variety of CD players, including one specially modified for STIPa use.

As the table shows, not all CD players are created equal and some contributed a significant error. It is therefore essential when using a CD player that it is properly calibrated and checked throughout the length of the disc, not just at the beginning, as also shown by *Table 2*. One of the interesting aspects to emerge from the above series of experiments and also observed in extensive field testing, was that it was not always obvious when a significant

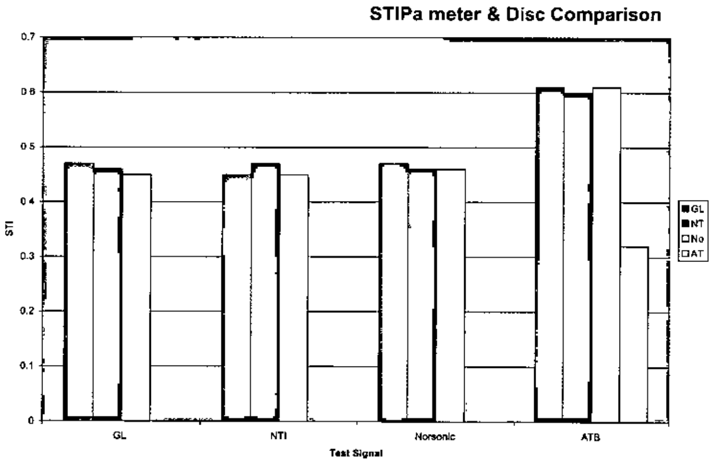

Fig 5 Comparison of meters & test discs

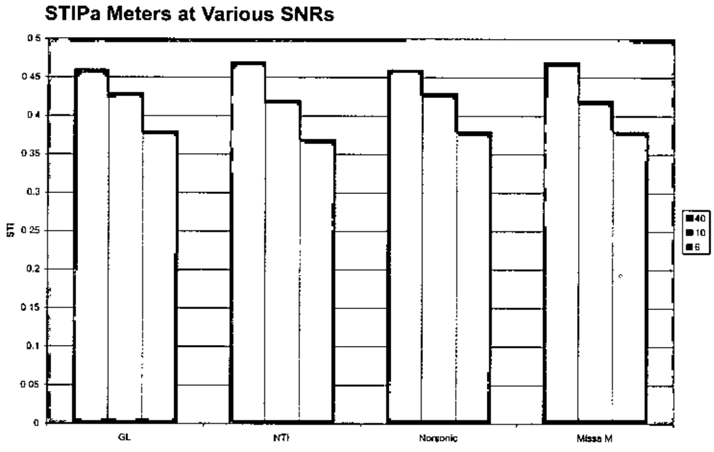

Fig 6 Comparison of STIPa meters at different SNRs

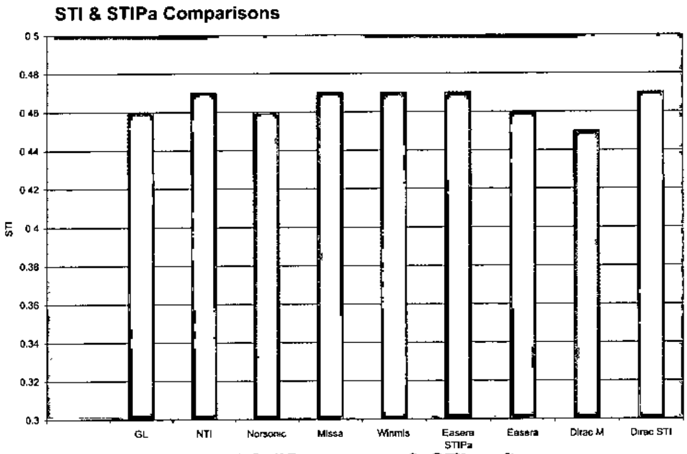

Fig 7 Comparison of STIPa meters & STI software programs

error had occurred. In one case, a large area of a stadium was shown to fail the minimum safety and contractual STI requirements. Had the results been accepted at face value, the implications for both the stadium owners in not getting an operating licence, and the installation contractor in terms of liquidated damages and legal expenses, would have been considerable! The culprit was found to be the local CD player, which sounded completely acceptable with normal speech and music programme material when checked initially.

Table 2: CD player STIPa errors

player	average STIPa	variance
Marantz – A	0.95	0.04
Marantz – B	0.96	0.04
Sony – A	0.97	0.05
Sony – B	0.94	0.04
Philips – A	0.98	0.03
Philips – B	0.82	0.02
Citizen	0.94	0.03
after 1 min	0.98	0.02
after 25 min	0.94	0.05
after 37 min	0.91	0.02
after 53 min*	0.88*	0.03

* *badly distorted*

Some initial tests have also been carried out by the author with minidisc players and other audio data compression and reduction systems. Initially these look encouraging, and the early results suggest that it may be possible to use media other than CDs. However, considerably more testing will be required over a range of operating conditions before the viability and accuracy of such an approach can be confirmed.

One observation that did emerge was that a second minidisc recording could not be made from the original, either directly or indirectly (*eg* from the system). This practice results in significant errors.

Effects of signal processing

Most modern sound systems incorporate some form of signal processing, which these days is more and more likely to be digital. Typical processing includes automatic gain control and compression, limiting, gating, equalisation, delay and possibly phase or frequency shifting. Some forms of system may also incorporate codecs or other forms of data compression. Such signal processing may or may not affect the resulting measured STI value. A series of experiments conducted by the author showed that the effect on the STI value was often stimulus-

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dependent. For example, time variant signal processing such as phase and frequency shifting, or decorrelation techniques employed to prevent acoustic feedback, had virtually no measurable effect when using the modulated STIPa signal. However, the processing had a disastrous effect when using MLS-based signals or sine sweeps, rendering the techniques completely useless.

By contrast, some forms of dynamic processing such as compression or dynamic equalisation were often (though not always) found to affect the STI results when using STIPa or similar modulated test signals. The effects were found to be highly dependent on the attack and decay times, processing thresholds and the compression ratio employed. Reductions of up to 0.26 STI have been measured by the author when employing typical compression ratios. When using swept tone or MLS test signals however, virtually no effect was noted within the normal operating range of the devices when set up for normal sound system operation.

Perversely, and somewhat worryingly, the author has often found when testing sound systems on site that by-passing essential signal processing elements, although producing a subjectively poorer sound quality and perceived intelligibility, actually improves the measured STI value! In particular, simple amplitude compression and equalisation illustrate the problem.

Frequency response effects

It is well established that appropriately equalising a sound system can have a dramatic effect on intelligibility. The author has reported improvements of up to 21% for a sound system operating in a reverberant but high SNR environment **(10, 14)**. Extensive experimentation with impulse derived STI and STIPa measurements shows that neither of these two measures is able to account for very obvious subjective improvements brought about by equalisation. The author had hoped that the introduction of STIPa, as it is specifically intended for sound systems, would have resolved the problem, but this is not the case. The underlying mechanism for this failure is now understood and it is disappointing that this fundamental failing has not been addressed.

Conclusions

The reported test results show that, although initially there were significant discrepancies among the various STIPa measurement meters, these now tend to converge. However, very significant differences still exist and confidence in the method is therefore reduced. There are a number of areas for concern, namely:

1 *The inconsistency in the application of the absolute sound pressure level correction factors, particularly at high sound levels (> 80dB(A)) within the meters;*
2 *The variability in the CD players and other media currently used to provide the test signal;*
3 *The inconsistency and poor performance of the test loudspeakers and artificial mouths currently on the market, which may be used generate the acoustical test signal; and*
4 *The inability of STIPa or the parent STI method to deal with sound systems exhibiting a poor and uneven frequency response when operating in reverberant, high signal-to-noise conditions.*

It is encouraging to note, however, the conformity of most of the test signals, enabling a number of meters to make accurate measurements when using test signals from different manufacturers. This will be of great practical importance when auditing and assessing real world systems operating under real world site conditions. Whereas items 1 to 3 listed above are relatively simple to rectify and overcome, item 4 is a far greater and more fundamental problem. For applications requiring the measurement of STI in rooms (*eg.* classrooms and auditoria) the limitations of STI and STIPa were discussed at the 2003 IOA *Sound-bite* conference **(13)**.

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Channel Tunnel rail link Section 2

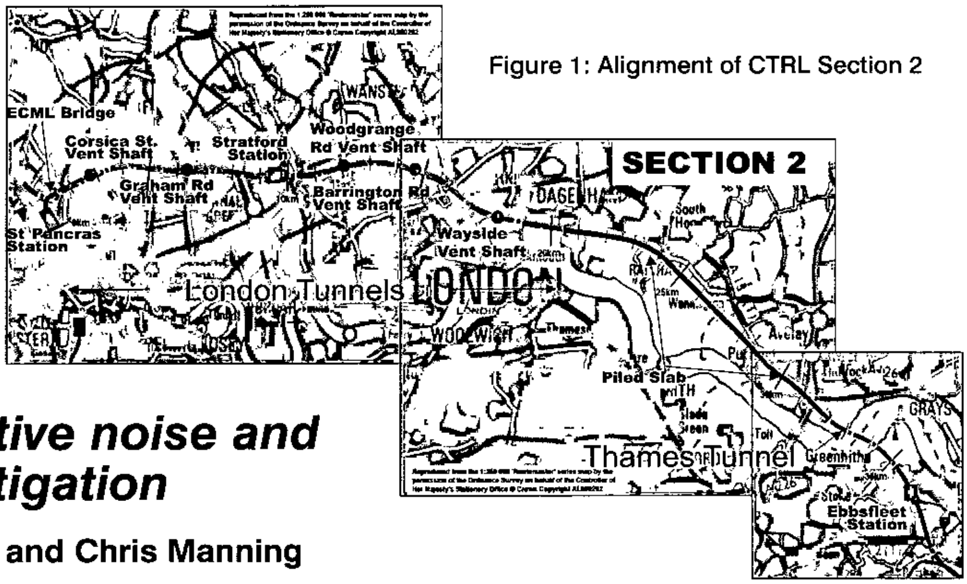

Figure 1: Alignment of CTRL Section 2

A review of innovative noise and vibration mitigation

Richard Greer, Ted Allett and Chris Manning

This 'consultancy spotlight' looks at a side of consultancy not covered in previous articles: participation in the very largest projects. The nature of this kind of work is that the costs and risks involved mean that consortia are formed to deliver projects and that senior staff are often seconded to the consortia project teams to ensure the dedicated technical and commercial focus required.

The largest project in recent times is the Channel Tunnel Rail Link (CTRL). The principal author, Richard Greer of Arup Acoustics, was seconded into the Rail Link Engineering (RLE) consortium, responsible for the design and construction of the link, from the organisation's creation in 1996.

The Channel Tunnel Rail Link is the new high-speed rail link between the Channel Tunnel and London.

A paper published in the Institute of Civil Engineers Transport Journal (1) presented the progressive design, management and procurement processes employed on the project to minimise the noise and vibration impact associated with the construction and operation of CTRL Section 1. This first part of the line came into operational service on 28 September 2003 on time, on budget and compliant with all the onerous noise and vibration commitments applied by the UK Government.

This article focuses on Section 2 of the project and is based on the paper presented to the 8th International Workshop on Railway Noise which is to be published later this year in the *Journal of Sound & Vibration*.

Though only half the length of Section 1, at £3.3 billion it is considerably more expensive as a result of several major engineering challenges, particularly: a 3 km tunnel under the River Thames; long lengths of piled slab over marshland; 20 km of tunnel under urban London; and three international stations.

The successful and progressive methods employed to minimise the impact of noise and vibration from construction, in such densely populated areas, were described in the last paper. Here, we focus on the innovative design solutions that have been developed to control groundborne noise and vibration from tunnels, noise from tunnel ventilation, structure-borne noise in stations and structure-radiated noise from a steel viaduct. All achieved in compliance with the operational requirements of a high-speed railway and at reasonable cost.

Background

The Channel Tunnel Rail Link (CTRL) is Britain's first new major railway for over a century. The high-speed line runs for 109 km (68 miles) between St Pancras Station in London to the Channel Tunnel. The link is in two sections. Section 1, with a line speed of 300km/h (or 180mph) runs mainly on the surface from the Channel Tunnel to the existing rail network near the River Thames. It commenced operation in September 2003, on time and on budget. Section 2 *(see Figure 1)* is primarily in tunnel. Construction started in 2001 and it will become operational early in 2007. Section 2 line speed is 230km/h (145mph).

Section 1 and 2 will together carry international and domestic passenger services with the capability to carry freight (up to 22.5 tonne axle load).

Reference (1) describes the environmental impact assessment, the public consultation and the UK Government parliamentary proceedings that resulted in the powers to build CTRL and the environmental minimum requirements (EMRs) to be achieved during the project's design and construction.

The CTRL Act was passed in 1996. In the same year the UK Government selected London and Continental Railways (LCR) as a private sector partner for the project. LCR appointed Union Railways (North) Limited (URN) to run CTRL, who in turn appointed a bespoke engineering consortium, Rail Link Engineering (RLE), to design the railway and project manage the construction. RLE's member companies are Arup, Bechtel, Halcrow and Systra.

Design philosophy

Reference (1) described the progressive approach developed by RLE to achieve the balance between effective noise and vibration control and reasonable costs. The approach is based upon four fundamentals of: integrated design; accurate noise and vibration predictions; incremental innovation; and an open and progressive approach to approval authorities and neighbours.

CTRL Section 2: construction

Reference (1) presented the proactive and preventative approach to control of construction noise and vibration on the project. CTRL Section 1 showed the value of the approach, one of the reasons it was on-time and on-budget. CTRL Section 2 was more challenging given the size of the construction sites, their close proximity to large numbers of noise-sensitive receptors, the need to work continuously 24 hours a day on some activities (*eg.* tunnelling and its support activities to minimise settlement) and the need

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in some areas to undertake CTRL work during night-time, weekend or public holiday closures (possessions) of existing railways and highways.

Section 2 further developed the process for management of construction noise and vibration. Some of the good practice lessons learned were:

- The need to predict, control and monitor *cumulative* noise from sites with multiple contractors;
- Groundborne noise and vibration from underground construction activities (*eg.* tunnelling) should be included, and advanced public notification of such 'unseen' noise sources should be provided;
- The need to maintain standards using audits and management control (a challenge for large, long term projects where often there is a high turnover of staff);
- The need to have a range of contractual noise and vibration specifications to suit the range of types of contract let (*ie.* from trade contractor to large scale main contractor); and
- Noise control must be understood and implemented by everyone on site.

CTRL Section 2: permanent works

The following examples present some of the highlights of the noise and vibration control measures implemented on CTRL Section 2.

London tunnels: track

Groundborne vibration arising from the operation of trains through the CTRL London Tunnels may potentially give rise to groundborne noise or perceptible vibration impact, or both, on occupants of overlying properties. The rolling stock is defined for CTRL and the alignment is finalised. The only means of providing significant groundborne noise and vibration control is by increasing the train-track system vibro-acoustic isolation.

The track must also comply with the RAMS (reliability, availability, maintainability and safety) requirements of a high-speed railway.

Noise and vibration commitments

The commitments are onerous for a high-speed rail project. Union Railways Ltd understood when entering into the commitments that the vibro-acoustic performance of the track would require incremental innovation based on current high-speed track design. Equally the British Parliament accepted that it was not reasonably practicable to avoid low levels of groundborne noise impact (groundborne noise between 35 and 40 dB $L_{Amax,S}$) in several areas.

The first of the project's main commitments was for the predicted levels of groundborne noise impact not to be materially worse than the 630 'low' impacts (between 35 and 40 dB $L_{Amax,S}$) **(2)** accepted by Parliament. This commitment includes consideration of any freight traffic (CTRL is designed with the capability to carry freight) and any increase in passenger train speeds (the final design has a line speed of 230km/h compared with the 215km/h assumed during the parliamentary process). The commitment specifies a number of impacts by local authority area. This provided the flexibility required in finalising the tunnel alignment (within limits of deviation) as it was accepted that some of the properties predicted during the parliamentary process to experience an impact might not be subject to a predicted impact from the final RLE design and *vice versa*.

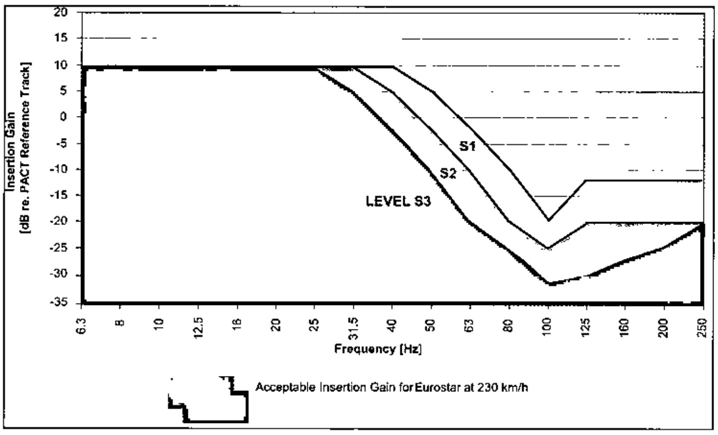

Figure 2: Insertion Gain Specifications

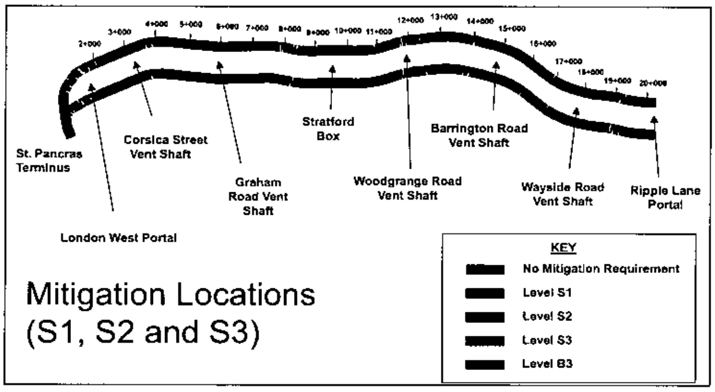

Figure 3: Location of Specifications

The second commitment required the project to employ best practicable means (BPM) to reduce groundborne noise levels below 40 dB $L_{Amax,S}$. Importantly, it was accepted by Parliament that complying with this commitment would not require changes to the alignment and would not require the use of floating slab track (FST). In the latter case this was because FST is not proven under high-speed operation and would also require a substantial increase in tunnel diameter. Given the need to construct the twin tunnel arrangement required by the safety authorities (with a single track in each tunnel), the increased diameter would have been required for all 40km of tunnel with a consequent enormous increase in capital cost.

Predictions

The part empirical and part theoretical model for predicting groundborne noise and vibration from CTRL tunnels and its validation is described by Allett *et al* **(1)**. This model was used to make design calculations to determine the level of acoustic mitigation required (insertion gains as a function of chainage) to ensure compliance with the commitments. These calculations were based on the final tunnel alignment and the final geological and building foundation datasets gathered during detailed design and construction.

Based on these calculations, a track-work acoustic specification was developed that defined three levels of mitigation (as 'insertion gains' compared with PAved Concrete Track, or PACT) which would ensure compliance with the project's commitments. The three levels of mitigation in the specification are termed levels S1, S2 and S3 in increasing order of mitigation *(refer to Figure 2)*, with level S2 mitigation being similar to the 'vibration reference case' (VRC) considered by Parliament. This specification formed part of the contract for the detailed design and supply of the track-work. *Figure 3* shows the locations of the three levels of mitigation, although it should be noted that that these reflect an acoustic requirement only. As discussed later, the number of track types used in the tunnels was later reduced so that maintainability is maximised.

Track options

URN and RLE made a number of reviews of generic track systems comparing them with the various CTRL criteria (acoustics, RAMS, spatial constraints *etc.*). These reviews considered all the generic track options used throughout the industry. The options considered worthy of further study were limited to resilient baseplates and booted sleeper solutions.

Overall, the RLE reviews confirmed that there were slab track systems proven at high-speed, albeit with stiffer rail support than was required for CTRL, and that the levels of resilience required had also been achieved although at lower speeds. The incremental innovation was therefore to take proven high-speed slab track systems and 'tune' them to provide the greater resilience required whilst ensuring compliance with the RAMS criteria critical to the railway.

The contract to undertake detailed design and installation of the track-work was awarded to the ACT Joint Venture (see below) in August 2002. ACT validated the RLE track option review and then made a final review taking account of all the latest technological developments. It concluded that the booted sleeper family of system best suited to the CTRL requirements. ACT launched a tender process for supply of the track and the Stanton-Bonna/Sateba (SBS) JV was selected.

Track-work final design

ACT and RLE's detailed design work confirmed a number of key points:

❑ S2 track-work would be provided instead of S1 to reduce the number of track systems.

❑ The very high level of resilience required for S3 could be achieved for high-speed operation:

a) without any effect on the safe operation of the line;

b) without affecting passenger comfort; and

c) without affecting the reliability, availability and maintainability performance other than the lifespan of the rail be reduced (by about 20%).

❑ Stress and fatigue analysis showed that S2 and S3 could be achieved with the same system (the Sateba 312, see *Figure 4*), only the sleeper pads need to be changed.

❑ It was critical to specify separately static, dynamic and acoustic stiffness for a system based on the relevant loads and frequencies appropriate for the project.

The ACT modelling results showed that with a Eurostar, the S2 and S3 levels of mitigation could be achieved using standard S312 sleepers, rail pads with an acoustic stiffness of 150MN/m and sleeper soffit pads with an acoustic stiffness of 18MN/m and 10MN/m respectively per block (half sleeper). With high

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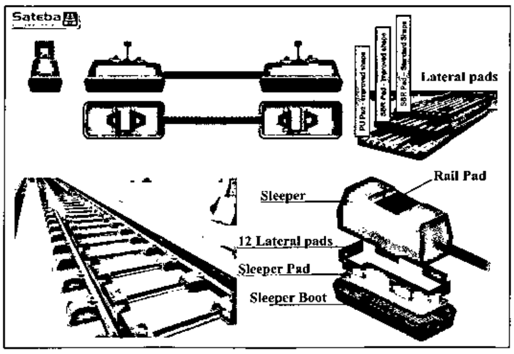

Figure 4: Selected booted sleeper track system for London tunnels

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quality resilient pad materials these values are approximately equivalent to static stiffness of 12 to 15 MN/m and 7 to 8 MN/m respectively. For reference, Sateba's S312 and Pfleiderer/Vossloh's Rheda 2000 are among the best performing high-speed systems in terms of vibration isolation. The sleeper soffit pads of the S312 system installed in LGV Marseille tunnel and the baseplate pads installed in Rheda 2000 have an approximate acoustic stiffness of 25 to 30 MN/m and a static stiffness of 17 to 20 MN/m. Thus S2 is nearly twice as resilient and S3 is approximately three times more resilient, compared with the best high-speed track currently in operation.

Getzner Sylodyn sleeper soffit pads were selected and an exhaustive range of tests was set up by ACT and SBS that covered the RAMS performance (especially fatigue and ageing) and the acoustic performance for both tangent track and curves. The latter is particularly important given the mixed traffic profiles CTRL is designed to accommodate, and thus the significant lateral forces associated with cant deficiency or excess. *Figure 5* shows the test rig set up to measure the acoustic stiffness of the overall system. This was a bespoke system measuring vibro-acoustic stiffness of the complete system using the 'direct' method. The test rig imposes 'static' forces on the rails to simulate the load imposed by the train wheels and smaller amplitude dynamic forces to simulate the vibration generated at the wheel rail interface caused by wheel and rail roughness. A lateral load is also imposed to simulate the centripetal forces caused by the cant deficiency or cant excess apparent in curves for the different types of rail service that will use CTRL. A bespoke test was required because prEN 14841-6 covers neither a booted sleeper/block system nor the provision of lateral forces.

The acoustic tests showed how important the shear stiffness of the lateral pads is to the overall S3 system acoustic stiffness in curves and that the overall system stiffens under increasing axle load. Müller-BBM was commissioned to undertake bespoke laboratory tests to compare the acoustic shear stiffness of different lateral pad profiles and materials *(refer to Figure 4)*. These led to the selection of a modified profile with the pad formed from polyurethane. This pad has a shear acoustic stiffness that is less than one-sixth that of the standard synthetic rubber pad. Tests were also undertaken on a range of different sleeper soffit pads, but none showed any marked improvement in the increase in acoustic stiffness with increasing pre-load.

The mechanical tests showed that the S3 system performed very well under fatigue testing but that an increased strength steel tie bar was required. Separate peer reviews and assessments have demonstrated that the system should not give rise to rail corrugation.

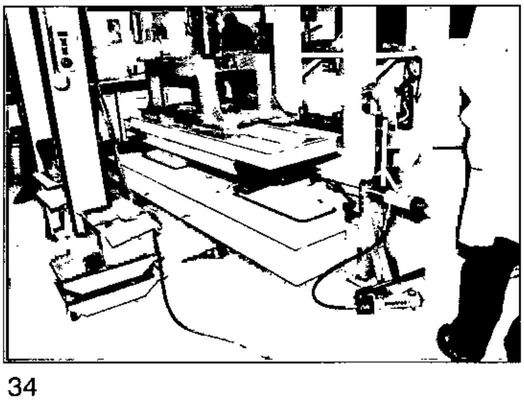

Figure 5: Measuring acoustic stiffness

Final acoustic performance

ACT's acoustic consultant D2S International predicted the insertion gains with passenger and freight rolling stock based on the measured acoustic stiffness of the S2 and S3 final systems. *Figure 6* shows the predicted performance for S3 with

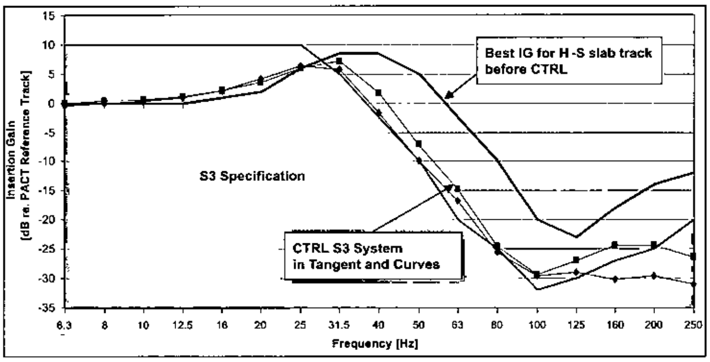

Figure 6: Final insertion gains

passenger trains in tangent and curved track (at maximum cant deficiency or cant excess).

At this final stage, and based on the results of the mechanical tests, URN instructed RLE and ACT to provide the final S3 system throughout the entire length of London tunnels. This provides a single system that benefits future maintenance and provides a best possible environmental solution in all locations. The final insertion gains for the S3 system were then entered into RLE's overall model to predict groundborne noise over the London tunnels. The final results show that only 100 properties are now predicted to experience levels of groundborne noise above 35dB $L_{Amax,S}$, compared with the 630 properties identified at the time of the parliamentary process. Only one property is predicted to experience levels above 40dB $L_{Amax,S}$. This property is close to one of the portals and is already owned by the project because it was affected by settlement during the construction of the tunnels.

Whilst the predicted insertion gains fall slightly short of the S3 specification *(see Figure 6)* the overall predictions with passenger services are substantially better than the parliamentary commitments. The predicted levels of groundborne noise with freight traffic are dependant on the type of freight (particularly the overall and unsprung mass per axle). Currently URN does not foresee a business case for running regular 'heavy' freight services through the tunnels. Freight services are more likely to be low mass, high value and high-speed services (*eg* parcel trains) running in modified passenger rolling stock. In the unlikely event that heavy freight runs regularly through the tunnels it is likely to be a slow speed, reducing any short fall in the track insertion gain due to the additional pre-load. The London local authorities have been fully consulted on the best practicable means employed to provide the best performance possible.

London tunnels: ventilation shafts

The are five ventilation and pressure relief shafts along the lengths of the London tunnels *(see Figure 1)*, each of which has the potential to generate high noise levels - from both pressure relief and forced ventilation modes - at adjacent noise sensitive properties. An indicative layout is presented in *Figure 7*.

The prediction work required to define noise control measures and hence ensure compliance with the project commitments was complicated by the fact that there were no proven methods for predicting either train noise break-out or aerodynamic (regenerated) noise for the anticipated pressure relief air-flow velocities, up to 50m/s.

Prediction method for train noise breakout and high velocity aerodynamic noise

The project developed and calibrated its own prediction method for aerodynamic noise generated by pressure relief airflows passing over the in-duct damper and security grille and the direct breakout of airborne train noise through the same pressure relief shaft. Existing methods for predicting aerodynamic noise were reviewed and the following conclusions were drawn:

❑ Very little measured data exists for aerodynamic noise from air velocities above 20ms^{-1}.

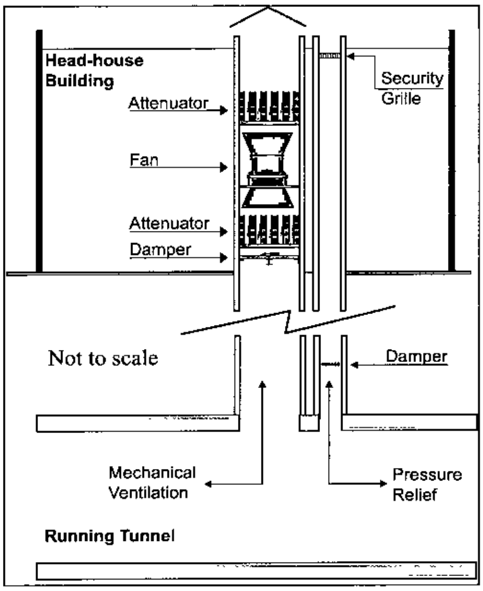

Figure 7: Indicative vent shaft

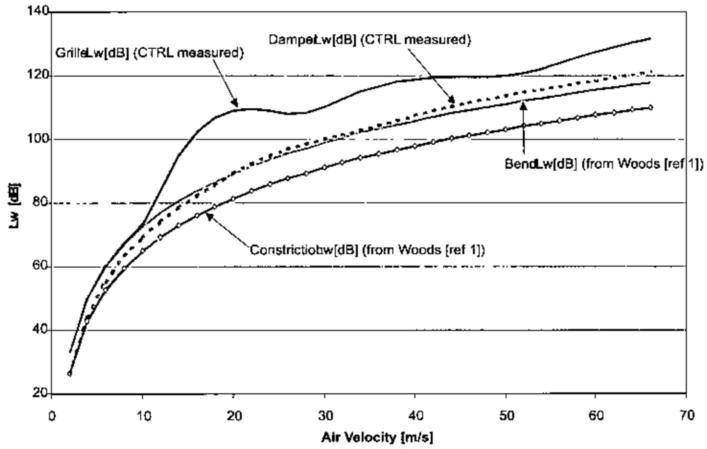

Figure 8: Measured sound power levels

❑ The direct extrapolation of the existing models for air velocities above 20ms^{-1} (outside their reported limits) could be a risk to the project as it could give rise to significant over or under prediction. Comparison with documented jet noise prediction models would indicate some form of non-linearity between 20 and 100 ms^{-1} velocities.

The key components of the model developed are the prediction of aerodynamic noise from the in-flow grilles and dampers. The 'source' part of the model was developed and calibrated against measurements undertaken at the Fraunhofer Institut Bauphysik in Stuttgart on sample grilles and dampers at air speeds up to 55ms^{-1} *(Figure 8)*. This source was coupled with standard methods for dealing with other issues such as the radiation directivity, propagation losses, and meteorological conditions **(3, 4, 5)**.

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Train noise break-out from the pressure relief shafts is considered by a separate part of the model. This draws on the project teams' experience and published data (6) on the semi-reverberant sound field for a source in a tunnel and the unusual propagation of noise with increasing distance from source along the length of the tunnel.

The results showed the combined noise generated by the pressure relief shafts *(Figure 9 provides an example)* would give rise to significant failures of the project's noise commitments. This resulted in a number of significant changes to the structural design of the ventilation shafts:

- ❑ Separate ducts for pressure relief and mechanical ventilation;
- ❑ 'Smoother' routes for the pressure relief shafts (avoiding corners *etc*);
- ❑ Exhaust pressure relief and mechanical ventilation through the roof of the 9m tall head house buildings (*ie.* pointing away from surrounding receptors); and
- ❑ A parapet round the edge of the head house building roof was added, to screen nearby receptors from noise emitted from the exhausts.

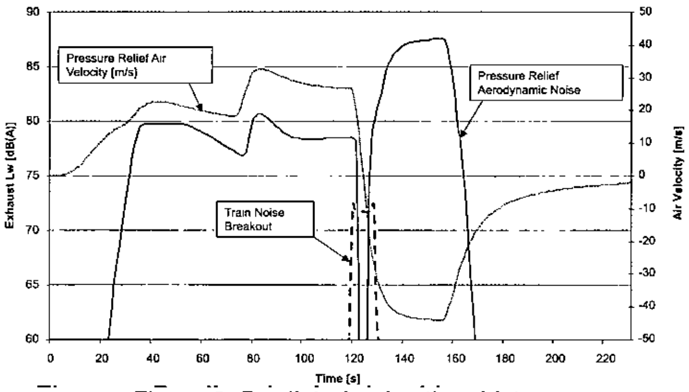

Figure 9: Predicted noise time history

Further predictions were then made based on these modified designs. The worst-case predictions still failed the commitments at three vent shafts. The specific commitments are based on the total noise level at the receptor not exceeding the background noise level (without the vent shaft) by more than 5dB. The worst case assessment was in the middle of the night when the background noise levels are at their lowest. The source levels at night were also presumed to be the cumulative noise from mechanical ventilation to one tunnel (in maintenance mode) and pressure relief noise from the remaining operational tunnel in bi-directional working. Whilst this will be the mode of operation the means of providing mechanical ventilation to the tunnel being maintained has been modified. The worst-case impact is therefore the last passenger services into London late at night and the first services out of London very early in the morning. RLE therefore set, in the relevant contract, maximum sound power level spectra for the combined aerodynamic noise from the in-duct damper and security grille. This required the selection or design of low noise equipment. Emcor, the contractor (see below), proved compliance by wind tunnel tests.

The compliant design features a modified low-noise rotating vane in-flow damper and a wire mesh security grille on a 25mm grid. The latter resulted in significantly lower aerodynamic noise than the 30mm deep rectangular bar grille originally tested by RLE.

Mechanical ventilation noise

Noise from mechanical 'forced' ventilation of the tunnels was evaluated by Emcor using accepted prediction techniques (refer to (3) and (4)) despite the size of the equipment (2.8m

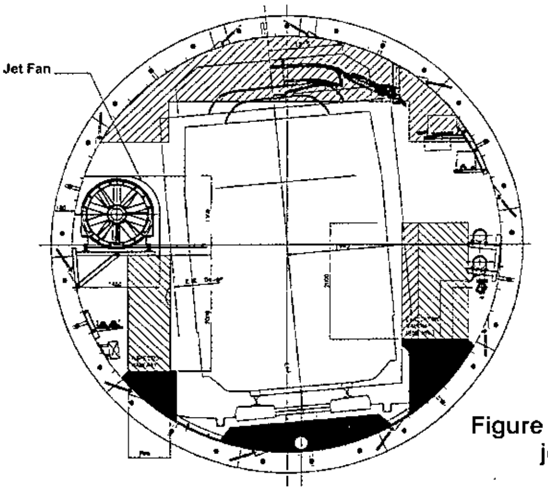

Figure 10: In-tunnel jet fans

diameter reversible fans). Control of noise inside the tunnel, to ensure speech intelligibility during an emergency, necessitated attenuators on the tunnel side of the vent shaft fans as well as on the environmental side.

The greatest concerns about mechanical ventilation noise were: providing ventilation to night-time maintenance staff in the tunnels; ventilation at night necessitated by congested or delayed revenue train services; and the need to safety-test the fans weekly at night during closure of the tunnels to regular train services. Emcor's accepted final design resolved these noise issues. There were two principal modifications that reduced noise.

Firstly, six rows (at 50 m spacing) of axial 'jet' fans are now included at each of the eight portals *(see Figure 10)*. These generate little noise breakout from the portals, and the portals themselves are in less noise sensitive locations. The jet fans provide the mechanical ventilation required for the tunnels in normal and congested running conditions. The five vent shaft fans are only required in case of an emergency (such as a fire).

Secondly, at each vent shaft site, a closable 'cross-shaft' was provided between the two mechanical ventilation shafts (one to each tunnel). Given that the mechanical ventilation shafts will be closed to the tunnels (except in emergencies), the cross-shaft can be opened allowing each fan to be tested in turn, during the less noise-sensitive daytime, exhausting through the adjacent fan shaft.

St Pancras Station

St Pancras is the magnificent Victorian Grade 1 listed station that will form the main international station for CTRL

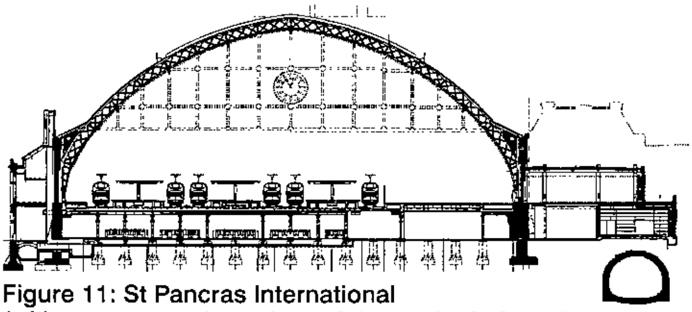

Figure 11: St Pancras International
(with concourses in undercroft beneath platforms)

in London. The station is being sympathetically refurbished. An extension is also being constructed that will double the length of the current platforms to accommodate the 400 m long international passenger trains, and which will be double the width of the original station train shed, to accommodate the existing Midland Mainline services and the new high-speed domestic passenger services on the CTRL. The existing Barlow train shed will be maintained and refurbished. The design of the public address and voice evacuation system in this vast space, with a current reverberation time of over seven seconds, is intended to be the subject of a future article.

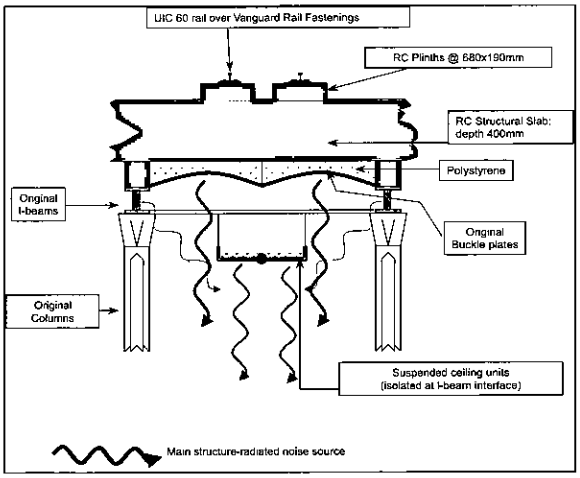

Figure 12: Structure bourne noise

As *Figure 11* shows, the refurbishment includes converting the undercroft beneath the international platforms into passenger concourses, ticket offices, customs and excise and other noise-sensitive uses. Structure-borne noise from train movements was therefore a key design issue, exacerbated by the need to retain the existing and Grade 1-listed iron

Figure 13: St Pancras interim station with Pandrol Vanguard rail fastenings

columns, I-beam girder lattice and buckle plate superstructure *(Figure 12)*. The arrangement was extensively modelled using specialist dynamic simulation software written by Arup. The software employs a time domain solution of finite element [FE] and boundary element [BE] models of the structure, which enable accurate prediction of structure-borne noise at frequencies up to 300Hz. This modelling demonstrated that using very resilient rail fastenings (Pandrol's Vanguard was finally selected - *Figure 13*), an enhanced structural slab design, and resilient isolation of the new suspended ceiling units, structure-borne noise levels in the undercroft could be reduced to the levels experienced in other successful railway stations without the expense (~£5 million) of floating slab track.

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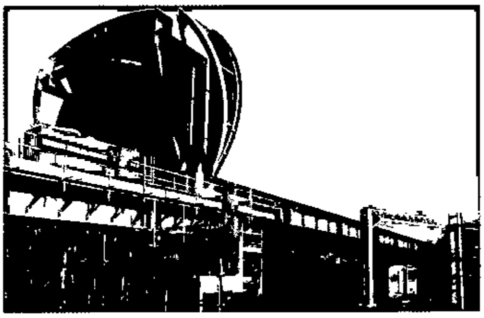
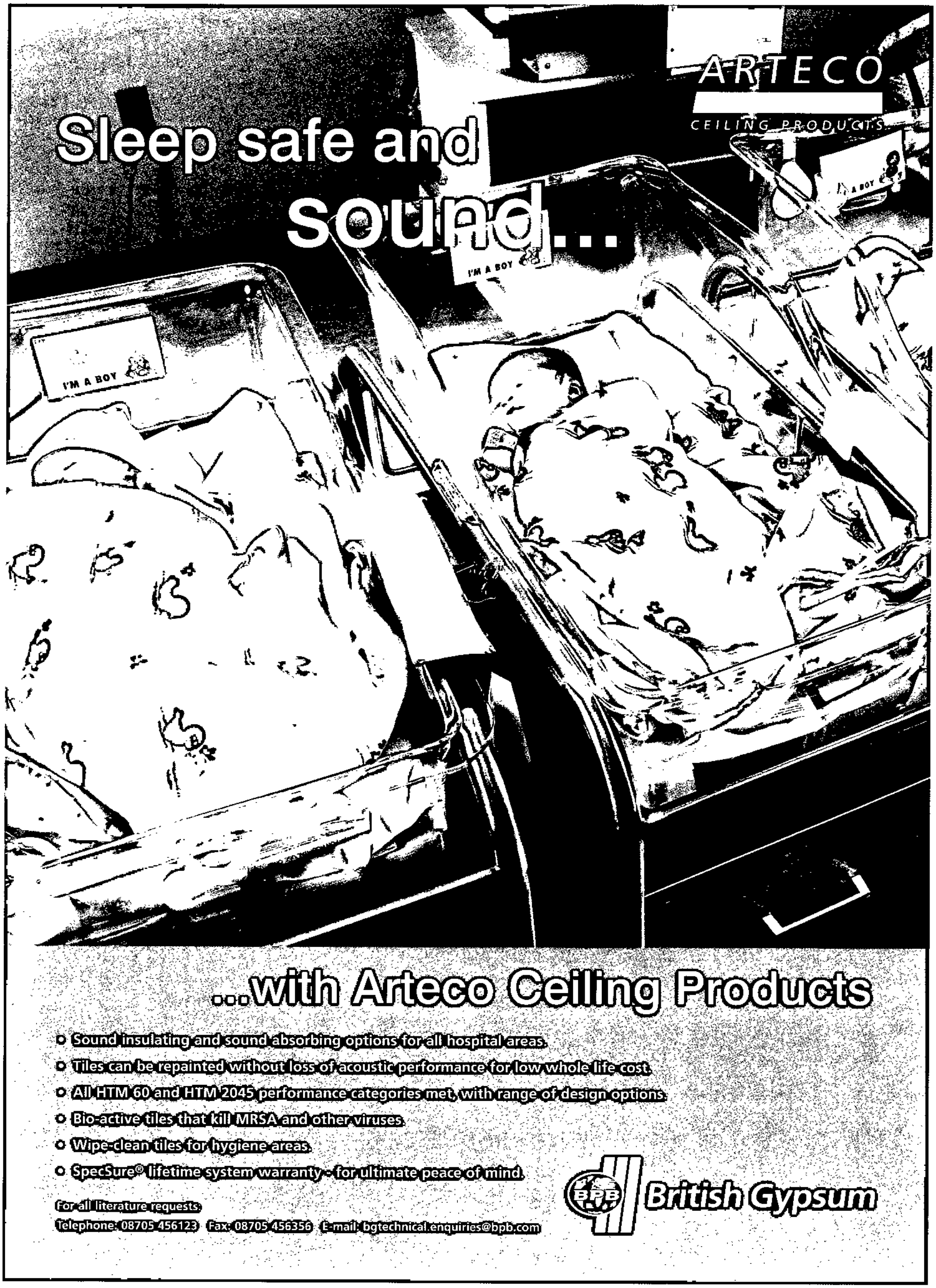


Figure 14: ECML bridge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East Coast Main Line (ECML) bridge

The bridge *(Figure 14)* carries the CTRL over the ECML and is the first structure immediately west of the London tunnels. As shown in *Figure 15*, the bridge is close to a number of residential properties. Noise from the bridge is an issue because:

- ❑ To minimise impact on the very busy ECML this is a lightweight 75m single span bridge made predominantly of steel, allowing it to be lifted into place during a single ECML closure but increasing structure-radiated noise;
- ❑ Vertical alignment constraints (associated with the tunnel approach to the bridge) combined with the need to provide a minimum clearance over the ECML mean that there is a vertical 'pinch point' which limits track construction depth such that standard ballast track constructions cannot be employed;
- ❑ There is a parliamentary commitment to provide a canopy: whilst this reduces airborne noise it increases structure-radiated noise; and
- ❑ A crossover has to be provided half on and half off the bridge.

The overall noise received at the residential properties consists of airborne rolling noise, power car fan noise, and structure-radiated noise from the ECML bridge *(Figures 15 and 16)*. The detailed finite element [FE] and boundary element [BE] analysis models described in the last section were applied to the bridge to predict structure-radiated noise. A specimen output is presented in *Figure 17*.

This and other modelling work identified that mitigation was required for airborne noise and particularly structure-radiated noise. In terms of airborne noise an overall level difference of 15dB was required. This is comfortably achieved through the sound insulation provided by the solid steel firewalls on the inside of the bridge main girders *(Figure 16)*, the sound insulation of the canopy, and sound absorption on the inside of firewalls (to reduce reverberation and reduce noise levels at source). The provision of damped cladding panels, rubber bushes between each cladding panel and the cladding rails, vibration isolators between the main bridge structure and the cladding rails, and a floating slab track *(Figure 16)* controls structure-radiated noise.

The floating slab track has three purposes: to form part of the mitigation of structure-radiated noise; to accommodate the differential longitudinal thermal expansion between the pre-tensioned continuous welded rail and the bridge deck (the rail and track slab exhibit less thermal expansion as they are shielded by the canopy); and to control the rate of change of rail deflection (laterally and longitudinally) to protect the crossover and turn-outs. The detailed design of the floating slab track, which will feature discrete resilient bearings under a 290m thick track slab, is being finalised at the time of writing.

Conclusions

This article outlines some of the key elements of noise and vibration mitigation on Section 2 of the Channel Tunnel Rail Link and shows how incremental innovation can be used to develop mitigation resulting in low levels of noise and vibration at reasonable cost.

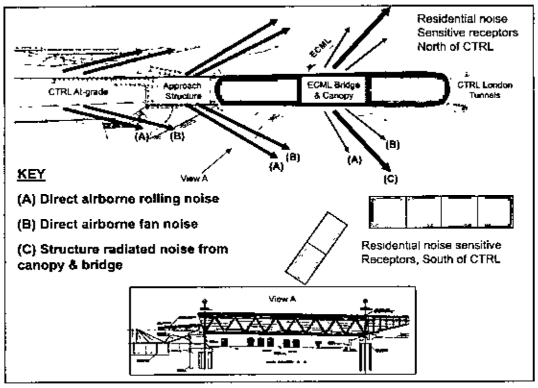

Figure 15: Plan and elevation of ECML bridge and noise sources

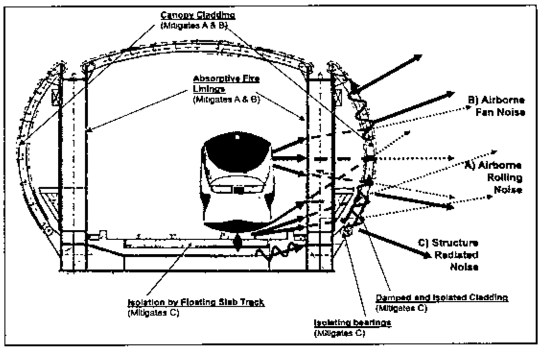

Figure 16: Bridge noise sources

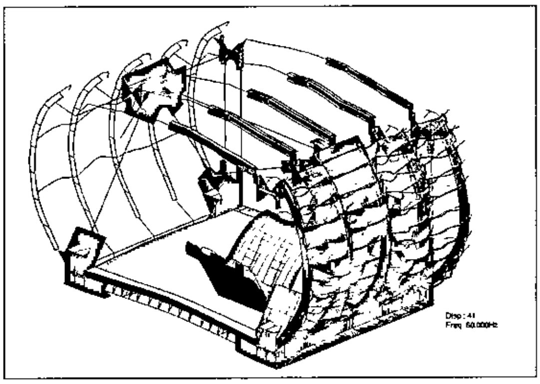

Figure 17: FE model at 50Hz

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4 Sound Research Laboratories Ltd, Noise Control in Building Services, 1988 ISBN 0-08-034067-9

5 Nelson P (ed), Transportation Noise Reference Book, 1987, ISBN 0-408-01446-6

6 Barnett P, Acoustics of Underground Platforms, *Proc IOA 16* (2) 433-444,1994

Acknowledgments

The authors acknowledge the contributions of the following, without whom these successes would not have been possible: the many staff in URN, RLE, its home companies involved in this work, and other acoustic consultants (unfortunately, too many to mention by name); the Alstom Transportation Projects Ltd, Carillion Construction Ltd, Transport du Sud-Ouest JV [ACT] (Contract 576); Emcor Drake and Skull Group plc (Contract 588); J Mowlem & Company plc (Contract C104H); the Kier Construction Ltd and Edmund Nuttall Ltd JV (Contract 103); the Morgan Est plc and Vinci Construction Grands Projets JV (Contract 310).

Richard Greer, *Rail Link Engineering, London;* **Ted Allett**, *Union Railways (North) Ltd., London; and* **Chris Manning,** *Arup Acoustics, Cambridge*

How up-to-date is your sound level meter's calibration?

Richard Tyler

For many years, the two IEC standards 60651 and 60804 (formerly known as BS 5969 and BS 6698 in the UK) formed the basis of the tests used to check the performance of sound level meters. In the UK, a set of tests was defined in BS 7580 and laboratories were able to gain UKAS accreditation for tests on meters carried out in accordance with this standard.

In late 2002 IEC 60651 and 60804 were withdrawn and replaced by IEC 61672-1:2002, also known in the UK as BS EN 61672-1:2003. The IEC Committee responsible for creating this standard was tasked with providing tests for periodic checking of meters designed in accordance with the new requirements, but to date these have yet to be published. In the meantime, manufacturers have been producing meters claiming to meet IEC 61672-1 but there have been no UKAS-accredited calibration facilities for them, due to the lack of standardised test procedures.

This has now changed as the National Physical Laboratory, in conjunction with UKAS, has produced NPL Guide 2004/1 **(1)** detailing tests based on the requirements of IEC 61672-1. It is similar to BS 7580 in content and was first published in 2004, but was updated to Edition 2 in 2005. The tests forming the basis of this document are those that have been broadly agreed within the IEC Committee, but are yet to be finalised before publication as IEC 61672-3. The NPL Guide is therefore a temporary document that is to be used until IEC 61672-3 is available **(2)**, and will be withdrawn six months after that standard is published (date as yet unknown).

With this series of tests defined, it is now possible for sound level meters designed to meet IEC61672-1 to be tested for conformance with some of the requirements of this standard for which checking on a regular basis is deemed advisable. It does not guarantee that the meter fully meets the new Standard, as several aspects of the requirements are not tested at all. These include the effects of temperature, humidity and electromagnetic radiation; however these were not tested in BS 7580 either. There are, however, significant differences in some areas between the old and new standards, and some of these are covered by the tests in the NPL Guide.

UKAS-accredited calibration is now available for meters claiming to meet IEC 61672-1

One aspect of the new standard that has provoked considerable discussion is the inclusion of measurement uncertainties in all the tolerances given in the new standard. This means that any laboratory carrying out testing on meters must understand, and have credible figures for, the uncertainty of any measurement undertaken in connection with those tests. As the maximum uncertainty value for each test is defined in IEC 61672-1, any laboratory which has larger uncertainties is automatically excluded from testing the meter.

The knowledge of uncertainties is not limited to the calibration laboratory, as the manufacturer now has to supply far more data about the meter than was previously the case, including their measurement uncertainties for some data. To date, this has been an aspect of the new standard that many manufacturers appear to have ignored in their rush to claim conformance to the latest requirements.

Other significant differences arise in regard to Peak response, for which mandatory testing is now carried out using C-weighting, and in the testing of Fast and Slow time constants, which is now much more demanding. Many other tests follow similar lines to the old BS 7580, but with the accuracies redefined. The new Standard defines only two grades of meter, Class 1 and Class 2, and both are covered in the NPL Guide and can be tested accordingly.

With the publication of what is expected to be the final version of the NPL Guide, laboratories which can meet the measurement uncertainty requirements have been able to seek UKAS accreditation for the tests which it defines.

AV Calibration Ltd is the first calibration laboratory to be awarded UKAS accreditation **(3)** for periodic testing in accordance with Technical Guide NPL Acoustics 2004/1 Edition 2 for Class 1 & 2 Sound Level Meters originally manufactured in accordance with IEC 61672-1:2002 (BS EN 61672-1:2003). This means that UKAS-accredited calibration is now available for meters claiming to meet IEC 61672-1. Until now, meters also had to claim that they met IEC 60651 and IEC 60804 if verification in accordance with BS 7580 was to be applicable. This is no longer the case.

The requirements of the old and new standards, whilst similar, are by no means identical and it seems logical that new meters designed to meet new standards are checked for conformance with the new requirements rather than the old ones that have applied since 1979.

However, there is one aspect of the new document which continues a tradition from the old standards which, in the author's opinion, leaves a strange gap in the validity of any sound level meter verification, past or present. This involves the accuracy of the microphone fitted to the meter. Both the old and new procedures require a test of the microphone at 1 kHz, 125 Hz and 8 kHz (although 4 kHz in place of 8 kHz is an option in the new document). No other frequencies are actually tested, but great detail is expended on electrically testing the accuracy of all the weighting networks from 63 Hz to 16 kHz in the new procedure.

For the remaining frequencies, the old standard allowed the use of data from the original frequency response chart (which could be anything up to 40 years old); the new procedure uses the typical frequency response of the appropriate model of microphone. To offset this disparity, AV Calibration Ltd has added to its test procedures a check using the actual microphone response at 10 frequencies (8 for Class 2), and the results of this will be presented alongside all other data measured during the testing of the meter.

Testing for microphone accuracy remains an issue

If the microphone meets the requirements at the few specified points, then the meter must be deemed to pass the requirements of the technical Guide as a whole; however if other points would fail to meet the requirements, if the actual microphone response were used, then the owner will at least be aware that there are concerns about the accuracy of the microphone, even though the meter has a 'pass' certificate! There are discussions planned at the IEC Committee about this aspect of the testing, but these are likely to take a long time to resolve; so for the foreseeable future, these additional measurement data give the best way to inform equipment owners of any problems with the microphone outside the limited test points.

Owners of modern sound level meters can now have them verified to the latest standards and accuracies. It will be up to the owners to specify this when seeking calibration, but as the time (and therefore the cost) to complete testing is likely to be similar for both old and new versions, the change to the latest requirements is a sensible move for all who have invested in new meters meeting the latest requirements.

1 Technical Guide NPL Acoustics 2004/1 Edition 2 is available as a download from www.npl.co.uk/acoustics/techguides/

2 See UKAS publication TPS 49 *Interim arrangements for IEC 61672 Sound Level Meters – Period Tests,* which is available as a download from www.ukas.com

3 Full details are given in the Schedule of Accreditation at www.ukas.org/calibration/schedules/actual/0653CcalPerm_005.pdf

Eurlng Richard Tyler CEng, FIOA, FIEE is with AV Calibration Ltd

Commons Written Answers

17 March 2005

Speed cameras and speed humps

Mr Greg Knight: To ask the Secretary of State for Transport what assessment he has made of the environmental impact of speed humps, with particular reference to *(a)* air pollution and *(b)* noise pollution; and if he will make a statement.

Mr Jamieson: The Department has commissioned a number of research projects in recent years to assess the environmental impact of road humps. The research has indicated that emissions from individual vehicles may increase with the implementation of traffic calming measures, due to increased driver acceleration and deceleration. However, the reduction in the volume of traffic within traffic calming schemes usually means that the overall changes in air quality are roughly neutral.

After the installation of road humps and speed cushions, research has shown that the maximum noise levels from light vehicles (cars) are reduced, as is the overall traffic noise level when light vehicles form most of the traffic stream. However, the effect on noise from large vehicles is more complex. While there are some decreases in maximum vehicle noise levels from large commercial vehicles due to reductions in their speeds, this can be offset by increases in noise from the bodywork of such vehicles as they pass over the humps and cushions. The net effect of these measures on the overall traffic noise depends on the proportion of large commercial vehicles in the traffic stream, and on the type of road hump installed.

'The environmental impact of road humps has to be considered against the need to improve road safety'

The environmental impact of road humps has to be considered against the need to improve road safety. Around 3,500 people are killed and a further 34,000 are seriously injured on our roads every year. Nearly 2,400 of these casualties are child pedestrians. Compliance with speed limits would reduce these unacceptable numbers, and experience shows that traffic calming measures such as road humps have significant safety benefits.

17 March 2005

Heathrow Airport

John McDonnell: To ask the Secretary of State for Transport what process would need to be pursued *(a)* to amend and *(b)* to delete the environmental mitigation measures on airport operations at Heathrow under the Cranford Agreement.

Charlotte Atkins: Any proposals to amend or abandon the existing noise amelioration operations at Heathrow under the Cranford Agreement would need to be subject to a full environmental appraisal, public consultation and ministerial approval. Any agreed changes would then need to be reflected in operational instructions in the NATS Manual for Air Traffic Services.

Commons Adjournment Debate

4 March 2005

John Cryer (Hornchurch) (Lab): Let me now continue with whingeing gits day, as I affectionately refer to these Adjournment Debates. Like most Members, I have a number of constituency issues to raise. The first relates to the channel tunnel rail link, which runs through the south of my constituency, through Rainham. The Bill that paved the way for the link took many months to complete its passage in the House, and that is part of the problem with which a number of my constituents are living today.

A baffle has been erected between the houses of some of my constituents and the new channel tunnel rail link but, between the baffle and the houses, is a smaller railway line used by c2c on the London, Tilbury and Southend line, which goes through my constituency and ends in that of the hon. Member for Rochford and Southend, East. The problem is that the noise from the smaller, suburban line reverberates off the baffle. The noise level has actually got worse since the baffle was erected.

Union Rail, the main contractor, has refused to do anything about this; it has refused to change the design and structure of the baffle. The problem originated in this place, in that these issues were not properly addressed when the Bill to create the channel tunnel rail link was going through Parliament - there should have been specific measures in the Bill on how these baffles were to be constructed - but Union Rail is now being obstructive about the problem.

'The noise level has actually got worse since the baffle was erected'

24 March 2005

Channel Tunnel Rail Link

Jonathan Shaw: To ask the Secretary of State for Transport pursuant to his letter of 22 December 2004 to the hon. Member for Chatham and Aylesford in respect of residents living near the channel tunnel rail link, when he will provide a full reply to the issues raised.

Mr McNulty: Department for Transport officials are working with the Department's advisers and Union Railways on possible options for a compensation model for residents concerned about the noise and vibration impacts arising from the operation of the channel tunnel rail link at the North Downs tunnel. However, this is a complex matter which needs to be given careful consideration. I hope to write to the hon. Gentleman soon setting out our proposals to resolve this issue.

7 April 2005

Fireworks

Ms Walley: To ask the Secretary of State for Trade and Industry what discussions she has held with the RSPCA on ways of restricting *(a)* the sale and *(b)* the use of noisy fireworks; and if she will make a statement.

Mr Sutcliffe: In developing the *Fireworks Regulations 2004*, which, among other things, places restrictions on the sale and use of noisy fireworks, officials met with animal welfare representatives, including the RSPCA. All animal welfare organisations were also consulted formally on the proposed measures during the summer of 2004.

More recently, officials have met with the RSPCA to discuss the current noise levels of fireworks (as set out in the 2004 Regulations) and possible ways to achieve further reductions in sound levels.

Hearing loss

Mrs Brooke: To ask the Secretary of State for Defence what assessment his Department has made of whether an additive relationship exists between noise-induced hearing loss and age-related hearing loss; and if he will make a statement.

Mr Caplin: The Ministry of Defence's clinical practice in this area is based on publicly available knowledge that an additive relationship does exist between noise-induced hearing loss and age-related hearing loss. This is based on information in the following references:

King P F, Coles R R A, Lutman M E, Robinson D W (1992) Assessment of Hearing Disability, Whurr Publishers, London;

Coles R R A, Lutman M E, Buffin J T (2000) Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes. *Clin. Otolaryngol.* *25*, 264–273;

Copies of these will be placed in the Library of the House.

Mr Heath: To ask the Secretary of State for Defence how many members of the armed forces are recorded as having sustained noise-induced hearing loss on service in Iraq since March 2003.

Mr Caplin: *[holding answer 4 April 2005]:* Information on specific injuries sustained on Operation Telic is not held centrally, and could be provided only at disproportionate cost.

BOOK REVIEW

'Managing Noise and Vibration at Work - A practical guide to assessment, measurement and control'

by Tim South

This is a very useful and well laid out handbook, running to 240 pages plus appendices. The primary purpose of any handbook aimed at clarifying regulations, and assisting in their implementation, is fulfilled if the book is more readily understood than the regulations themselves. The author draws on his wide experience of noise and vibration consultancy in industry, and on the practical aspects of the course he teaches both at Leeds Metropolitan University and for the Institute of Acoustics, and succeeds admirably.

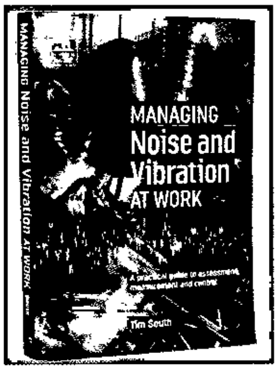
The book was prompted by the imminent incorporation into UK law of the EU 'Physical Agents' Directives governing the exposure of working people to noise, hand-arm vibration (HAV) and whole-body vibration (WBV). In order to meet their legal obligations employers will soon have to assess noise and vibration levels on their premises and provide whatever personal protection is necessary for their employees. Because they must also monitor, and if necessary, reduce the risks then a degree of competence in the measurement of noise and vibration will be required.

The author deals with the three related topics in three separate sections covering noise, hand-arm vibration, and whole-body vibration, then proceeds to a fourth section on reducing the risks. This division of sections works very well: the first two follow similar plans, with introductory chapters called *Noise and how it behaves* and *Fundamentals of vibration*. The human response to the noise or (hand-arm) vibration is then considered, and methods of measurement are described. The appropriate doses and limit values are then discussed, and a final chapter in each of the two sections provides a straightforward guide to assessment of the 'physical agent' in the workplace.

The chapters are clearly set out in language well calculated to suit the intelligent layman, with simple line diagrams, helpful graphs and a few black-and-white photographs. Most chapters end with at least one case study, in which the points discussed are explored and illustrated in order to consolidate the reader's understanding of the topic.

The third section, on whole-body vibration, is only 20 pages long because it avoids the repetition of relevant material already covered. It nevertheless deals concisely with the effects of WBV and the measurement and assessment of exposure as it might affect drivers and others. In this section and elsewhere the author has carefully balanced the requirement for mathematical treatment with his readership's general aversion to equations on the printed page.

The fourth section of the book begins with a chapter on the management of controls on noise and vibration exposure. This addresses the costs involved, illustrating the author's empathy with the reader who would like to introduce control measures but may be prevented from doing so by economic considerations. The various ways in which exposure can be reduced are dealt with, then the following chapters cover noise control by

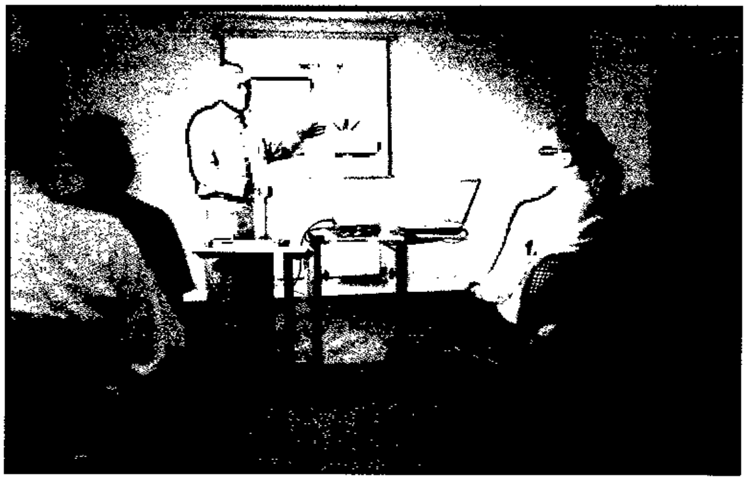


engineering means, the provision and use of hearing protection, the reduction of hand-arm vibration risks, and the control of whole-body vibration exposure.

The Appendices contain useful reference data, apparently selected on the basis that the book will be used as a day-to-day tool. Useful summaries of the action levels in the 1989 Noise at Work Regulations, the new exposure levels in the Physical Agents (Noise) Directive (which has since come to be referred to as the Control of Noise at Work Regulations), and the Physical Agents (Vibration) Directive are provided, together with a glossary of symbols and abbreviations. There are another 19 worked examples, a bibliography and a concise index.

This 'one-stop' reference succeeds in being useful to those who wish to consolidate their existing knowledge, but also forms a good introduction to the subject matter for first-timers.

Ian F Bennett BSc CEng MIOA



Lorient's new CPD seminar has all the sound answers

In meeting new acoustic regulations for doors

The 2003 amendments to Approved Document E of the Building Regulations for England and Wales mean that, for the first time, the acoustic performance of door assemblies must be taken into account in building design. For 'dwelling-houses, flats and rooms for residential purposes' a rating of 29dB R_w must be attained, and for schools the requirement is a minimum of 30dB R_w.
In response to strong demand, **Lorient Polyproducts**, manufacturer of fire, smoke and acoustic sealing systems for doors, has launched a new CPD-certified seminar entitled *Performance door design: the basics of sound reduction*.
The one-hour session comprehensively covers all the information needed to help specifiers confidently meet requirements of the new Regulations.
The presentation includes information on understanding the nature and movement of sound, the effective design of door assemblies for acoustic containment, acoustic testing procedures and standards, and regulatory requirements.
It also tackles the important area of design conflicts arising out of the need to achieve acoustic containment alongside fire and smoke containment, while still maintaining easy operation of the door, and ensuring durability of the chosen solution. Lorient offers practical examples and presents solutions for typical applications.
The seminar is presented by Phil Cavalier, the company's specification and projects manager, who brings years of experience in the door industry to his engaging presentations, which are well-known among specifiers throughout the UK.
The seminars are offered free of charge, and all attendees will be awarded a certificate for one hour's Continual Professional Development. For more information, or to arrange a seminar, contact Lorient on 01626 834252, or e-mail cpd@lorientuk.com

Managing uncertainties in noise measurement and prediction

This International-INCE symposium organised by INCE/ Europe and CIDB will take place in Le Mans (France)

27-29 June 2005

The following five main topics will explore uncertainties through 125 papers and discussion sessions:

- **Instrumentation**
- **Environment/Transport/Traffic**
- **Building and Construction Products**
- **Machines, Vehicles and Sources**
- **Occupational Noise**

Participants will have the opportunity to visit the Le Mans 24-hours racing circuit and automobile museum as well as its medieval town and cathedral.
Le Mans is 55 minutes from Paris by TGV.

For further details of papers and registration information visit www.uncertainty-noise.org

UKAS-accredited testing for new IEC standard sound level meters

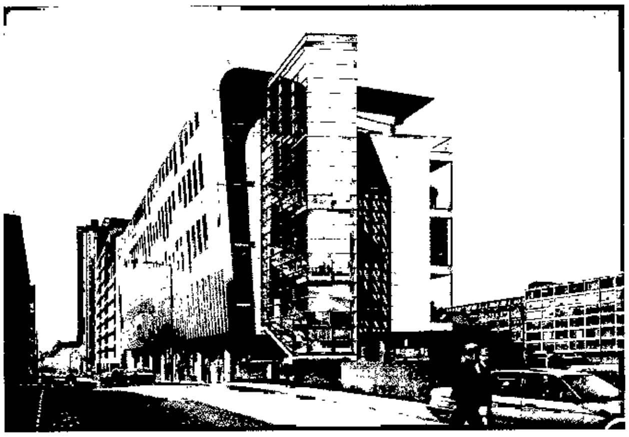
UKAS-accredited periodic testing of instruments designed to meet the new IEC 61672-1 standard for sound level meters is now available for the first time in the UK from **AV Calibration Ltd**.
Since the old standards for sound level meters (IEC 60651/BS.5969 and IEC 60804/BS.6698) were withdrawn in 2002, no UKAS-accredited verification for meters claiming to meet only the new standard, IEC 61672-1 has been available, as no standard test procedures have yet been published. BS.7580 gives such procedures only for meters designed in accordance with the old standards, and continues to be valid for these.
In 2004, UKAS, in conjunction with the National Physical Laboratory, drew up a Technical Guide similar to BS.7580, but with tests tailored to the requirements of IEC 61672-1. This opened the way to achieving UKAS-accreditation in the interim period.
AV Calibration Ltd is the first calibration laboratory to be awarded UKAS accreditation for periodic testing in accordance with *Technical Guide NPL Acoustics 2004/1 Edition 2* for Class 1 and Class 2 sound level meters originally manufactured in accordance with IEC 61672-1: 2002 (BS EN 61672-1:2003).
Prices for testing using the new Technical Guide will be the same as for verification using BS.7580, which will continue to be available for older instruments. The aim is that most instruments will be calibrated in seven working days.
Further details: Richard Tyler,
tel: 01462 638600 fax: 01462 638601
e-mail: lab@avcalib.co.uk

The (acoustic) power of crystals

Silence noisy neighbours with white moonstone

The following was spotted in a 'serious' publication by a member (it was the *Daily Express*, so his identity will not be revealed).
Apparently, because moonstone is a symbol of love and confidence, it will spark one's intuition and help to find creative ways to solve potentially insurmountable problems.
It calms emotions, soothes stress, and helps prevent over-reaction to difficulties. So far, so good, albeit rather questionable to the more cynical among us.
However, the article goes on to recommend holding a white moonstone in the hand for several minutes, and asking it to silence unwanted noise and disturbance. The stone should then be placed beside the boundary of the noisy neighbour's property, resting on the ledge of a fence or tucked into a crack in the wall. Flat dwellers should place it on the floor next to an adjoining wall where it will not be disturbed.
The wish for peace has more power on a night when the moon is waning. Within a few days, we are told, intrusive noise lessens and serenity takes its place.
Alternatively, you could try chucking the stone through his b***** bedroom window.

Planners approve BDP's new northern HQ



BDP has received planning approval from Manchester City Council for its new northern headquarters building on Ducie Street, which is being developed by Town Centre Securities plc.
Situated along the Piccadilly canal basin's southern edge, the building will be used exclusively by BDP's Manchester team and will accommodate up to 275 employees.
Town Centre Securities chairman and chief executive Edward Ziff expressed his delight that this development, a major commercial element of the overall scheme and a catalyst for regeneration, could now proceed.
The six storey building will provide large open plan studio space and ancillary accommodation, including a 'linear hub' at ground floor level which will incorporate an interactive area including café, staff restaurant and extended reception space.
The building blends with existing structures, having a punctuated stainless steel façade to Ducie Street which rises to form the roof of the building and contains the studio areas.
By contrast, the canal side elevation is transparent to take advantage of north light and provide a suitable backdrop to the wider basin area. Circulation between floors is achieved via a dramatic cantilevered glazed staircase, located above the Ashton Canal spur.
The site lies within Town Centre Securities' Piccadilly Basin master-plan and was selected by BDP following an exhaustive search of suitable locations within central Manchester. The building provides 10,000 m^2 of sustainable office accommodation and will be naturally ventilated and night time cooled to assist in achieving an 'excellent' BREEAM rating.
BDP's multi-disciplinary appointment includes architecture, interior design, all engineering professions, lighting and acoustics. AYH is quantity surveyor.
The project is expected to start on site in early 2006.

Noise Action Week

23 - 27 May 2005

Noise Action Week runs from Monday 23 to Friday 27 May 2005. It provides an opportunity for everyone involved in the management of noise issues to raise awareness of the services they provide to deal with noise, and to publicise the simple measures which individuals can take to solve problems of neighbour noise.
The week of action aims to:

- *Promote practical solutions to everyday noise problems;*
- *Promote communication and consideration between neighbours;*
- *Support local authorities, housing organisations, mediation services and others in informing the public about the services available to tackle noise problems;* and
- *Educate and inform noise makers and noise sufferers about the noise reduction remedies available.*

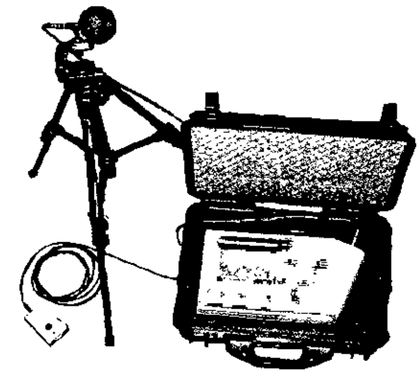
Last year's Action Day has expanded to an Action Week in order to give participants more flexibility in when and where they get involved.
More information appears on the web site at www.noiseactionweek.org.uk

NOISE ACTION WEEK
23 - 27 May 2005

Campbell Associates

New digital annoyance recorder

The **Norsonic** *NOR 121AR 'Light'* has been launched as the latest and most advanced tool in the fight against noise nuisance and anti social behaviour.
The instrument has been developed specifically to deal with annoyance recording and is a leaner, simpler and more cost effective version of the original *NOR 121AR* digital noise nuisance recorder so beloved of environmental health officers across the country.
The *'Light'* comes complete with a robust and secure carrying case so that the device can be left with complainants to activate as and when the noise nuisance arises.
All recordings are date and time stamped within the instrument without external devices being required.



Features of the new version now incorporated in the base price include full fidelity 'DAT quality' recordings, dedicated post-processing software for the user's own PC, an internal media player for professional audio playback through a PC, an integral rechargeable battery, and a 1Gb compact flash card for data transfer.
The testing and trials in the field that the unit's 'older brother' has undergone over the last three years have established a reputation for accuracy and reliability.
The latest (4.0) software release makes operating the device simple and straightforward with no requirement for specialist knowledge. It enables rapid review of recordings and consequently reduces the time spent collecting evidence personally on site.
Targeting the recorder specifically at annoyance and noise nuisance has meant that many features of the full Environmental Health version, redundant in annoyance recording, have been dropped allowing a significant reduction in price.

Further details: John Campbell,
tel: 01371 871033
e-mail john@campbell-associates.co.uk

Bruel & Kjaer

Latest PULSE innovations

With the introduction of *PULSE X*, **Bruel & Kjaer** has expanded its PULSE PC-based sound and vibration analyser system.
This new measurement solution delivers innovative and unique technologies for safer, more productive operations, standardised data management, and product problem resolution.
PULSE X's revolutionary Dyn-X 6-channel and 12-channel input modules boost measurement performance and accuracy over an extreme dynamic input range - for the first time - 160dB. The measurement performance and accuracy of Dyn-X matches or outperforms the capacity of today's high-quality transducers.
The technology eliminates the need for an input attenuator for ranging the analysis system input to the output of the transducer. Users no longer need protect their measurements from overloading or under-ranging, and can be concerned only with selecting the right transducer for the measurement.

First time accuracy

Dyn-X is therefore ideal for applications where an accurate measurement has to be right first time, or where many different transducers and unknown signal levels are involved, for example in crash testing, destructive testing, and rotating machinery (run-up and coast-down). Cutting-edge aerospace and automotive applications will benefit from the innovative real-time digital signal processing algorithms, combined with state-of-the-art analogue conditioning to achieve the utmost quality and accuracy gains.
The new technology is also well suited to time-limited applications such as test cells, wind tunnels, road testing and flight testing, as well as to high-dynamic applications such as structural measurements, impulsive testing, room acoustics and electroacoustics. Minimal user interaction is necessary for field or road testing, reducing the skill level required for production line testing. Time and money can be saved because trial runs, overloads and the necessity to re-take measurements become things of the past.

Advanced SPC solution

A further innovation in *Pulse X* is an advanced source path contribution (SPC) solution with the emphasis on usability, data management, and source-path-receiver model management. Brüel & Kjaer provides complete solutions, combining dedicated transducers for measurement of operating and body characteristics with instrumentation and signal processing platforms, contribution analysis, and vehicle target management. Which, says the company, allows NVH automotive engineers to comprehend and analyse structural and airborne contributions in vehicles, and also to tune and design sound and vibration contributions according to particular design parameters.
A new user interface coupled to *PULSE Data Manager* provides a framework for an hierarchical vehicle NVH model that reflects the physical structure. An additional benefit of this approach is that targets can be allocated at each point in the model, providing a platform for target cascading and verification.
Finally, users who prefer to record time data and postpone their analysis decisions will appreciate the new, stand-alone multi-channel data recorder. This provides an economical replacement for instrumentation tape recorders for in-vehicle or portable recording, from one to hundreds of channels, with a user interface optimised for ease-of-use and productivity. The data recorder can be used directly with *PULSE X* portable front-ends, and the time files post-processed either in the field or back in the office.
Further details: Nicola Parker,
tel: 01438 739000. fax: 01438 739099.
email: ukinfo@bksv.com
website: www.bksv.co.uk

Sound Reduction Systems

Acoustic insulation guide published

The latest brochure from **Sound Reduction Systems Ltd** details acoustic solutions for commercial, educationa and industrial environments. 3D diagrams highlight common sound paths within these areas, and direct the customer to the relevant product section within the document.
Products detailed include: *Soundblocker*, acoustic suspended ceiling tiles; and the high performance acoustic barriers, *Soundstop* and *Soundbar*.
The new brochure can be used as an acoustic guide, and referred to every time the customer is confronted by an acoustic problem within these environments.
For your free copy, please phone 01204 380074 or visit the website www.soundreduction.co.uk

ANV Measurement Systems

Rion's three-channel human vibration meter now available

The **Rion** *VM-54* will be available from the end of May 2005. This three-channel portable meter is used with program cards for measurement of hand arm vibration (VX-54HA), whole body and building vibration (VX-54WB), FFT (VX-54FT) and ship vibration (VX-54WS).

This easy-to-use meter incorporates two clear illuminated LCD displays. The main display shows the measurement results whilst the sub-display shows the input channel signal conditions or FFT values (when used with the VX-54FT program card). Designed with open architecture, the VM-54 can potentially be used with most Rion or other manufacturers' charge or line-drive accelerometers.

Used with the tiny (4.7 gram) Rion *PV-97C* or slightly larger (28 gram) Rion *PV-93* triaxial accelerometers the *VM-54/VX-54HA* achieves all the current hand-arm vibration measurement standards (BS EN ISO 5349 Parts 1 & 2) and ISO DIS 8041: 2003.

The whole body version (*VX-54WB*), to be released in October 2005, will be of special interest to consultants and local authorities involved in environmental vibration (BS 6472). The UK model will incorporate frequency weightings W_g, W_b, W_d, W_m, W_k, W_c and W_j independently selectable on each channel.

The instrument, which can be set to log VDVs as easily as using a logging sound level meter, can be used to measure VDV vibration levels in accordance with the current (1992) version of BS 6472 and in accordance with the anticipated amendment to BS 6472 (the use of W_b instead of W_g to measure vertical vibration levels). Used with the practical *Rion-83CW* triaxial accelerometer the *VM-54/VX-54WB* is also fully compliant with ISO 2631 Parts 1 and 2. Used with the *Rion PV-62* seat accelerometer the instrument is also fully compliant with ISO 2631 Part 4.

Used with the *Rion PV-83CW* for floor measurement and the *Rion PV-57* for wall measurement the *VM-54/VX-54WS* is fully compliant with ISO 6954 for the assessment of ship-board vibration.

ANV Measurement Systems are sole UK distributors for Rion sound and vibration instruments and would be pleased to answer questions on the *VM-54*, or any of the manufacturer's sound and vibration products.

Further details: tel: 01908 642846, fax: 01908 642814, www.noise-and-vibration.co.uk

British Gypsum

Think sound - think blue!

This is the latest message from UK plasterboard manufacturer, **British Gypsum**, following a move to standardise the face colour of all products in the company's *Gyproc SoundBloc* acoustic board range.

This is now the fastest growing product group in the company's performance board range, following the introduction of new Part E Approved Document for housing, and recently-changed PPG3 Planning Density Regulations, which have increased the demand for acoustic separation in and between dwellings.

The high performance boards are being used by many housebuilders to improve the performance of existing internal and separating wall constructions in order to meet the new standards. The blue face colour will now make it easier for site agents and planning personnel to identify the boards by sight once installed on the project.

The new blue colour facing is being applied to all products in the range, including a *Gyproc SoundBloc Rapid*, a special sized board designed for use in GypWall Rapid, the housing partition system designed to achieve the 40dB Part E requirement for internal walls without an insulating quilt. It will also be applied to the moisture resistant versions, *Gyproc SoundBloc MR* and *Gyproc SoundBloc Rapid MR*, which are widely used for areas such as bathrooms and kitchens. They are also increasingly being used where installation is required before the building is fully weather tight, in order to speed up the build programme.

According to the company's housing sector manager, Stacey Davis, under the new Part E requirements, there could be significant penalties for housebuilders who inadvertently use the wrong lining board. As the distinctive new blue facing will be easily identified on site, it could help to prevent potentially expensive mistakes.

Further details: Paul Smith, tel: 0115 945 1938 fax:0115 945 1111

Frogbox

Synergy in refrigeration and air-conditioning

Retail systems provider, **Frogbox**, has launched a unique product which integrates refrigeration and air conditioning plant within a single compact housing. The new range is offered under the brand name *Synergy*, reflecting the fusion of two applications.

Although *Synergy* has been designed specifically for small supermarkets, convenience and forecourt stores, licensed premises, hotels, restaurants and fast food outlets, it is equally effective in any environment using both heating and cooling technologies. It has been developed to eliminate the inherent drawbacks of heat pump technology in winter months and dramatically increase efficiency.

This is achieved, in part, by eliminating the need for outdoor coil defrosting and reliance on any supplementary heating, which is a standard feature of conventional heat pump systems. In short, the heat generated by the refrigeration plant is used, rather than wasted, in order to increase the overall efficiency of the combined system. This provides continuous heat, stable environmental conditions, and lower energy bills. The output is often sufficient to provide domestic hot water or heat for door air curtains.

Frogbox engineers have challenged conventional thinking to overcome the disadvantages associated with heat pump systems. The new condenser and heat exchanger design doubles heat pump efficiency, and the 'one box' solution reduces capital and installation costs.

In many commercial outlets located in urban areas, air-conditioning is only operated during daytime hours, because of noise implications. As standard, *Synergy* is housed in a Frogbox acoustic enclosure, allowing refrigeration and air-conditioning to run in tandem 24 hours a day. The enclosure may be sited in locations considered inappropriate for conventional plant and machinery. The appearance of the enclosure may be altered with a range of colours and finishes, including mock brickwork, corporate branding or promotional advertising.

Further details: tel: 01622 772433 fax: 01622 772434

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2 June
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7 June
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14 June
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16 - 17 June
Diploma Examinations

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Research Co-ordination
London

23 June
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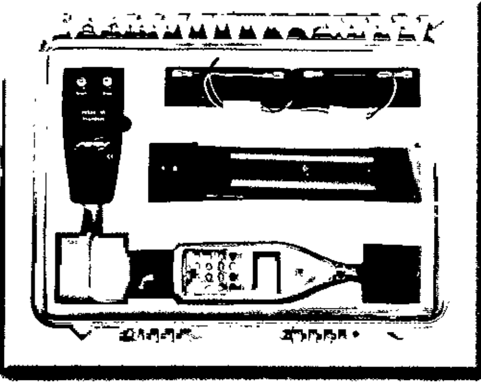

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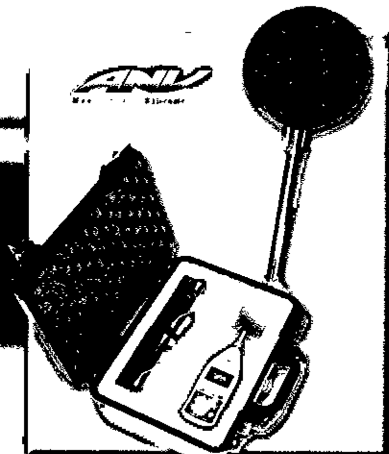

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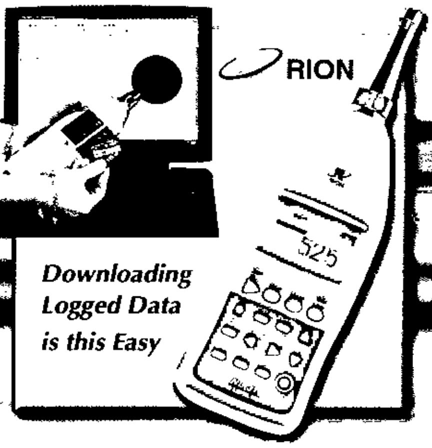

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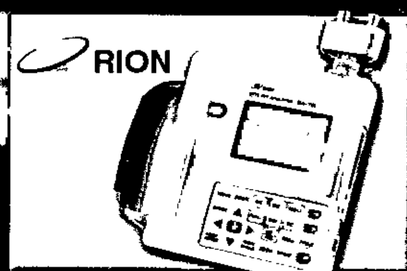

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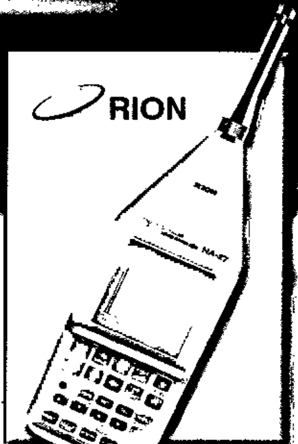

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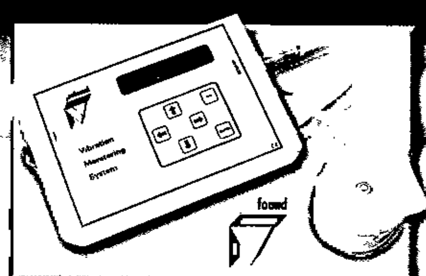

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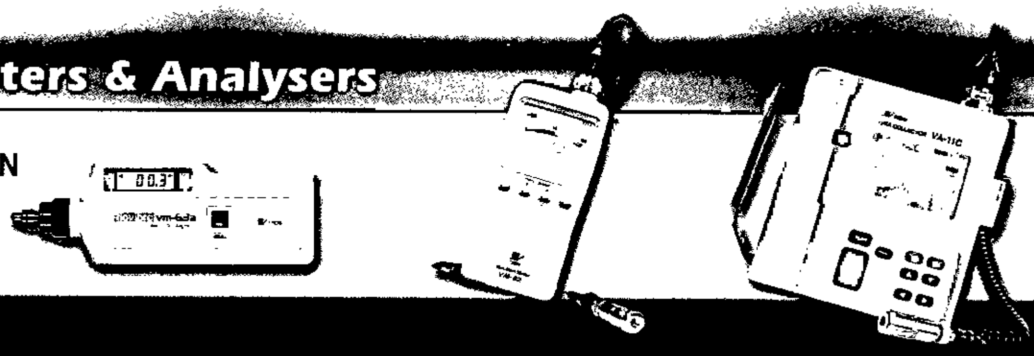

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