Acoustics Bulletin

July 1989 Volume 14 Number 3

INSTITUTE OF ACOUSTICS

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Acoustics Bulletin

July 1989 Volume 14 Number 3

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Tel: (0272) 741640 Fax: (0272) 737116

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Reading RG6 2AY

Published by:
The Institute of Acoustics
5 Gombards
St. Albans
Herts. AL3 5NW

Printed by:
Newnorth-Burt Ltd
College Street
Kempston
Bedford MK42 8NA

Single copy £6.00

Annual subscription (4 issues) £22.00

ISSN: 0308-437X

ABC
MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS

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The Institute of Acoustics was formed in 1974 by the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is now the largest organisation in the United Kingdom concerned with acoustics. The present membership is in excess of one thousand and since the beginning of 1977 it is a fully professional Institute.

The Institute has representation in practically all the major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental acoustics, architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration.

MEMBERSHIP DRIVE

The Institute of Acoustics was formed in 1974 by the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society, and now represents the largest single organization concerned with the profession of acoustics in the UK. Membership is currently in the region of 1500.

Members are drawn from most of the major educational, industrial, planning and consultancy establishments, and their areas of expertise include: aerodynamic noise, architectural acoustics, auditory acoustics, building acoustics, electroacoustics, engineering dynamics, environmental acoustics, infra- and ultra-sonics, musical acoustics, noise and vibration, physical acoustics, speech, transportation and underwater acoustics.

Branch and Group activities are available to members on a wide geographical base, as well as Spring and Autumn Conferences, the proceedings of which are published. This regular programme of conferences, day meetings and short courses on all aspects of acoustics ensures up-to-date dissemination of information, for which members qualify for reduced registration rates.

The Institute offers a Certificate of Competence in Workplace Noise Assessment and a Diploma in Acoustics and Noise Control. Courses are available at approved colleges and universities; a distance-learning video scheme is also available. Undergraduate and postgraduate courses in acoustics are also offered at the Universities of Heriot-Watt, Salford and Southampton. The Institute is an Engineering Council institution-affiliated body and offers routes to professional engineer (CEng) and incorporated (IEng) status.

By being a member you are not only supporting the profession of acoustics by belonging to an exclusive group of people, but you are also helping indirectly to secure a future livelihood. The Institute provides and stimulates the education and training of acousticians, gives status with its membership grades and designatory letters, provides a forum for meetings and the exchange of information, is a vehicle for public comment and by providing professional accreditation so generates manpower for the industrial base. Without the profile provided by the Institute there could well be fewer opportunities for consultancy, hardware and equipment sales, research and teaching.

Please note that the subscriptions paid by members joining during the last quarter of 1989 will be valid throughout 1990, that lapsed members will be granted an amnesty and need only pay a combined rejoining fee/subscription of 50% for 1989. Also be aware that some new professional benefits have recently been introduced by Council. These include the non-corporate grade of AMIOA, and special exemptions for corporate members wishing to obtain the Certificate of Competence.

Chris Rice

NEW ELECTIONS

The following elections to corporate and non-corporate Membership of the IOA have recently been approved by Council.

Fellow

S C Bennett	W K W Hong	E J Simmonds	P D Wheeler
F J Fahy	H G Latham		

Member

A S Anderson	J C K Chung	C F Kwan	A W M Somerville
P T Bassett	G R Coleman	Y W Lam	M K Tai
P J Bailey	C Gower	T Moran	M E Westcott
R J Brind	J A Harrison	R Muir	S W Wong
J M Burrows	S A Heaton	A Rupkus	S Yates
J Chapman	S Kurra	H S Sagoo	

Associate

C M Alston	C M Dawson	D G Jones	C M Pink
P R Anderson	P J Dawson	G H Jones	N Pilling
G D Aveyard	G C Edwards	R Kirk	B Rochester
T Bannigan	M G Esom	R C Klein	J A S Salter
S M Beaghan	L J Fawthrop	A D Laidlaw	M C Selley
F C Blyth	M J Henery	L Leadbeater	N J Shaw
A Bourlet	J A Herman	C P S Ling	P Slinger
T J Braund	J G Hilton	S Looser	M A Stagg
S R Butler	M P Hollier	L McLintock	H M Thornton
M C Checkley	R N Hunter	P G Michel	S J H Wain
I J Cook	P T Jackson	D J Osborne	P D Ward
S J Daniels	S Jackson	S Payne	P Whitaker

Associate Member

The following recommendations for this new grade of Membership were confirmed by Council on 1 June.

N J H Alexander	F C Blyth	J R Pyke	S M Summers
D K Anthony	W J Davies	M Roberts	A N Woodger
N Antonio	F S Gillan	C P Stollery	

Student

K A Wallace

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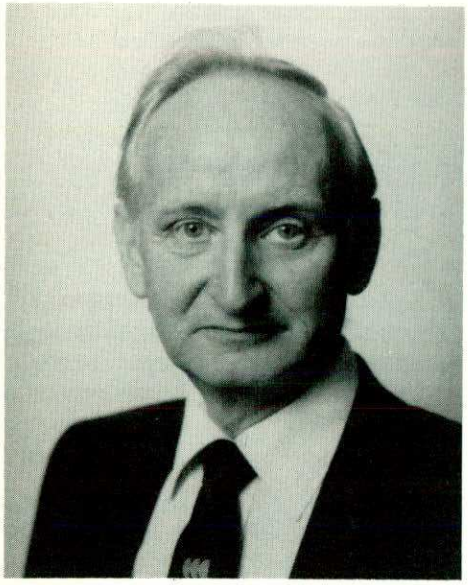


President's Letter

Dear Fellow Member,

Council is preparing a business plan for the future growth of the Institute, and part of this is to increase our numbers of Sponsors and Members. The larger the membership core the more stable will be our financial base and the better the services that can be provided. Please help us to maintain and increase our level of activity by taking part in this recruitment drive.

I am therefore writing to inform you of ways in which you can help to recruit new members. For example, perhaps you could encourage your immediate colleagues to join, as their long-term acoustical interests are probably similar to your own, or even persuade them to rejoin if their membership has lapsed? Also do not forget that the people you meet from outside organizations in the normal course of your work might similarly be encouraged.

Most important however, is the need to expand our industrial base, so please encourage your commercial contacts as well as your employer to become Sponsor Members.

The advantages of both Membership and Sponsor Membership, which have just been extensively revised, are given elsewhere in the Bulletin. *With a little effort on your part we could easily achieve a significant increase in the level of fixed funding for the Institute.*

By being a member you are not only supporting the profession of acoustics by belonging to an exclusive group of people, but you are also helping indirectly to secure a future livelihood. So, please ask yourself: 'What can I do for the Institute?', rather than demand: 'What is the Institute doing for me?'

I do hope you will be able to help.

Chris Rice

Book Review

Speech Recognition by machine 1988

W A Ainsworth
Published by Peter Peregrinus Ltd., 1988, £35.00

This book is no. 12 in the IEE Computing Series, and seems to be primarily aimed at those with a background in electrical engineering. It sets out to present the various strands in speech recognition research, both historically and at the present day.

The style is clear and readable, but misprints abound (my favourite being on p. 79: 'The control structure decides how to use the knowledge available in the base. It produces interferences from this knowledge.'). While the second chapter (on phonetics) is much less satisfactory, chapters 4 to 7 inclusive form a core of very useful material. These core chapters are each presented in three parts: signal processing, pattern processing, and knowledge processing. There is a generous number of diagrams, which considerably aids understanding (apart from the consistent misspelling *syntatic*). The general approach is that of a quick tour through every avenue of research. An explanation is given of the principles behind each method, setting out its salient features, and advantages and disadvantages in relation to other methods. This type of background material is indispensable for anyone new to the field, and is not as easily (if at all) available elsewhere. In this sense, the book certainly fills a gap, and would be a useful acquisition for those beginning work in, or teaching courses on, speech recognition.

The first chapter, 'Introduction', defines automatic speech recognition and indicates the type of situation in which it would be useful.

Chapter 2, 'Speech production and perception', is something of a disappointment. Space limitations no doubt dictated a most cursory treatment of phonetics. However, one might have expected some consideration of such topics as: the reduction and deletion of unstressed vowels, the variation introduced by coarticulation and assimilation, and the range of structure-dependent allophonic variation. In general, the somewhat simplistic approach fails to address the question of loss of phonetic and phonemic distinctiveness, and so runs the risk of conveying the impression that the ultimate object of the search – the phoneme, however defined – is an unchanging and reliable entity. It may well be possible for a phoneme-based speech processing algorithm to hypothesize (for example) a [p] with one hundred per cent accuracy; but this is of limited value if one does not know what then to do with that [p].

The third chapter, 'Problems of automatic speech recognition', first gives a history of speech recognition research that provides a useful summary, then considers the units of speech recognition and briefly sketches some causes of variability and ambiguity.

Chapter 4, 'Techniques for processing speech', is the beginning of the core section of the book, in which there is a much wider breadth of coverage. There are presentations of analogue-to-digital conversion, short-term frequency analysis, discrete Fourier transforms, filter banks, autocorrelation analysis, cepstral processing, and linear prediction analysis, under the heading of 'Signal processing'. Under the heading of 'Pattern processing', the author outlines pattern classifiers, correlation, discriminant analysis, nearest-neighbour classifiers, probabilistic classifiers, multidimensional scaling, dynamic programming, cluster analysis, hidden Markov models, adaptive networks, and syntactic pattern recognition. Under 'Knowledge processing' there are brief descriptions of intelligent knowledge-based systems, various knowledge sources, and types of system organization. Too little space is available in the book for a full treatment of each one: the strength of the approach lies in the juxtaposition of different methods which can thereby be more easily assessed in relation to one another.

The fifth chapter, 'Speech-recognition algorithms', is laid out in the same tripartite manner. Under 'Speech analysis', the author deals with spectral analysis, formant tracking algorithms, fundamental frequency estimation, endpoint detection, noise compensation, reverberation reduction, and vector quantization. Under 'Speech pattern matching' one finds time normalization, codebook recognition, statistical modelling, speaker independence, connected-word recognizers, sub-word pattern matching, and large vocabulary systems. Under 'Speech-understanding systems' are grouped blackboard systems, controller systems, and integrated systems. In general, this chapter attempts to show how speech processing algorithms, such as those described in the previous chapter, may be applied to the task of speech recognition, with some indication of performance.

Chapter 6, 'Architectures', considers the hardware implementation of the algorithms described in chapter 5. Under 'Preprocessing hardware' there is a brief discussion of analogue preprocessing and digital hardware. Under 'Dynamic programming processors' there are descriptions of multiprocessor systems and systolic arrays. Under 'Knowledge-based systems' are grouped a consideration of computational requirements, systolic machines, (computer) language-oriented machines, parallel machines and networks of processors (e.g., Boltzmann machines). This chapter (like the previous three) is written on the assumption that the reader has a firm background in electrical engineering. However, it may profitably be read by others without this background, because of the clarity of the text and the abundance of diagrams.

The seventh chapter, 'Performance assessment', is commendably rooted in the real world of less-than-perfect speech recognizers. It describes different performance measures, and also considers databases for use in assessment. It outlines some desiderata for hardware specifications and performance, and for overall system performance. This chapter is necessarily short and speculative, as little work has been done in this area to date.

Chapter 8, 'Applications', outlines some actual and potential uses of automatic speech recognition, and considers the factors influencing its introduction. Some types of application are sketched out. A useful and interesting feature of this chapter is its collections of actual examples of recognizers in use. The question of human factors is rightly considered in comparative detail.

The ninth and last chapter, 'The future', is a brief conspectus of what has been achieved so far, and what remains to be achieved. Some current lines of research are outlined, together with their characteristic problems.

This book is by no means an in-depth study of any aspect of speech recognition. Its value lies in the telling summaries of many strands of research, which make clear the justification for each and the problems encountered by each. The wealth of references will also prove useful to those wishing to explore a topic in more detail. However, inasmuch as the technological aspect of speech recognition today can be covered in one book, this book may well be it.

Briony Williams

Acoustics '89

Report on the 1989 Spring Conference

Acoustics '89 was held at University College, Oxford in our customary academic setting, and despite the rain, snow, car parking and minor organizational problems, was generally considered a success. The technical papers covered a wide range of topics in three parallel sessions and attracted our normal quota of overseas delegates. From the conversations overheard in the dining hall and bar, significant stimulating thought was provided for most attendees.

The success of the conference was primarily due to the hard work put in by the individual session organizers and the authors who prepared their papers and visual aids to give an overall programme that resulted in some interest for most acousticians. The session organizers selected the papers, sometimes with subtle persuasion and encouragement, and also chaired most of the sessions, persuading others where necessary to cover the longer-running technical programmes.

Organizational problems on the day(s) were, hopefully, not apparent to most delegates but typically consisted of late and non-arrival of the odd speaker, the inclusion of a paper previously withdrawn and a late requirement for a video player and monitor. These problems were quickly overcome and for the majority the days ran relatively smoothly.

A special word of thanks must go to the intrepid duo, Mike Carson and Martin Lester, ably assisted by Kate Lawrence, who set up and kept the visual aids operating in each session. Cathy Mackenzie smoothed out the problems as they arose in her inimitable style and ensured that everyone was reasonably happy.

Even after the conference the session organizers and chairmen have been busy and the following reports have been received from them. These will give some indication of the events occurring in the two-thirds (or more) of the conference that you did not manage to get to.

Derek Sims, Programme Chairman

From left to right: Dr Henning von Gierke; Mrs Rice; our President, Chris Rice; Cathy Mackenzie, and Dr Tony Embleton

OUTDOOR SOUND PROPAGATION

Sixteen papers were presented in this session which extended over three half days. The R W B Stephens lecture 'Review of Outdoor Sound Propagation – the Sound Field Micrometeorology and Topography' by Tony Embleton was an additional significant contribution and provided both a focus and a context. As a result of slight disruptions caused by the late appearance of one speaker, the presence of another who was not scheduled, a rather speedy presentation by the last speaker before lunch and somewhat dubious chairmanship by the author, the morning sessions observed a timetable that was a poor approximation to the printed schedule. Nevertheless it contained a variety of interesting contributions. Three of these were linked both by use of the Boundary Element technique and by the joint authorship of Simon Chandler-Wilde who is currently lecturing in mathematics at Coventry Polytechnic, having gained his PhD with David Hothershall at Bradford. David Berry of the Open University described applications of the Boundary Element technique to the prediction of the sound field above a porous surface when a rigid sphere is present below the surface. David Hothershall described results obtained from using the Boundary Element technique to explore the influences of barrier shape on insertion loss. J N B Harriott of the University of Bradford presented a calculation method and corresponding results for sound propagation over ground impedance discontinuity.

The unscheduled speaker, Paul Hammerton (Cambridge University), described a theoretical analysis of shock wave propagation and presented new results for near- and far-field behaviour in the presence of weak viscous losses.

Four further papers on aspects of the interaction of sound with porous ground followed. Yu Chen and Stephen Tooms from the Open University have investigated the possible influences of ground elasticity on the impedance and propagation over the ground. Yu Chen's work concerned possible surface wave types. Stephen Tooms showed examples of measured wet soil impedances that he could explain in terms of layered elastic behaviour and predicted the possibility of significant elastic effects on short range propagation over snow. In the afternoon, chaired by David Hothersall, Professor Mechel from the Faunhofer-Institut für Bauphysik, Stuttgart, was the first of five speakers from overseas (in addition to Tony Embleton) to present papers on Outdoor Sound Propagation. His paper concerned possible schemes, in particular numerical integration, for calculating the field due to a point source above an impedance or bulk reacting boundary. He had harsh words to say about several of the asymptotic series solutions to be found in the literature. It came as something of a relief to hear Craig Howard's (Open University) main conclusion in the following paper that several of these series solutions give results in close agreement with those of numerical integration for several short range geometries and impedance types. Johann Wempen from Oldenburg, W. Germany showed the results of careful measurements indicating the influence of meteorological conditions on ground effect at ranges of the order of 50 to 100 metres. He found it possible to model these effects by an effective change in the ground impedance and in the relative contributions of the ground and surface waves.

The following paper, by Heather Hess of the Open University, demonstrated the superior fits to short range ground effects over cultivated soils obtainable with an

impedance model that uses porosity and tortuosity as parameters as well as flow resistivity, rather than the widely used model that uses flow resistivity alone. Indeed the results indicate a basis for deducing soil surface porosity and effective flow resistivity non-invasively from acoustic measurements.

Of the remaining five papers, two given by Kai Li and Ren Wentang of the Open University were concerned with ground effect on propagation from a radiating panel and construction plant respectively. Willibrord Huisman from the Netherlands described the results of measurements of reverberation and attenuation in a pine forest, together with a ray-based multiple scattering model that, when combined with ground effect, predicts these phenomena tolerably well. However, his measurements indicated a height dependency that is not explained by these models. Charles Don (Australia) and Martin West (Salford) both described work concerned with using creeping wave analysis, based on an assumed linear sound speed gradient to predict observed impulse wave forms in the shadow zone. However, they used different approaches to the problem of the actual non-linarity of the gradient near to the ground surface. Charles Don found some success with fitting observed attenuation with range by use of a range dependent gradient, while Martin West achieved improved predictions by use of accurate ray tracing to determine a suitable average gradient.

The number and quality of the presentations and discussions in this session indicate the rapid burgeoning of research in the subject of outdoor propagation. It was a fitting tribute to Tony Embleton, the Stephens Lecturer, who has pioneered many of the recent approaches and who chaired and closed the final part of the session during the morning of 5 April.

Keith Attenborough

PHYSICAL ACOUSTICS AND ULTRASONICS

The seven papers in the session concerned with physical acoustics covered a wide range of the physics and applications of ultrasonics, reflecting the increasing impetus behind profound science as developing technology makes it readily applicable in a production environment.

The first paper (by P F Smith and M A Player from Aberdeen) was superficial only in the sense that it was devoted to a discussion of the maximum entropy method applied to ultrasonic surface characterization. On model and real data the method has clear advantages over conventional linear filters (e.g. Wiener-Hopf). In particular it appears that full spectral reconstruction may be possible, even when some of the spectral content is absent from the measurement data.

Consideration of bulk wave propagation in crystals by J H Cantrell from Cambridge (on loan from NASA Langley in the USA) revealed good agreement between values of hardness parameters derived from measurements of the acoustic non-linearity parameters and those obtained by other methods. Using these parameters and ultrasonic velocity measurements, the elastic constants of orders 2 to 5 were calculated. The magnitude increases by approximately a factor of 10 per order with successive orders alternating in sign.

This discussion was followed by a joint paper by Dr Cantrell, M Qian (from China) and Mr Rocca from Cambridge on the piezoelectric detection of signals in scanning electron acoustic microscopy (SEAM). While SEAM is quite commonly used, the interpretation of the image is often ambiguous. This contribution was devoted to an investigation of some contrast mechanisms by focusing on the relationship between the output of the receiving piezoelectric transducer and the thermoelastic properties of the sample.

Introduction of another physical dimension to the multi-faceted aspects of ultrasound was provided by T G Leighton, also from Cambridge (co-workers A J Walton from the Cavendish and Drs Dendy and Pickworth from Addenbrookes Hospital), describing experiments on the sonoluminescence from cavitation in high amplitude pulsed ultrasonic waves. The unexpected experimental result was that the amount of sonoluminescence increased when the ultrasound was pulsed. Two different mechanisms were proposed for this based on bubble migration during the off-period of the excitation. It appears that for therapeutic ultrasound the driving force for these migrations is due to a coupling of the acoustic pressure field with the bubble oscillation at the end of each pulse.

The remaining three papers of the session were devoted to materials characterization. R C Chivers (Surrey) outlined a theoretical analysis of the reflection from continuous variations in impedance, extending the discussion to include continuous attenuation variation. Computational results agreed qualitatively with observations in underwater acoustics. R E Challis (Keele) presented two papers – one (with T Alper) on absorption measurements in thin films of adhesive polymers and one (with A K Holmes) on a wide-bandwidth absorption spectrometer for liquid materials. Those inclined to perambulate beneath adhesive-secured glass windows will be relieved to hear that the novel measurement technique reported shows clear changes with the state of cure of the adhesive and should provide real and imaginary modulus values for the bond in the near future. Application of similar instrumental concepts in another area produced an ultrasonic absorption spectrometer (in the second paper from Keele) giving spectra between 3 and 50 MHz. The agreement with published data confirms the existence of a reliable, elegant and extremely rapid analytical tool.

Bob Chivers

INSTRUMENTATION

Two of the four papers in the instrumentation session were concerned with measurements on ultrasonic transducers. R A Hazelwood (of Acoustics Partners) described the use of an advanced digital storage oscilloscope for calibration measurements on high power underwater transducers, particularly with application to measurement of the (almost) instantaneous power dissipation. This can then be used to calculate efficiency, the power factor and effective susceptance and inductance. Linear acoustic regimes were explored in the paper by J R Blakey (co-authors R A Bacon and R C Chivers) from Surrey. Reconstruction of the original source velocity amplitude distribution can be achieved by measurement in a remote plane and 'back propagation' to the source. Some of the limitations on the source reconstruction that can be achieved, arising from experimental constraints, were discussed.

Professor Fahy (Southampton) provided an energetic and convincing case for a greater exploitation of the reciprocity principle in complex measurement situations. Essentially the contributions of complex radiating structures to the sound level at a given point can be found by putting a source at the point and measuring the normal velocity generated at carefully selected points on the structure. This was followed by a rather whimsical presentation of a two-microphone

technique for measuring acoustic impedance in free field conditions by D C Waddington of Salford (co-author R J Orlowski). The preliminary results presented seemed promising but raised a number of questions.

Bob Chivers

WARNING SIGNALS AND BEHAVIOURAL RESPONSE

The morning session commenced with the chairman, Roy Patterson (MRC Applied Psychology Unit (APU), Cambridge), presenting a paper on guidelines for the design of auditory warning sounds. This set the scene for the rest of the day's proceedings by establishing the auditory and ergonomic considerations involved in making warning sounds. The use of appropriate sound levels and the necessary temporal and spectral characteristics of warning sounds were all taken into consideration. Practical examples were taken from sounds used in civil aircraft.

Melanie James (Royal Aerospace Establishment (RAE), Farnborough) presented a paper on reaction time to auditory warnings. She found that prioritized attensons (attention getting sounds) in conjunction with voice messages, and a 'blocked' rather than 'scrambled' response keyboard, both had the desired effect of reducing reaction times. One interesting result of the study was that something as innocuous as a 1 kHz tone had a positive effect on response time to a warning sound.

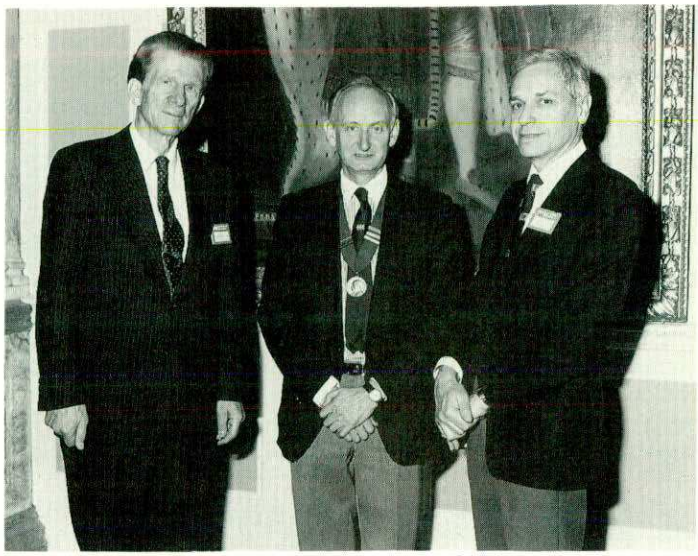
Chantal Laroche from the University of Montreal then described a method for calculating auditory masked thresholds which enable the user to set levels for auditory warnings in working environments. A particular problem with noisy working environments is that warning sounds are not heard due to the incorrect setting of levels. Using a model based on loudness summation and excitation patterns (from Zwicker) predictions were made about the audibility of warning sounds for workers of various ages.

Mike Lower (ISVR, Southampton) presented a paper on sound levels for warnings used by railway track maintenance workers. The proposed system delivers a warning automatically if a train enters a certain section of the track. The author described a method for calculating auditory masked thresholds (which differed from that of the previous speaker) for each of the 45 different background noise sources identified as common to the trackside environment. With this data he then demonstrated how the sound levels of a warning system could be set.

Paul Cosgrove (MRC APU) then described how a set of auditory warnings had been designed for the British Rail trackside warning system. The main constraints were sound levels (as dealt with by the previous speaker) plus the need to make as much use of the existing sounds as possible. The warning sounds incorporated the spectral and temporal characteristics as recommended by Roy Patterson at the beginning of the morning session. They were also tested to make sure that all the sounds were mutually discriminable.

After lunch Mike Lower, in the absence of Graham Rood (RAF), read the latter's paper on auditory warnings for fixed and rotary wing aircraft. The project incorporated the work of Patterson, Lower and Edworthy on ergonomics, noise and perceived urgency. The main problems were how to design sounds for a loud, high risk environment (as in helicopters). After tests of warnings in aircraft simulators, a commercial auditory warning system has been designed.

Judy Edworthy (Polytechnic of the South West) presented a paper on the perceived urgency of auditory warning sounds. Parameters known to have an effect on urgency, such as fundamental frequency and amplitude envelope to name but two, were systematically varied in isolation and combination. The results of judgements on perceived urgency due to such variations were used to design a set of warnings where the rank ordering of their urgency was predicted beforehand. High correlations between predicted and acquired results were obtained demonstrating the reliability of the original perceived urgency measures.



Chris Rice with (left) Dr Henning von Gierke, who gave the Rayleigh Medal lecture, and (right) Dr T F W Embleton, The R W B Stephens lecturer

G Taylor (ICI, Billingham) described the installation and testing of a toxic alarm system for a large chemical plant complex. The main problem was one of audibility over the whole site as such plants typically cover an area of several square kilometres. The criterion that ICI set out to achieve was to be able to evacuate a site, in the event of toxic release, in three minutes. This they managed to do despite encountering such problems as the screening of sound by large buildings and high noise areas of working.

Bill Gaver (EuroPARC, Cambridge) rounded off the proceedings by presenting a talk and supporting video on auditory icons. These icons, which were designed by the author, are used (on an Apple Macintosh) to give auditory feedback of computer events such as selecting files and opening windows. These sounds are all designed to be analogous to the events they describe so that, for example, putting a file into the waste basket really does sound like an object being thrown into a 'trash can'.

The main themes that emerged during the day were: The audibility of warning sounds is obviously crucial but many existing systems are set at incorrect levels. Current psychoacoustic knowledge allows us to predict with a high degree of confidence what these levels should be for varied noise backgrounds. Warning sounds can be rank ordered in a consistent fashion in terms of their perceived urgency. Warnings should be designed to be analogous in some way to the situation that they are trying to draw attention to. Finally, there is no substitute for being informed about the purpose of each warning sound so that appropriate action in any event can be taken.

Paul Cosgrove

VIBRATION AND HUMAN RESPONSE

The 1989 Spring Conference was the first occasion on which the Institute of Acoustics has organized sessions devoted to human response to vibration. In addition to the Rayleigh Medal Lecture by Dr Henning E von Gierke, there were ten

papers concerned with other aspects of human response to vibration.

Four papers were concerned with the transmission of vibration to buildings, its transmission through buildings and the effects of vibration on people in buildings. G R Watts provided a procedure for predicting the vertical peak particle velocity at building foundations from the passage of heavy goods vehicles. The prediction of vibration in ground floors and first floors of houses from measurements made in green field sites before the construction of the houses was discussed by R Randell. T M Dawn presented a paper in which he emphasized the complexity of the transmission of vibration to buildings from railways and showed how British Rail use a vibration dose procedure based on root-mean-quad measurements as defined in British Standard 6472. H J Woodroof reported on a survey of human response to building vibration and showed that it was not possible to predict the proportion of persons perceiving vibration solely from a knowledge of the distance of their houses from railway lines. He also showed that vibration was generally less annoying than the noise associated with railway lines.

J A Lines and R M Stayner presented results showing that an improved suspension mechanism for agricultural vehicles will often result in an increased driving speed and suggested that the cost of improved suspension systems could therefore be justified by the increased work rates. The use of active engine mounts for improving vehicle comfort was the subject of a paper by C F Ross *et al.*, but this paper was not presented due to the absence of the authors.

M R Taylor discussed the effects of vibration on speech and presented results for assessing the performance of speech recognition systems in vibration environments. Two papers were concerned with standardization of the measurement and evaluation of whole body vibration. A W James provided a guide to the use of vibration dose values and concluded that they are similar in concept to SELs and Leqs but, if anything, even easier to calculate. C M Nelson reviewed various techniques for measuring vibration with respect to current national and international standards. He was able to illustrate the methods with the use of a battery-powered portable computer capable of data acquisition and all relevant analysis in the field.

The 'human response to vibration' session ended with a report on a survey of the use of vibrating tools in British industry. K Kyriakides reported that in any working day about 130,000 workers are engaged in work for long periods using tools which generate significant vibration, in the manufacturing sectors, the public utilities, agriculture and forestry work. In addition, on any one day, there are approximately 22,000 workers using powered tools in the construction industries. It was suggested that these processes are a significant potential cause of vibration-induced white finger.

Mike Griffin

AIRCRAFT NOISE

Papers on a variety of subjects associated with aircraft noise were presented at this session which was chaired by Stephen Turner (LSS).

Nigel Peake of the University of Cambridge started the proceedings by describing 'an asymptotic theory of propeller noise in the near field'. This was followed by John Walker of the University of Southampton on behalf of fellow workers from the CAA and Loughborough University presenting results of 'a study of annoyance due to general and business aviation noise'. This was a follow-up to the 1981 study and looked more closely at people's attitude to general aviation. One result showed the importance of the overall attitude of people to a particular aerodrome in determining the level of annoyance caused by the activity there. Peter Henson of Bickerdike Allen Partners then described some interesting features when measuring ground noise, referring to specific examples at the London City Airport.

The session then took on a military flavour with Darren Bexon of the RAF Institute of Community and Occupational Medicine describing a joint study with W S Atkins Engineering Services of the insulation of mobile homes subjected to military aircraft noise. The MOD operate a grant system for sound insulation treatment but a particular problem of an increasing number of mobile home sites near airfields has been identified. The current insulation was found to be poor and some cures were suggested. Bill Stubbs of Wimpey Laboratories followed by describing the methodology being adopted in the major study of aircraft noise around military airfields. Bill tried hard not to give away too many military secrets (especially as his client was listening) but he did demonstrate an impressive expertise in identifying different aircraft types! Finally, the conference programme chairman, Derek Sims of British Aerospace, found time to speak on 'in-flight measurement of boundary layer noise and its vibration effects'. An understanding of this subject is needed because externally carried stores on military aircraft contain sensitive equipment which needs to be able to withstand the environment in which they are transported and operate.

The session was well attended and showed just how wide is the range of diverse subjects that fall into the category of aircraft noise.

Stephen Turner

ENVIRONMENTAL NOISE

This short session of only three papers was opened by Bill Utley of the Building Research Establishment who presented the results of a survey on neighbourhood noise. This showed that the sources of most complaints were dogs and people but that further research was required to provide solutions to the problem. Jeanette Brookes from the Open University presented the results of a study (with Keith Attenborough) relating the subjective annoyance of domestic appliances with the proposed EEC method of labelling appliances with their A-weighted sound power level. This showed that the annoyance was not directly related to this parameter but correlated well with L_{eq} and L_{ax}. Amongst other things this research showed that it is necessary to have plenty of obliging friends as it involved the use of 11 hairdryers, 8 vacuum cleaners and sundry food mixers and food processors. On a slightly different note Ralph Weston of the Institute of Community and Occupational Medicine, RAF Halton, reviewed the methods of rating ear defenders with the objective of defining a method of single number rating in the variable military environment.

This short session was the prelude to a further period on environmental noise on the following morning.

Derek Sims

OPEN SESSION

The open session contained a wide variety of topics. The first presentation was given by C P Stollery of Cirrus Research who described a computerized system for the automated testing of low cost sound level meters. This enabled the extension of detailed testing into this class of

instrument thus improving the product quality. R S Ming from ISVR then reported on SEA work, with G Stimpson and N Lalor, on noise and vibration transmission across flanged joints. In this they established formulae for calculating coupling loss factors of flanges with and without gaskets.

Experimental work at the Malaysian Rubber Producers Research Association examining the characteristics of natural rubber was presented by A H Muhr. This demonstrated the effects of composition on damping in spring applications. Brigit Rasmussen of Bruel & Kjær then detailed the improvements attainable in the measurement of reverberation time in studios by the use of a time reversed analysis. This was followed by Alan Cummings of Hull University who described a theoretical treatment of noise generation within a duct with negligible mean flow. It was shown here that some applications of bulk acoustic linings could increase the noise due to obstructions within the duct. The session was closed with G J MacNulty and G R Symmons describing how they made slip-stick noise worse in order to develop suitable diagnostic tools.

Dudley Wallace

STUDENT SESSION – 1

This is the third occasion on which a student session has been held during Spring Conferences and each year the support has increased, so justifying its continuance as a regular feature. Thirteen papers were presented, together with the Simon Alport Prize paper delivered by Dr Adrian Raper, a recent post-graduate from the ISVR now working with Arthur Andersen & Co. The occasion gave both final year undergraduate and post-graduate students the opportunity of presenting their work in a formal manner before it was formally discussed in a peer review situation. This environment provides the ideal situation for a young person's introduction to the conference arena.

The standard of presentation of the material was high and students delivered their papers with a confidence to be commended. Members should make the effort to attend such sessions in future and give every encouragement to our student colleagues whose academic ability should not be underestimated. Students came from five different academic institutions and the papers covered a wide range of acoustical topics.

In the morning session, which was chaired by the President and Professor F J Fahy, G Rodwell from Sheffield City Polytechnic discussed the influence of air flow resistance on the acoustic absorption properties of polyurethane foams; P Wright from Salford University presented results obtained from acoustic scale modelling experiments in which nitrogen was successfully used as an alternative to air; M Stewart from Heriot-Watt University described a longer term experiment just being started to investigate the effect of loading on the impact of concrete floors with a floating raft on a resilient layer; C Swift from Salford University described work he had undertaken in his placement year at the ISVR in which he had correlated the annoyance and impulsivity ratings of a series of environmental noises with selected physical measures. Also from Salford was C W Dilworth who discussed the difficulties involved in trying to evaluate the loudness of low frequency impulses; D Moore from the ISVR outlined noise measurement problems associated with the quantification of community background noise levels; A Shadbolt from Salford University discussed some of the fundamental analytical considerations necessary for the computer based measurement of random signals, and M Santer from the ISVR (whose paper was read by N Hogwood) presented his work on a hemispherical cap array for noise source location.

The Simon Alport Prize paper by A Raper was entitled 'An expert systems approach to understanding signals and systems'. The prize of £200 was presented by Dudley Wallace on behalf of the sponsor, Cirrus Research Limited, in a special ceremony which took place later in the day.

Chris Rice

STUDENT SESSION – 2

What a pleasure it is to see the student sessions grow from strength to strength. It is equally rewarding to observe that the students' presentations are highly professional, so much so that Professor Frank Fahy feels he has to respond to them with his legendary incisive questioning and pithy comments – and the students stood up to him well, which is an achievement in itself. So it appears that the student sessions have come of age and that student participation in the events of the Institute in the future will enrich both the Institute and students alike.

In the session which I chaired there were five papers, three on the propagation of sound under water from ISVR, one on loudspeaker enclosures from the University of Salford and one on loudspeaker modes from the University of Wales.

Nick Hogwood from ISVR explained the differences in propagation resulting from shallow and deep water explosions and described a Shallow Water Correction Coefficient for making predictions in shallow water. This was a very well-thought-out and well presented piece of work.

Susan Boyle from ISVR continued on the watery theme by discussing the effect of bubble curtains in reducing underwater shockwave propagation. She indicated that the pressure from waterborne shockwave can be reduced by up to 37 dB at low frequencies using this technique. This paper was also of a high academic standard.

Claire Herbert, the third member of the ISVR group, described auditory hazard to divers from underwater explosions. I found her descriptions of what happens to the human body when exposed to underwater shockwaves very vivid and an experience to be avoided.

David Philip of the University of Salford described a method of quantitatively measuring the acoustic loading on loudspeakers using an impedance bridge. With careful experimentation he was able to observe successfully the effect of loading, thus demonstrating the potential of the method in this type of measurement.

The final paper by M Brooke of the University of Wales College of Cardiff described the viewing of loudspeaker modes by laser speckle. Mr Brooke showed some fascinating slides illustrating loudspeaker mode shapes and concluded that this method is more straightforward than holography and less expensive than the new electronic speckle pattern interferometer.

This student session maintained the high standard of previous ones and I expect that by next year delegates will find these sessions as attractive as any others.

Rafal Orlowski

Erratum

The January edition of the *Bulletin* carried incorrect information relating to the A B Wood Medal. The Medal is awarded alternately to acousticians domiciled in the UK or in the USA/Canada. The 1987 award was to D M F Chapman who is domiciled in Canada.

A STUDENT'S VIEW OF THE STUDENTS' SESSIONS AT THE SPRING CONFERENCE

Having observed the vigour with which a group of Electroacoustic undergraduates had immersed themselves into the Spring Conference being held at Salford University, Raf Orlowski and Bob Chivers suggested the idea of having student sessions at IOA conferences to the chairman of Salford University Acoustics Society. The suggestion was adopted with much enthusiasm by the Acoustics Society committee and was subsequently proposed to the Meetings Committee of the IOA. The Meetings Committee agreed unanimously (we like to think) to the inclusion of a student session in the IOA Spring Conference. At the same time the committee responded to the enthusiasm of the student acoustic societies at both Salford and Southampton universities by recommending that the annual and conference fees for student members be minimized.

That was back in 1986. The student session has now reached its third successful year, thanks to the support and nurturing it has received from some established members of the Institute, notably Raf Orlowski and Chris Rice. As I had been one of those 'enthusiastic' undergraduates I was keen to attend the student session while at the Spring Conference in Oxford this year. I was very pleased to see that it had flourished, with papers being presented by a wide range of students from many educational establishments, not just from Salford and Southampton. In all 13 papers were presented over two sessions. They were of an exceedingly high standard, the visual aids and clarity of exposition being very impressive. This year many delegates agreed that the papers presented by students were of a high standard of exposition and content and compared well with many of those presented at other conference sessions by more experienced authors.

One presentation of particular note was that by Adrian Raper who was awarded the Simon Alport Prize for 1988. Not only was it an excellent paper but also it served as a reminder to other young engineers that the Simon Alport Prize is a fitting means of encouraging young acoustic engineers to present their own fresh ideas to their older and more experienced colleagues. This is very important to the industry as I am sure there are many who possess the same foresight that Simon Alport had.

I was also glad to find that the original objectives of the students' sessions were being fulfilled: the first being to provide a platform from which students of acoustics would be able to inform the membership of the research or project work they are undertaking as part of their education; the second being a means by which students could benefit from the experience of delegates in terms of discussing the relevance of their results to practical acoustic applications and suggesting ways of improving their experimental techniques. At Oxford the lively discussions after each presentation served only to benefit all parties.

Consequently the main objective for bringing students of acoustics and professionals in the industry into closer contact, to strengthen the profession and its Institute, was and is continuing to be met.

Finally, I hope that next year the involvement of students and indeed all younger members will be even more evident, especially with the Spring Conference being held at Southampton University. However, this should not only be up to some of those more senior members of the Institute, who have been more than enthusiastic in encouraging a greater involvement in the Institute by members under 30, but, even more, to the younger members themselves.

Nicola Alexander, Salford University

isvr Short Courses

1989

Sept.

11-15 Technical Audiology

12-14 Introduction to Mechanical Vibration Measurement Techniques

13-15 Engine Noise and Vibration Control

18-22 Advanced Course in Noise and Vibration

25-27 Condition Monitoring

25-27 Noise Measurement & Instrumentation

Oct.

23-27 Noise Reduction in Machinery Installations by Vibration Isolation – Venue: The Netherlands. Joint organizers: TPD-TNO, Metravib, ISVR.

1990

March

20-22 Vibration Measurement using Laser Technology

21-23 Active Control of Sound and Vibration

26-30 Clinical Audiology

April

18-22 Engineering Applications of Statistical Energy Analysis

Adaptive Signal Processing

Digital Audio Signal Processing

To be arranged:

Industrial Audiology and Hearing Conservation

Contact: Conference Secretary, Institute of Sound and Vibration Research, The University, SOUTHAMPTON SO9 5NH.

Institute of Acoustics Meetings

Calls for Papers

Noise within Buildings

One-day Meeting on 12 December 1989, organized by the Building Acoustics Group. This meeting will explore and discuss the guidance given in BS 8233:1987 with respect to achieving adequate control of noise within buildings. Practical situations will be considered along with criteria adopted and principles and practice of noise control. Papers are invited on any topic in this wide subject, particularly health, education, domestic, leisure, hotel, industrial and office buildings. Additional interest would be provided by papers relating to spaces with specialized noise control performance specifications. Abstracts of 100-200 words (papers to be 20 minutes in length) should be sent to the Programme Committee Chairman as soon as possible before 1 August 1989: Neil Spring, FIOA, Sandy Brown Associates, 1 Coleridge Gardens, London NW6 3QH. Tel: 01-624 6033.

Digital Speech Coding

Speech Group Meeting on 14 September 1989

Papers are invited on the subject of digital speech coding, for a Meeting to be held on 14 September at Cambridge University Engineering Department. Contributions relating to research on coding algorithms will be particularly welcome, but papers reporting coder implementation, pitch extraction, distortion criteria, or any other topic likely to be of interest to workers in this field will be considered appropriate. Please send short abstracts, before 1 August, to Tim Thorpe, ECR Laboratory, Cambridge University Engineering Department, Trumpington Street, Cambridge CB2 1PZ. Departmental Fax: (0223) 332662.

THE INSTITUTE OF ACOUSTICS FIFTEENTH ANNUAL REPORT OF THE COUNCIL 1988

This year the Institute acted as host to one of the major international acoustic conferences, the FASE Meeting SPEECH '88, held in Edinburgh during the Festival. The organization of this event was a great tribute to the hard work put in by the Speech Group, and the event proved to be a great success for all concerned. It also contributed significantly to the income of the Institute.

It is a fact of life that the Institute now has to rely upon the financial success of meetings and conferences, such as FASE, to finance its other activities. The Spring Conference this year – Acoustics '88 – returned to Cambridge ten years after our last visit to that historic University. Although Queens' College made us very welcome, and there was an excellent technical programme relatively well attended by the membership, it was unfortunate that the high costs involved in the Conference made it less than successful in financial terms for the Institute. This should not, however, detract from the hard work and enthusiasm put in by the various Groups and individuals in organizing the technical sessions. At this meeting there were six parallel sessions on a very wide range of acoustic topics, and six plenary sessions with invited or medal lectures. The 1988 Rayleigh Medal was presented to Professor David Crighton in recognition of his inspiring leadership in theoretical acoustics. Dr Victor Humphrey was awarded the 1988 A B Wood Medal and Dr David Weston was invited to give the R W B Stephens Lecture.

In November the Hydro Hotel at Windermere was yet again the venue for two very successful conferences. The first was the fourth in the Reproduced Sound series and the second was the Autumn Conference, which was this year devoted to 'Noise in and around Buildings' and was organized by the Building Acoustics Group. It was appropriate that this should be the venue for the award of the 1988 Tyndall Medal to Dr Michael Barron for his important and continuing contributions to auditorium acoustics.

Two major discussion documents were circulated in 1988: The HSC Consultative Document on the 'Prevention of Damage to Hearing from Noise at Work' and a draft revision of British Standard BS 4142. For both these documents the Industrial Noise Group organized one-day meetings to discuss the documents and the consensus views expressed at these meetings were collated and sent to the proposing bodies as the Institute's responses.

In terms of Membership, the Institute has continued to grow slowly with nearly a 5% increase in total membership over the previous year which is very satisfactory. Details of the membership in the various grades, Groups and Branches are given in the Tables at the end of this Report. It should be noted that the increases in Group and Branch membership are due more to changes in administrative procedures at Headquarters than to a significant upturn in interest in Groups and Branches themselves. There has, however, been sufficient interest in the Eastern counties to make the formation of an Eastern Branch viable and this was approved by Council in December.

Significant progress was made during the year towards reorganizing Group and Branch finances. With some assistance from the Secretariat and Vice President (Groups and Branches) the Treasurer compiled a set of draft guidelines which were sent to Group and Branch committees for comment. A Group and Branch representatives meeting was held in September at which the guidelines were discussed and subsequently modified. The final version was approved by Council in December and it is intended that the proposals will become operational during 1989. Coupled with the greater flexibility being programmed into the main accounts computer it is anticipated that the guidelines will significantly ease the problems previously encountered with Group and Branch finances.

The Group and Branch representatives meeting also provided a forum for discussing current and planned activities. There was a useful interchange of ideas together with a discussion on problems associated with attracting members to meetings. At the request of a number of participants the exercise will be repeated.

The Speech Group continued its international activities with two meetings. As well as the FASE symposium they hosted another meeting with their French counterpart the Groupe Communication Parlée of the Société Française d'Acoustique. In addition they organized or took part in three other one day meetings. The Group's newsletter *Speakeasy* continued to flourish and they added to their literary output by publishing a survey of UK speech researchers and laboratories.

The Underwater Acoustics Group organized a tutorial day on finite element methods. This meeting format was a new venture which proved quite successful and which is to be repeated. In addition

the Group participated as co-sponsors of two further meetings, one with the IEE and one with a commercial company. The sales of *Proceedings* of past UAG meetings continued at a steady pace with many going overseas. The Physical Acoustics Group also organized a meeting jointly with the IEE and held another 'Annual review of progress in Physical Acoustics and Ultrasonics'. Two newsletters were published during the year for members.

Once again the fortunes of the regional Branches have been mixed. The London Branch has now become established with a popular programme of meetings which include a one day main meeting. The Southern Branch continued its series of quality technical meetings despite an almost complete change of committee. They also plan to run a main meeting on behalf of the Institute. The North West Branch struggled a little to maintain its programme because increased activity in industry left little time for accommodating visits. However the committee responded by rescheduling lectures planned for the future.

Sadly the South West Branch is now without a committee. There is hope that some members in the Bristol and Bath area will organize a meeting in the near future. The Yorkshire and Humberside Branch has been dormant throughout the year and the East Midlands Branch is struggling for support. The North East Branch is also struggling a little as many of its past members have responded to local industrial needs and left acoustics altogether. A programme of meetings jointly arranged with other local societies has met with some success. The Scottish Branch has built on the successful format of half-day meetings and extended their programme, proving that with a little imagination some local problems can be overcome.

The Student Societies at Southampton and Salford have continued with their own programmes. Encouragement from local Branch members has resulted in an increase in student member applications.

Group and Branch activities form an important part of the Institute's service to its members. The Groups and larger Branches have programmes well in hand. Every encouragement must be given to the smaller Branches to adopt a flexible approach to furthering the work of the Institute.

Now that the Institute has been accepted as an Institute-Affiliated body of the Engineering Council work is proceeding on formulating the routes to Chartered Engineer status for individual members. The first task has been the setting up of the Committee of the Engineering Division and this has in turn established an Education and Training Sub-Committee and a joint IOA/IMechE Board of Registration Committee. It is anticipated that details will be available to the membership in 1989.

The Annual General Meeting was held, as usual, at the Spring Conference in Cambridge. At that time the office of President passed from Professor Orhan Berktay to Mr Chris Rice. Dr Geoff Leventhall and Dr John Holmes retired from the posts of Immediate Past President and Vice-President respectively but would remain on Council as co-opted members. Mr Mike Ankers became the President-Elect and Dr Bill Ainsworth was appointed a Vice-President. Council's thanks for his past service went to Mr John Mills who was retiring from Council and a warm welcome was extended to Dr Bob Chivers and Dr Brian Smith who were newly elected to Council and to Professor Peter Lord who was re-joining Council as a Vice-President to act as Chairman of the Engineering Division Committee.

We must, of course, thank Cathy Mackenzie and all her staff at Edinburgh for their continued hard work and goodwill during the year. Theirs is never an easy task, but when they have absorbed the additional burden of a major international conference such as FASE on their own territory without showing outwardly any sign of the strain that they were undoubtedly subject to, they must qualify for a special vote of thanks.

The following sections give more detailed reports from the various Committees, Groups and Branches of the Institute.

STANDING COMMITTEES

The operation of the Institute is guided by Council through the following Standing Committees: Membership, Meetings, Publications, Education, and Medals and Awards. There is also a Finance Committee, the Committee of the Engineering Division and the Institute's involvement in the Noise Council.

Membership Committee

During 1988 the membership of the Institute continued to grow in both corporate and non-corporate grades. Although there were slightly fewer new Fellows than in both of the two previous years, applications for Member were up by nearly 50% over 1987, and the number successful increased by more than 50%. As always there were a few membership losses during the year, but after allowing for the losses the combined increase in numbers of Fellows and Members was a very satisfactory 48 – nearly a 5% growth rate. The non-corporate grades of Associate and Student have had a similar proportional increase in applications over last year, and the numbers in these grades have also gone up by about 5%. The Institute's membership at the end of the year had increased by 73, to 1526 (excluding Honorary Fellows and Sponsors). The details are shown in Table 1.

Tables 2 and 3 show the figures for Group and Branch membership respectively. All Groups have shown a substantial increase during the year, a major part of which was caused by a change in policy in the office when processing membership renewal forms. It was realized that the previous large fluctuation in Group membership was a result of members not noticing that they needed to tick the appropriate box on the form to maintain their Group membership. In 1988, for all people who had specified no Group membership, the Office checked whether they had belonged to a Group in previous years. If so their membership was carried forward. This process should

not be necessary in future years because the renewal form has now been re-designed so that maintaining the previous Group and Branch membership pattern is the default option. The membership of all Branches also increased greatly during the year, but for a slightly different reason. It was decided by Council that all UK and Hong Kong members should be allocated to their most appropriate Branch if they had not already chosen to belong to a different one. The total membership of Branches is thus 1419, which is a very high proportion of the membership of the Institute.

There were four new Sponsor Members accepted during 1988, but unfortunately some other Sponsors have allowed their membership to lapse, so that the total is still only 15.

During 1988 Council decided that the Institute may be failing to attract many members because there is no grade between Associate (which only needs quite low qualifications), and Member (which requires good academic qualifications and a substantial amount of responsible work experience). There was thus no grade well suited to the newly qualified acoustician. It was therefore decided to propose forming a new grade, to be called Associate Member and carrying the designatory letters AMIOA, to fill this gap. The necessary changes to the Articles of Association and the Membership Bylaws will be put to an Extraordinary General Meeting on 23 February 1989.

Meetings Committee

This was generally a good year for meetings. Eleven main meetings were held, two of them with attendances of over 200. The small numbers at some others meant that the contribution of meetings to the IOA finances was lower than hoped for, but the technical quality continued to be high.

In any one year, some meetings are the result of long term planning, whilst others are staged at a few months notice when the need is recognized. Long term planning was required for Acoustics '88 and for the Speech FASE Symposium. The organizers of these are to be congratulated on the success of their meetings, resulting from much detailed planning. The BS 4142 meeting was arranged at short notice in response to a perceived need and, following a period of intense effort by the organizer, was a remarkably successful and lively meeting.

Our two meetings at Windermere in November continued the high standard which has become traditional for them. The Institute owes a great debt to the organizers of these and of our one day meetings, which are an important point of contact between the Institute and its members and between members themselves. A list of meetings is shown below with numbers of participants.

Publications Committee

1988 has been a year of steady development with no dramatic events to report. Mr Bernard Berry joined the Committee during the year providing further valuable support. Dr Bernard Richardson agreed to take on the task of secretary for which the Committee was very grateful. In common with other standing committees the composition of the membership including chairmen has been discussed by Council. It has been agreed that Dr Bill Ainsworth will take over the Chairmanship of the Publications Committee during 1989 leaving Mr John Tyler with more time to devote to the task of Editor of *Acoustics Bulletin*.

The format and content of the *Bulletin* has continued to be the subject of much discussion and the Committee hopes that the increased technical content, two special features in addition to individual articles on other areas of acoustics, will have met with approval. Consideration is also being given to the possibility of having colour photographs on the front cover and greater variety of content. For the latter, suggestions have included, further 'Acoustics at . . .' articles, news from past years, reports from Student Societies, a series on 'Women in Acoustics', and appropriate crossword puzzles. The Committee proposed and Council agreed that the cover price of the *Bulletin* for non-members be increased to £6.

The updating of the Institute's General Information and Career Leaflets has been discussed and new versions are being considered.

As usual the Committee is indebted to Mr Sydney Jary for his continued good work in handling the advertising business for the Institute. Advertising income has continued to increase even though not so rapidly as in past years.

Education Committee

The main concern of the Education Committee was the running of the Diploma course in Acoustics and Noise Control, which again showed an encouraging

INSTITUTE MEETINGS, 1988

February	Noise to the Year 2000	Birmingham	37
February	Noise and Vibration Control on Construction Sites	London	62
March	The 1987 HSC Consultative Document	London	32
April	Acoustics '88	Cambridge	211
April	'Inaudibility' in the Assessment of Noise Nuisance	Edinburgh	78
May	New Sources and Problems in Urban Transportation Noise	London	44
June	More About Noise Control in Factory Buildings	Salford	46
June	BS 4142 – (1988)	London	116
August	Speech '88 – 7th FASE Symposium	Edinburgh	250
November	Reproduced Sound 4	Windermere	98
November	Noise in and around Buildings	Windermere	126

number of registrations and a high pass rate. Dr H G Leventhall was replaced as Chief Examiner by Dr J M Bowsher and Mr J G Charles was appointed Assistant Chief Examiner.

A new initiative which occupied much of the Committee's efforts this year was the setting up of a structure for a Certificate of Competence in Workplace Noise Assessment. Discussions were also held with Colleague Societies such as SCIF and AES, for the setting up of a Training Initiative for Professional Sound.

Engineering Division Committee

One of the responsibilities of the Engineering Council is to maintain a Register of Engineers and only those registered as such can call themselves Chartered or Incorporated Engineers. The Engineering Council recognizes that the Institute of Acoustics has members employed in engineering but at the same time covers a much broader spectrum of interest than just engineering. In order to cater for the engineers the Institute has become an 'Institute Affiliate'. This means that the IOA has the same responsibility for processing applications but instead of sending approved applications direct to the Engineering Council they are assessed by a nominated body. The Institute of Acoustics is an Institution Affiliate of the IMechE. The IMechE will act on behalf of the Engineering Council in checking that the criteria set by the latter are met.

As the process of applying for engineering registration must be kept separate from the process of applying for membership of the IOA, an Engineering Division Committee was set up in 1988 to deal with all matters relating to engineering registration. To assist it in this task two sub-committees have also been created, one covering Education and Training, whose task will be to receive, assess and process CEng and IEng applications from members of the IOA. The other sub-committee is for Joint IOA/IMechE Registration whose principal responsibilities will be to assess and process applications for Chartered Status to the IMechE Membership Committee for consideration and to ensure that successful applications are passed to the Engineering Council for registration by the Board of Engineering Register (BER). The Engineering Division was given the task of vetting the forms of application for registration and the associated guidance documents originally prepared by an ad hoc committee. These should be available to the members early in 1989.

Medals and Awards Committee

The Rayleigh Medal was awarded to Professor David G Crighton of the University of Cambridge for inspiring leadership in theoretical acoustics and for fundamental research that benefits modern technology, particularly in flow/acoustic interaction effects. The presentation, which was followed by the Rayleigh Lecture 'Fluid Loading: the Interaction between Sound and Vibration', was made during the Spring Conference at Cambridge.

The Autumn Conference at Windermere was the venue for the presentation of the Tyndall Medal to Dr Michael Barron of Fleming and Barron for his important and continuing contributions to auditorium acoustics. Dr Barron then gave the Tyndall Medal address entitled 'Reflections on Reflections in Concert Halls'.

The A B Wood Medal and Prize was awarded to Dr Victor F Humphrey of the University of Bath for his work using parametric sources for acoustic experiments in water. The presentation was also made at the Spring Conference at Cambridge and was followed by the lecture entitled 'Applications of Parametric Acoustic Arrays in Laboratory Scale Experiments'.

The 1988 R W B Stephens Lecture entitled 'Sonar Ichthology' was delivered by Dr David Weston of the Admiralty Research Laboratory at the Spring Conference at Cambridge.

The second award of the Simon Alport Prize was made to Adrian Raper whilst he was a research student at the University of Southampton. Dr Raper is now with Arthur Andersen and Co, and will give his lecture entitled 'An Expert Systems Approach to Understanding Signals and Systems' at the 1989 Spring Conference at Oxford.

Noise Council

The Noise Council has had an active year 'behind the scenes' through its working groups. During the year the following groups were in operation:

WG2 – Occupational Noise Exposure – responded to the HSC document on worker protection.
WG3 – Neighbourhood Noise – concentrated on noise from clay pigeon shoots. A questionnaire was sent to all local authorities to elicit their experience. It was found that shoots were held in over half the local authorities in the UK and that there have been complaints of noise in over 75% of these.
WG4 – Motor Cycle Noise – continued to study the problem of noisy motor cycles in preparation of a report and recommendations for a roadside test method.
WG5 – European Issues in Noise – has not yet made significant progress due to problems of co-ordination with European colleagues.
WG6 – Entertainment Noise (Reproduced Sound) – made good progress on its work relating to noise of discotheques and similar operations.

On the financial side priming support was received from the Department of the Environment together with contributions from local authorities and industry. The Council appointed Graham Custard as Technical Co-ordinator and commissioned him to write a book on hearing loss in industry, related particularly to attitudes to industrial noise.

There were several other changes during the year. Steve Battersby, of the Institution of Environmental Health Officers, who had acted as Assistant Secretary of the Noise Council since its formation, left the IEHO and was replaced by Graham Jukes. Additionally, new members were appointed by the supporting organizations. The membership of the Noise Council during

the year is shown below and our thanks go to all former members for their work.

Chairman:	Lord Elliott of Morpeth, DL
Vice-Chairmen:	H G Leventhall (IOA)
	B Camfield (IEHO)
Secretary:	C M Mackenzie
Assistant Secretary:	G Jukes
Technical Co-ordinator:	G R Custard
Representing IOA:	A D Wallis, B F Berry, I H Flindell, S W Turner
Representing REHIS:	J Stirling
Representing IEHO:	M Roberts, R Atherton, J Clegg
Representing IOSH:	W I Acton, P W P Anderson

REGIONAL BRANCHES

The Regional Branches of the Institute of Acoustics have been established to further the technical and social activities of the Institute at a more local level. The liaison between the Branches and the Meetings Committee is particularly important in extending the technical meetings programme of the Institute.

North East Branch

The first event of the year took place on 16 February 1988. This was a joint meeting held with the IERE in which Dr W G Allen of Newcastle Polytechnic gave a very interesting talk entitled 'Chips that Talk and Listen'. This talk was basically about speech being generated by microprocessors and computers and was demonstrated very well by a large number of electronic aids linked to a BBC microcomputer. This meeting was quite well supported and thoroughly enjoyed by all those present.

The meeting in March was a half day seminar entitled 'Vibrational Aspects of Condition Monitoring'. This too was a joint meeting, sponsored by the IOA, IERE and IMechE. Four speakers from various industries gave their presentations on the measurement and analysis of vibration monitoring in their particular sphere of interest. A number of instrumentation suppliers were also on hand to demonstrate their products. A total of 30 people attended which was a little disappointing as more were expected. This was a very interesting meeting in that it highlighted particular vibrational problems in a range of industries.

Since then it has been a quiet time for the North East branch with a general fall off in support for and interest in the Branch activities. This has been to a large extent to do with a scaling down of acoustics work in local industries with people's work being switched to other non-acoustic activities. Pressure of work on the Branch Committee members has also meant that it has not been possible for them to get together to organize future meetings and social events.

The Branch's future position is now under review with the possibility of suspending Branch activities unless more members come forward to serve on the Committee to help organize events and more members support future activities. It is also our intention to carry out a recruitment drive to get more new members involved in Branch activities. A new programme of events is now being considered and it is hoped that there will be a good turnout of members at the AGM in February in order that ideas and areas of interest can be identified and events organized to fulfil people's needs.

North West Branch

The best way of describing the NW Branch's year is by saying that it continued with a modest level of success. Again, as in 1987, there was limited activity, in some cases simply because of overcommitment by Officers of the Branch, in others due to business pressures within the organizations which were due to participate or to be visited. This led to no fewer than five cancellations in the programme published in January. The few events that did not fall victim to circumstance, or which were arranged subsequently, were reasonably well attended and new faces were warmly welcomed. A less ambitious but nevertheless comprehensive programme has been devised for 1989.

A happier feature of the year has been the increased participation in the activities of and future arrangements for the Branch by the students of the University of Salford. Although the full effect of their input will not make itself felt until the 1989 programme is implemented, we expect much mutually beneficial contact will be developed.

East Midlands Branch

This has been a bad year for the Branch, largely because of poor response from the membership in attending the meetings and visits that were arranged in the previous year. In an attempt to stimulate some vestige of interest a Christmas Social was arranged but in the event this had to be cancelled through lack of support. Serious consideration will have to be given as to whether it is viable for the Branch to continue to exist.

Scottish Branch

In terms of modern media hype, the Scottish Branch is entitled to claim a 50% increase in activity in 1988 as it held three meetings against two in 1987. In reality the record is even better than that, although 1987, it must be admitted, was a very quiet year. IOA activities in Scotland in 1988 included a very successful visit to the new acoustic facilities in the Department of Building, Heriot-Watt University, in February, a joint meeting with Edinburgh District Council in April on 'Inaudibility in the assessment of noise nuisance', a fascinating visit to the Royal Scottish Academy of Music and Drama in October and in December an excellent evening at the Department of Physics, Edinburgh University, on musical acoustics.

The Scottish Branch committee is very aware that it arranges meetings for an expected 15-20 members and friends and out of a total of 58 members, this represents a fair attendance. In 1989 the Scottish Branch hopes to arrange a joint meeting with the Royal Environmental Health Institute of Scotland, possibly on the topic of European legislation on noise.

In the course of 1988 the Scottish Branch Committee met on two occasions and sent its secretary to the Groups and Branches representatives meeting in London in September to raise questions on the level of subvention, the organization of income-generating meetings and the possibility of joint meetings with other Institutes. This is not to say that the Scottish Branch is in revolt or even complaining but indicates that the Committee is very aware of the need to promote acoustics in every way possible. Indeed the Committee believed that the feedback from the London meeting was very positive and the expectation of a higher minimum subvention for all Branches will enable them to plan more adventurous programmes.

The Annual General Meeting will be held in Glasgow College on 15 February 1989 and will be preceded by a meeting on aircraft noise.

Southern Branch

Southern Branch has continued with another year of full activity. The programme has again been a varied one, although the emphasis has tended more towards interests in environmental and community noise, reflecting perhaps the strong Environmental Health representation in our membership.

The year started with a very well-received account by Richard Clough and Bill Stubbs of Wimpey Laboratories of their experiences with the measurement and control of noise from piling operations near residential areas. This was followed by an equally comprehensive report by John Miller of Bickerdike Allen on problems of and solutions for good standards of sound insulation in property conversions. Later, Graham Custard gave us all an excellent insight into what may be in store with the advent of the hearing protection regulations in his outline of suitable strategies for reducing noise exposure in industry.

No programme of meetings on the general theme of environmental noise would be complete these days without a discussion on the eagerly awaited revision of British Standard BS 4142, and here we were fortunate to have had a presentation from John Sellar, a member of the revising committee, who brought us up-to-date on the way the new Standard is likely to move. Our year ended on the same high note with a splendid discourse by Mike Griffin of ISVR on the measurement and assessment of rail-induced vibration with particular reference to the interpretation of BS 6472.

In addition to matters environmental, the technical content of the year's programme was well represented by IAC's Derek Percy who enlivened the AGM in February of last year with his admirable summary of the state of the industrial noise control art, by Peter Henson of Bickerdike Allen and Bill Cory of Woods of Colchester who gave a noteworthy account of the pitfalls to be avoided when designing air distribution systems and when selecting and installing fans to power them, a joint meeting with CIBSE, and finally by R M Stewart who presented a most illuminating report on the design of fault-finding and diagnostic systems in modern helicopters.

In all, a very good programme in which interest, as expressed by meeting attendance at least, has been high. For this, credit is due to all our speakers and we are most grateful to them for supporting the Branch in this way.

Changes in Branch Committee membership during the year have included the retirement of Frank Fahy as Honorary Secretary, an office he had held for some three years. Frank's work was instrumental in maintaining the standard of Branch activities during that time and our appreciation of his efforts is gladly recorded. Southern Branch starts the current year with a new Committee under the Chairmanship of Brian Parker and they will be working to construct a branch programme of interest to all and would welcome suggestions and offers of assistance with activities from members at large.

London Branch

Although the London Evening Meetings have been held for many years, the London Branch has only been a legitimate entity for one year. It has been a very successful year, due in large measure to the efforts of the committee who have organized eight evening meetings which on average attracted 29 members, or put another way, just over 6% of the 333 person London Branch membership! The committee attempted to select speakers and subject matter that would appeal to a wide range of interests and not just restrict the meetings to public health topics although these still seem to attract the largest attendances. Our topics ranged from the theory and development of brass instruments to the noise generating mechanisms in the new class of unducted fan engines. On the way, we heard about sound insulation in dwellings and other community related topics.

Our one-day meeting in May was hosted by British Aerospace and included a very interesting visit to the high intensity noise facilities at Hatfield. We express our thanks to the Company for their generous hospitality.

The next year will continue to offer what we hope will prove to be a diverse and interesting series of London Evening Meetings with further half and full day meetings.

Eastern Branch

As most members will be aware, the Eastern Region Branch of the Institute of Acoustics did indeed get off the ground in October. The various Committee posts were allocated on the 'short straw' principle and most aspects of acoustics are covered by the members.

Three Committee meetings have been held and a programme of events for the coming few months has been organized. We do hope that members and non-members in the region will support the meetings and make this a successful Branch.

Yorkshire and Humberside Branch

No reported activity.

South West Branch

No reported activity.

Hong Kong Branch

No reported activity.

SPECIALIST GROUPS

The Institute as a whole reflects the broad span of the Science of Acoustics and a number of Groups have developed to foster closer contacts between members in various specialisms within this multi-disciplinary subject.

Speech Group

The Speech Group's technical meeting calendar for 1988 was dominated by the FASE Symposium, SPEECH '88, which was held in Edinburgh in August. The four-day programme covered a wide variety of speech topics including speech analysis, recognition, synthesis and coding, auditory modelling, phonetics, aids for the deaf and connectionism. Over 170 papers were presented. Earlier in the summer, Chris Darwin organized the second joint meeting between the Speech Group and its French counterpart – the Groupe Communication Parlée of the Société Française d'Acoustique – at Sussex University. This was a very successful meeting between the younger members of both communities. At the beginning of the year Sally Butterfield and Anne Cutler organized a one-day meeting on 'Prosody in Speech Recognition and Production' in Cambridge, and a meeting on 'Linguistic and Phonetic Knowledge Representation' was held in December at the University of Essex organized by Marcel Tatham and Katherine Morton. Also in December, the Group participated in an open meeting on 'Speech and Language Technology' held in Oxford to discuss a strategy for future speech and natural language research.

The Group's newsletter – *SPEAKEASY* – continued to provide a popular and convenient vehicle for the rapid dissemination of relevant Speech Group news and views throughout 1988. Five issues were published during the year, and the Editor, Dr Mark Huckvale (University College London), is to be congratulated on setting such a high standard of production and for providing such a valuable service to the UK speech community.

Also in 1988 the Group published a survey of UK speech research workers and research laboratories based on responses to a questionnaire circulated in 1987. The survey contains a description of the responsibilities and interests of over 70 speech researchers and it lists the areas of work and the facilities of 32 laboratories.

The Speech Technology Assessment sub-Group (STAG) steering committee met twice in 1988. The activities of STAG have been dominated by the need to monitor the progress of the Alvey project on Speech Technology Assessment (STA) and the ESPRIT project on Speech Assessment Methods (SAM). Discussions have also taken place on specific standardization topics and the sub-group is currently preparing a terminology definition document.

The programme of technical meetings for 1989 has yet to be finalized since it is going to be a busy year for international speech conferences in the UK and in Europe with the IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP-89, taking place in Glasgow in May and the 2nd European Conference on Speech Technology – EUROSPEECH – taking place in Paris in September. The Speech Group is currently planning to hold a one-day meeting on 'Phonetic Labelling of Speech Signals' on 24 February at University College London with Mark Huckvale as organizer.

Underwater Acoustics Group

Only one formal technical meeting was held by the Group this year: a tutorial day on the application of finite element methods to SONAR transducers. However, the Group did participate as co-sponsors in two other events during 1988; a 'SONAR simulation and modelling' one-day colloquium, organized by the Institution of Electrical Engineers and a large three-day conference and exhibition on 'Undersea Defence Technology' organized by a commercial company. The tutorial day was a new venture and involved a co-ordinated set of lectures and demonstrations on a specialist topic (in this case finite element methods applied to SONAR transducers), which were given by experts with the aim of providing delegates with a comprehensive, although somewhat rapid, review of the subject. This one-day event was felt to be a success and because it was relatively straightforward to organize, the Group intend to organize similar events in the future. A detailed report of the day was also published to provkde$phe delegates with a record of the talks.

Sales of past *Proceedings* of Group meetings continued well throughout the year with a total of 169 copies being sold. As in previous years it was encouraging to note that many of the customers were from abroad. All copies of past *Proceedings* are now held at Birmingham and the process of dealing with orders is efficient with an almost return-of-post response. This provides a useful income to the Group and ultimately the Institute and reflects the hard work put in by the Group treasurer; last year the money received by this route amounted to £1,669.38.

The draft manuscript of the book on SONAR transducers commissioned by the Group was completed towards the end of the year and is currently with reviewers; it is expected that this will be published soon. Also, a special feature on Underwater Acoustics appeared in the October *Bulletin* and the possibility of publishing this together with other research review papers is to be explored in the near future.

Physical Acoustics Group

During the past year the Group held a meeting jointly with IEE on 'Digital Signal Processing and Display Techniques for Ultrasonics' which was attended by 65 delegates. It attracted papers of a high technical content and was in all respects a very successful meeting. The Group had intended to participate in the Institute of Acoustics Spring Conference but was unable to do so because the local organizers failed to make the necessary provision in their programme

which was regrettable. The annual 'Review of Progress in Physical Acoustics and Ultrasonics' meeting was held at the University of Keele. This was an excellent meeting which attracted the largest ever number of contributions and attendees, despite problems caused by the postal strike. The Group AGM was also held during this meeting but it was a matter of some concern that a quorum was only just achieved.

The Group Committee has been instrumental in the plans for the formation of an Engineering Physics Division in the Institute of Physics and the Chairman has been closely involved during the year in the discussions with representatives of a number of other groups who were keen to set up the new Division. The IOP Council has agreed to the formation of this new Division and the PAG Committee look forward to participating actively in it in the future.

Members Newsletters were again produced in the Spring and Autumn. These contained reports of meetings, details of future meetings and a diary of events considered to be of interest to the Group members.

Musical Acoustics Group

The Committee is apologetic that due to circumstances beyond our control the Group has been inactive this year. However, Jim Woodhouse's organization of sessions on musical acoustics and auditorium acoustics at the Spring Conference provided for a variety of interests (including Jim's thoughts on the musical saw) and the Group is grateful for his hard work.

Building Acoustics Group

The main, formal activity of the Group was the organization of the technical content of the Autumn Conference held at the Hydro Hotel, Windermere, in November. The subject of 'Noise in and around Buildings' attracted 126 delegates, despite appalling weather conditions down south and the closure of the M6 due to a traffic pile-up. Over 40 papers were presented covering most aspects of noise production and transmission in buildings, the planning of internal and external spaces and the noise associated with building construction. Dr Mike Barron delivered the 1988 Tyndall Medal lecture on 'Reflections on Reflections in Concert Halls'. BAG also held its AGM during the conference, at which Dr Geoff Jackson retired after eight years as chairman, to be replaced by Jeff Charles. The other new addition to the committee was Dr Raf Orlowski.

Industrial Noise Group

Following the major involvement in the Autumn Conference at Windermere in November 1987 there have been just two one-day meetings during 1988. However, these meetings together covered the areas of interest of almost all Industrial Noise Group Members.

The first was an open discussion/workshop to discuss the Health and Safety Commission Consultative Document 'Prevention of damage to hearing from noise at work'. The meeting was self-financing and provided an excellent forum in which to discuss this key document. Distilled comments were forwarded to the HSC, together with the IOA proposals for a 'Certificate of Competence' training course. All comments were very favourably received.

The second meeting was held at North London Polytechnic, to discuss the revised British Standards Institution draft of BS 4142. This was again an open discussion format and was very well attended, with 116 delegates present. The interests of the Aerodynamic Noise Group were catered for by a session at the Spring Conference at Cambridge concerning aircraft and aero-engine noise.

1989 promises to be quite a busy year with two one-day meetings planned and the full Autumn Conference again at Windermere in November.

Table 1. Details of Institute Membership

GRADE	*1987*	*1988*	*Applications in 1988*	*Successful Applications in 1988*
Fellow	200	202	9	6
Member	779	825	96	71
Associate	437	461	126	126
Student	37	38	12	12
TOTAL	1453	1526	242	215
Hon Fellows	15	13	—	—
Sponsors	15	15	—	—

Table 2. Group Membership

	1986	*1987*	*1988*
Underwater Acoustics	123	105	150
Industrial Noise	551	445	638
Speech	102	95	119
Musical Acoustics	94	86	123
Building Acoustics	336	318	412
Physical Acoustics	61	69	97

Table 3. Branch Membership

	1986	*1987*	*1988*
North East	42	41	56
Southern	391	174	267
South West	72	62	107
North West	123	103	163
Yorkshire & Humberside	48	37	87
Hong Kong	67	64	80
East Midlands	102	68	139
Scottish	63	53	79
London	—	223	333
Eastern	—	—	108

Proceedings of the Institute of Acoustics – Abstracts

Acoustics '89

The 1989 Spring Conference of the Institute of Acoustics, held in University College, Oxford, 3-6 April, 1989 (Conference Organizer, Dr H G Leventhall; Technical Sessions Co-ordinator, D Sims)

A1 OUTDOOR SOUND PROPAGATION

Developments in BIE methods for outdoor sound propagation

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Department of Mathematics, Coventry Polytechnic and
D C Hothersall
Department of Civil Engineering, Bradford University

This paper commences with an explanation of how boundary integral equations (BIEs) arise in acoustics, and their physical interpretation. As particular examples, standard BIEs for scattering by rigid and transmitting obstacles in an infinite homogeneous medium are discussed. These examples are extended to develop novel BIEs for scattering by a partially transmitting obstacle above an impedance plane, and for propagation of noise from out of a depressed region within an otherwise flat plane. The problem of non-uniqueness of solution of some of the obvious BIEs in acoustics is mentioned.

A simple boundary element method for solving the BIE for scattering by a rigid obstacle is described. This boundary element method is easily adapted to the other BIEs given in the paper. The influence of element size on solution accuracy is discussed. Efficient BIE methods for outdoor sound propagation make use of the Green function for reflection at a locally reacting or extended reaction plane. The general method by which these Green functions may be evaluated is mentioned.

The boundary element method reduces the BIE to a set of linear algebraic equations. Recently developed methods for solving these equations efficiently are reviewed. The case of scattering by a vertical barrier on flat ground illustrates the special matrix structures that can occur. A complementary prospect for reducing computing times is the use of element shape functions which can accurately represent an oscillatory wave field on a boundary. This approach is illustrated by numerical solution of a BIE for acoustic scattering by an inhomogeneous region within an impedance plane.

Acoustic scattering by sub-surface inhomogeneities

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Department of Mathematics, Coventry Polytechnic

The application of boundary integral equation (BIE) methods to the problem of acoustic scattering is widely known. Here the method is used to predict the acoustic field, due to a point source in a homogeneous quiescent atmosphere, above an homogeneous rigid porous half-space containing a rigid inhomogeneity.

The three-dimensional physical problem is first formulated as a boundary value problem; the BIE is then derived by a standard reformulation via Green's Second Theorem. The resultant equation requires knowledge of the Green's function for transmission between the atmosphere and the porous half-space in the absence of the inhomogeneity. Methods for calculating this Green's function are discussed. The numerical solution of the BIE by a simple quadrature method is then described. Briefly, the pressure field due to the point source is determined on the surface of the inhomogeneity by forming and solving a set of linear algebraic equations. The numerical method of solution is applicable to any smooth rigid inhomogeneity which is axisymmetric about a vertical axis. The axisymmetry ensures that the coefficient matrix for the linear equations is block circulant, a structure that can be exploited to obtain a solution efficiently.

Results of numerical calculations are presented in the form of excess attenuation spectra for varying sizes and depths of burial of the inhomogeneity, and are compared with experimental measurements.

Long distance sound propagation over grounds

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Department of Civil Engineering, University of Bradford and
S N Chandler-Wilde
Department of Mathematics, Coventry Polytechnic

Three dimensional problems of long distance sound propagation from a point source are often too computationally expensive to solve exactly. Attention here is focused on the effects of impedance inhomogeneities in the ground. The problem is simplified by assuming a homogeneous, still atmosphere and a flat ground. When the impedance inhomogeneities occur fairly symmetrically about the vertical source-receiver plane, a two dimensional boundary integral equation can be used to obtain accurate results. If the ground then consists simply of two constant impedance regions, a plausible approximate solution to the integral equation can be used, so that the acoustic field is expressed simply as an integral over part of the boundary. However, the usefulness of this approximation is limited by the computation time required for evaluation of the integral.

In this paper an improved method of integration is presented. The method involves replacing part of the integral with a simple approximate expression suggested by asymptotic analysis at large wavenumber. The extent of replacement is automatically decided by insisting that simple error criteria are met. For typical error criteria integration time is reduced significantly, allowing a wider range of propagation conditions to be efficiently examined.

Results for long distance propagation over ground with two constant impedance regions are presented.

Numerical modelling of noise propagation over barriers

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S N Chandler-Wilde
Department of Mathematics, Coventry Polytechnic

An approximate method, which has been widely used to calculate the attenuation of noise by barriers, combines ray tracing techniques and the results of the Geometrical Theory of Diffraction. An alternative approach, which offers potentially improved accuracy, is to determine the acoustic wave field using the boundary integral equation method. This method allows results for barrier attenuation to be obtained for structures of any cross-sectional shape and distribution of surface type. Thus comparisons can be made of the acoustic efficiency of a range of barrier designs.

The two-dimensional numerical model will be briefly described and its advantages and disadvantages discussed. In its present form the use of the model is limited by the computing resources required, and, for certain, very restricted conditions, the method fails to provide unique solutions to the wave equation.

Calculated results of insertion loss will be presented for a variety of single barrier shapes and distributions of surface impedance, and the efficiency of the designs discussed. The two dimensional calculations will be compared with experimental model measurements using a point source of sound and excellent agreement will be observed.

Validity of approximate techniques for solving nonlinear acoustic propagation problems

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We consider the propagation of weakly nonlinear acoustic waves in a thermoviscous dissipative medium and subject to ray tube area variations. Problems of this kind are described by generalizations of Burger's equation, for which almost no exact solutions exist. Progress can be made through asymptotic theories based either on small diffusivity or large signal amplitude. However such asymptotic theories are cumbersome for the experimental worker and so much simpler approximations have been used in the past. As well as being simpler, these methods have the advantage of being physically more appealing; however the approximations made are not at first sight entirely rational. This paper compares two particular approximate methods associated with the names of Shooter, Muir and Blackstock, and Rudnick, with the rigorous asymptotic analyses. It is demonstrated why the approximate methods are useful for certain physical situations but not for others. In particular, the approximate methods are found, in many cases, to reproduce exactly the

rather intricate formulae furnished by the asymptotic procedures.

Interface waves at air/air-filled poroelastic media boundaries

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The dispersion equations for (a) an air/air-filled poroelastic half-space and (b) an air/air-filled poroelastic layer/poroelastic half-space configuration have been derived in matrix form. The roots of the corresponding determinant have been determined numerically. It is found that three surface waves are possible on the surface of an air-filled poroelastic half-space. One of these corresponds to the surface wave frequently predicted in the solution for the field due to a point source above an impedance boundary. However the dispersion and attenuation are less than predicted over a rigid porous half space. Nevertheless, it is highly attenuated. The second surface wave type is a pseudo-Rayleigh wave having low dispersion but fairly high attenuation. The third type has very little attenuation or dispersion and travels close to the P-wave speed.

On the poroelastic layer system interface, four modes have been found; three of which may be of practical significance. In particular there is a mode that travels near to the speed of sound in air and is identified clearly with the air-coupled Rayleigh wave frequently cited in the literature. A high speed mode with little dispersion or attenuation and travelling faster than the upper-layer P-wave speed has been identified.

Sound propagation over layered ground

S Tooms and K Attenborough
Faculty of Technology, The Open University

A fast field program, with corrections to reduce spurious oscillations in predictions, is presented, as a tool for studying sound propagation from a point source over a ground which is allowed to be a multiply layered poroelastic medium having parameters based on a modified Biot Stoll model, and thus introducing the possibility of three body wave types in each layer. The effect on propagation of introducing elasticity in the frame of the ground is examined by comparison with a rigid-frame limit of the model for both soil-like and snow-like parameters. Results of some measurements over snow and wet soils are explained in terms of rigid-framed and elastic-framed multiply layered models.

B1 PHYSICAL ACOUSTICS AND ULTRASONICS

Deconvolution by the maximum entropy method as applied to ultrasonic surface characterization

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Ultrasonics Research Group, University of Aberdeen

As part of wider research into surface texture measurement using ultrasound, we have undertaken an examination of the Maximum Entropy Method (MEM). This paper presents aspects of this work which considers the influence on the MEM output of the frequency content of the data. The results clearly demonstrate a potential advantage of the non-linear MEM over conventional linear filters such as the Wiener-Hopf filter.

The examples presented here involve the deconvolution of simulated data, chosen to resemble echoes of ultrasonic pulses from a sample surface. They have been carried out with variable added noise on both functions to demonstrate the noise suppression property of the MEM. If the frequency content of the data is restricted (due, for example to an experimental limitation), examination of the power spectra of the deconvolved results shows that there is little visible difference between these and the full frequency results. This 'frequency extension' property is conclusively demonstrated by comparing with the Wiener-Hopf filter.

The paper concludes with a demonstration of some real test results using 10 MHz and 40 MHz compressional-wave transducers operating in pulse-echo mode and stepped surfaces. The implications of these results are discussed, and we give a heuristic argument for the 'frequency extension' property.

Acoustic nonlinearity parameters and higher-order elastic constants of crystals

J H Cantrell
Cavendish Laboratory, University of Cambridge

The acoustic nonlinearity parameters are playing an increasingly important role in the description of fundamental properties of materials. The parameters appear, for example, in the thermodynamic state functions and in the equations describing the thermal expansivity of solids. They appear as scaling parameters in the equations for the acoustic radiation stress and radiation-induced static strains. They are also found to be strongly correlated with the Brinell hardness numbers of metallic alloys. It is shown that the magnitudes of the nonlinearity parameters strongly depend on the crystalline structure of the solid and that the dependence for many structures is dominated by the ionic core-core repulsive exchange interactions of neighbouring atoms. Measurements of the nonlinearity parameters are used to calculate the Born-Mayer 'hardness' parameters for several crystals of cubic symmetry. The results are in good agreement with values of the parameters determined from other methods. The Born-Mayer parameters together with sound velocity measurements are then used to calculate the elastic constants of orders two through five for the crystals. The complete set of fifth-order elastic constants for the most symmetric cubic classes is presented. It is found that the magnitude of the elastic constants of each order is approximately a factor of ten larger than the magnitude of the previous order and is opposite in sign.

Piezoelectric detection of signals in scanning electron acoustic microscopy

M Qian and J H Cantrell
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Scanning electron acoustic microscopy (SEAM) is a very useful tool for assessing near subsurface structures of materials. In order to understand the contrast mechanisms in SEAM, the relationship between the output signal of the receiving piezoelectric transducer and the thermoelastic properties of the sample must be determined. We assume that the electron beam is square-wave modulated at angular frequency ω and the thermal power density $H(r,z,t)$ of the heat source generated by the electron beam is nominally of the form:

$$H(r,z,t) = (2\eta P_0\beta/\pi^2a^2)\exp(i\omega t - \beta|z - z_0| - 2r^2a^{-2})$$

where η is the fraction of the primary electron beam power P_0 ($=I_0V_0$) converted to heat power, I_0 is the beam current, V_0 the accelerating voltage, and β is the attenuation coefficient. Both β and z_0 are dependent on V_0 and the properties of the material. Solving the thermal conduction equations for the sample and transducer, we obtain a two-dimensional temperature distribution which is used together with the thermoelastic potential function $\psi(r,z)\exp(i\omega t)$ to solve the Navier-Stokes equation for the acoustic strain amplitude in the sample. Using the piezoelectric equations we solve for the strains in the transducer from which the transducer output signal is obtained. The signal is generally proportional to the incident power P_0 and depends on the thermal and mechanical properties of the sample. This is in agreement with typical experimental findings for which thermal sources are the primary driving mechanism for acoustic signals.

The pulse enhancement of unstable cavitation by mechanisms of bubble migration

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M J W Pickworth and P P Dendy
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When ultrasound passes through a liquid, bubbles may be produced. These can subsequently collapse, adiabatically heating the gas contained to several thousand kelvin, creating free radicals. The radicals may undergo radiative recombination, giving rise to sonoluminescence. Therefore the presence of sonoluminescence may indicate potential biohazard.

Experiments have shown that, when ultrasound is pulsed, the amount of sonoluminescence may increase, contrary to the expected result. Two theories for this are proposed, tested, and found to be satisfactory. Both rely on the migration of bubbles away from bubble aggregates during the off-time of the insonation. Such migrations would: (a) reduce local degassing of the liquid at these aggregates, so promoting bubble growth by rectified diffusion there; (b) remove regions which have an acoustic impedance very different from that of the pure liquid (and would thus otherwise attenuate the passage of sound to the bubbles).

Experiments with agar gels of varying viscosity suggest that both mechanisms work together. The driving force for these migrations could arise through (i) buoyancy, (ii) acoustic streaming forces, or (iii) a coupling of the acoustic pressure field with the bubble oscillation at the end of each sound pulse. Calculations show that the particular driving force dominating in a given regime is frequency-dependent: for therapeutic ultrasound (operating at 1 MHz), process (iii) is responsible for the migrations.

Reflection from media with continuous variation of density, sound speed and attenuation

R C Chivers
Physics Department, University of Surrey

In many physical situations such as the decreasing porosity of sea sediments, the acoustic properties of the medium vary in a continuous way, rather than exhibiting discontinuities in such parameters as impedance. An analysis is presented to calculate the manner of reflection from continuously varying lossless media and it is shown to depend primarily on the gradient of the characteristic acoustic impedance.

Induction of continuously varying losses is complicated by the need for incorporating its strong frequency dependence. It will be shown that a procedure can be developed to analyse this

situation provided that the user assumes, at least at the end of the problem, that the interrogating waveform will be a long toneburst with a relatively narrow bandwidth.

Ultrasonic absorption measurements in thin films of adhesive polymers

R E Challis and T Alper
University of Keele

A novel wide bandwidth pulse transmission technique has been developed for the study of near plane wave ultrasound propagation in thin adhesive layers (down to 0.1 mm) set between aluminium or glass substrates. Acoustically thick PZT transducers in coaxial alignment are clamped on either side of the substrates; the transmitter is driven by very short voltage transients (120 V × 5 ns) and the receiver is terminated with a common base header amplifier. The signal received consists of a series of time resolvable multiple reverberations from the bond layer which are successively broader in the time domain due to the effects of absorption and velocity dispersion in the bond. The shapes of successive reverberations are compared in the frequency domain using conventional methods based on the FFT. Changes in the amplitude spectrum are used to calculate absorption as α, $\alpha\lambda$ or α/f^2 versus frequency in the range 1 MHz to 50 MHz. Calculations are also made of phase velocity versus frequency. Preliminary results for an epoxy adhesive at three stages of cure are presented.

A wide bandwidth ultrasonic absorption spectrometer for liquid materials

R E Challis and A K Holmes

University of Keele

A novel spectrometer instrument has been developed for measuring ultrasonic near plane wave absorption in small volume samples of liquids over bandwidths up to 60 MHz. In principle the bandwidth could be increased to 100 MHz. The instrument is controlled by computer and on-line digital signal processing is used to correct for transducer insertion, radiation coupling, and electronic circuit responses. The data acquisition time is short and the instrument can be used to estimate wide bandwidth absorption spectra at intervals of 100 ms. The instrument can therefore be used to study the dynamics of systems undergoing chemical reaction. Experiments have been performed which show excellent agreement between absorption measurements made with the instrument and with traditional (slower) techniques.

C1 WARNING SIGNALS AND BEHAVIOURAL RESPONSE

Guidelines for the design of auditory warning sounds

R Patterson
Medical Research Council, Cambridge

Aircraft have as many as 15 warning sounds to alert the crew to danger. The Civil Aviation Authority was concerned that the warnings were confusing and too loud. They asked the Applied Psychology Unit of the Medical Research Council to review the situation and to produce some optimal auditory warnings in accordance with the basic principles of human hearing. The result was a general method for analysing noise environments and producing ergonomic sets of auditory warning sounds. The method has been applied to environments as diverse as intensive care wards in hospitals, the flightdecks of North Sea Helicopters, and railway trackside maintenance.

The talk will review the design issues and illustrate the results.

Effects of audio warning format on subject response times

S H James and M R James
Royal Aerospace Establishment, Farnborough

A preliminary investigation into the effects of warning format on response times to auditory warnings used three warning formats – voice messages only, voice messages preceded by an alerting 1 kHz tone and voice messages preceded by a prioritized alerting signal (attenson). For each format, subjects were required to respond by pressing the key on a keyboard that was correspondingly labelled to the voice message presented in the warning. There were 9 voice messages and each was presented 5 times per session. Subjects attended seven sessions; one training and one for each warning format for two keyboard layouts. The keyboard layouts were Blocked (warnings grouped in their priorities) and Scrambled (warnings in a randomized layout).

The results show that the subjects were able to respond significantly faster with the prioritized alerting signals than with the 1 kHz tone which was in turn significantly faster than to the voice mesages alone. Also, in all format conditions the Blocked keyboard enabled subjects to respond significantly faster than the Scrambled keyboard. These results provide design guidance for the introduction of auditory warning systems into high stress environments.

The event-related potentials of the human brain to target and nontarget stimuli in one-channel and selective listening tasks

S Mäntysalo
Institute of Occupational Health, Finland
Anthony W K Gaillard
Institute for Perception, The Netherlands

In both tasks the event-related potentials (ERPs) to phonetic target and nontarget stimuli were recorded in one-channel listening conditions. The stimuli were eight, each equally probable meaningless consonant–vowel syllables of which one, or two, or all were targets to be counted in a stimulus block. Also the stimulus blocks where all the stimuli had to be ignored were provided.

The ERPs to the targets displayed a slow frontal negativity (NSW) and a slow parietal positivity (PSW) while the ERPs to the nontargets displayed a NSW only. The NSW was smaller while the PSW was larger in the 1-target than in the 2-target conditions. The NSW was larger for the nontargets than for the targets. Additionally, in the ERPs to both targets and nontargets, an early negativity (EN) was disclosed in relation to the ignore condition. N1 and N2 were larger for the 1- and 2-target conditions than for the all-targets and ignore conditions. N2 was larger for the nontargets than for the targets.

The positive and negative deflections of the ERPs differentiated between the stimulus processings, and between the 1T- and 2T-tasks, and were related to different phases of controlled stimulus processing. The results are discussed in association with stimulus encoding, target detection, and allocation capacity.

Sound levels for the British Rail Inductive Loop Warning System

M C Lower
ISVR, The University, Southampton
R D Patterson, P. Cosgrove and R Milroy
MRC Applied Psychology Unit, Cambridge

The Inductive Loop Warning System (ILWS) is being developed by British Rail Research to give advance warning of approaching trains to track maintenance gangs. The warning sounds generated by the system must be loud enough to be heard reliably by the operator, but not so loud that they are aversive, cause startle, interfere with thought or communication, or add significantly to the operator's noise dose. The system must also provide for the use of a noise-excluding headset in high noise levels.

The noise levels and spectra produced by representative plant, machinery, tools and trains were analysed for typical and worst-case positions occupied by the ILWS operator and the optimum warning sound level was predicted for each case using guidelines developed by Patterson (1982). The optimum spectrum for the warning sounds was also derived.

The range of noise levels was such that a single warning level would not be adequate for all situations, and a rule for setting the warning sound level in relation to the background noise was derived. Strategies for implementing this will be described.

Auditory warnings for the British Rail Inductive Loop Warning Systems

R D Patterson, P Cosgrove and R Milroy
MRC Applied Psychology Unit, Cambridge and
M C Lower
ISVR, University of Southampton

A set of four warning sounds has been produced for the Inductive Loop Warning System (ILWS) being developed by British Rail Research to give advanced warning of approaching trains to track maintenance workers.

The warning sound currently employed by BR (referred to as the PeeWee) was reviewed with regard to the guidelines for auditory warning sounds suggested by Patterson (1982) and was found to be broadly suitable.

The ILWS uses a total of four warning sounds. In order of greatest urgency these are Alarm, Reminder Warning, Qualified Safetone, and Safetone. The four new sounds were all produced from the original PeeWee sound to preserve the association between sound and function.

The paper illustrates the methodology used in designing the warning sounds with examples given.

A2 OUTDOOR SOUND PROPAGATION

Remarks on the numerics and on the modelling of spherical-wave propagation above absorbing ground

F P Mechel
Fraunhofer-Institut für Bauphysik, Stuttgart

A central problem in the analysis of propagation of spherical waves above absorbing ground has its eightieth anniversary this year. It is the question of the existence or non-existence of surface waves above absorbing grounds and the question of their practical importance. These question were raised in 1909 by Sommerfeld and they are still discussed controversially in the

recent literature. Problems arise only in the context of search for approximate solutions to the known exact analytical solutions of the sound field. Maybe the question is still open because, up to now, only different approximations are compared among each other. The difficulties of the immediate numerical evaluation of the exact solutions are solved by exact methods of acceleration of the convergence of the infinite integrals, and by an exact formulation of the steepest-descent integral formulation. Different approximations existing in the literature are evaluated numerically and compared to the results of these exact integrations. So it was possible to arrange these approximations according to simplicity and precision.

Further, the problem of the surface waves will be discussed, and it will be shown that neither of the statements that surface waves do exist nor that surface waves do not exist is true in a general sense. It is shown that surface waves do not exist (or at least are not important) above absorbing grounds of the lateral type. On the other hand, they do exist above locally reacting absorbers under conditions of practical interest, and in this case have a large influence on numerical results. Next, the observation that many second-order approximations in the literature produce numerical results which are worse than first-order approximations will be discussed briefly. Finally, some principal problems in connection with modelling of real grounds will be demonstrated.

Calculation of sound propagation from a point source over an impedance boundary

C Howorth, K Attenborough and N Heap
The Open University

It has been asserted recently (PhD Thesis, S Chandler-Wilde 1988) that the powerful asymptotic approach developed by Thomasson (*Acustica*, Vol. 45) is likely to be more accurate than that used by Kawai et al. (*Journal of Sound and Vibration*, Vol. 83). This assertion is checked by comparing numerically the output from both approximations with a numerical integration scheme based on adaptive quadrature. Furthermore, both approximations and the numerical integration method are compared with the widely used Weyl van der Pol calculation. The indications of differences in the predictions when considering ground effect characterization (with reference to level difference measurements) and in situ measurement of impedance near grazing incidence are considered.

The ground wave in outdoor sound propagation

J Wempen
Universität Oldenburg

The theory of outdoor sound propagation predicts the occurrence of a ground wave if the ground is not acoustically hard. The ground wave dominates the sound field at low altitudes, where the plane wave assumption predicts a complete destructive interference of direct and ground reflected waves.

The dependence of the ground wave on the properties of different surfaces is investigated through measurements of magnitude and phase of sound transmitting from source to receiver close to several grounds. Measurements at different distances and over different grounds are discussed. They are compared to theoretical predictions resulting from different models for the acoustical behaviour of the grounds. The variation of measured excess attenuation functions with distance is shown to be a measure for the frequency dependence of the ground impedance. Measured impedances for several grounds (sand, silt, grass covered and snow covered surfaces) are presented.

B2 INSTRUMENTATION

Calibration at high power of pulsed underwater transducers

R A Hazelwood
Aconics Partners

Full characterization of high power underwater acoustic transducers involves making all measurements at the maximum power level. This requires a change to the standard techniques used to calibrate transducers which are otherwise assumed to be linear, with electrical admittance properties independent of power level. When this assumption cannot be justified it becomes necessary to make the admittance measurements at the same time as the sensitivity measurements. The resultant knowledge of the characteristics of the transducer at high power can then be used to optimize the matching networks and power amplifier for the most critical condition of peak power output.

As well as being power level dependent, the characteristics will often also be time dependent, and it is necessary to be able to make these measurements on short pulses which can apply high stress levels without unrealistic heating occurring. Measurements made in this time will also be completed before echoes are received from the tank walls.

Recent developments in digital oscilloscopes have made such measurements much easier than before and when linked to a suitably programmed computer a wide range of options becomes available. Results will be presented to show the utility of these techniques.

Measured transducer field distributions for improved ultrasonic measurement and imaging

J R Blakey, R C Chivers and R A Bacon
Physics Department, University of Surrey

The key element in any ultrasonic measurement or imaging system is the transducer. In quantitative measurements of velocity, attenuation or scattering it is necessary to account for the effects of the finite apertures of the transmitting and receiving transducers. This is conventionally achieved by including diffraction effects based on an idealized model for the transducer behaviour (e.g. a pistonlike or Gaussian surface vibration distribution). With the development of miniature hydrophones and methods for calibrating them, it is possible to make measurements which identify the real behaviour of the transducers (as compared with that of the ideal model). This can be achieved in two ways which will be discussed in the present paper. The first is to use a small number of amplitude measurements of the field radiated by a transducer in order to define effective dimensions which may be inserted into the ideal theoretical model.

The possibility of making both amplitude and phase measurements of the field distributions raises the second possibility of the inclusion in the signal processing of the actual field (as opposed to the good approximation provided by the effective parameter approach). This involves measurement over a surface of regular geometry and extrapolation (propagation) to the surface of interest. The limitations that arise in practice will be discussed in detail.

Some applications of reciprocity to acoustic and vibro-acoustic problems

F J Fahy
ISVR, The University, Southampton

Many acoustical and vibro-acoustical experiments involve the determination of relationships between controlled inputs and resultant responses. Physical constraints, such as lack of space, inaccessibility of the input point, or problems of connection of the input device, may make direct measurement very difficult. Provided that a system under test is linear, it may be possible to take advantage of the Helmholtz/Rayleigh theorem of acoustic reciprocity, or the Liamshev theorem of vibro-acoustic reciprocity, to overcome, or reduce, these difficulties.

The paper will begin with a brief review of reciprocity principles, physical means of implementation of reciprocal measurement techniques, and their practical advantages and disadvantages. Some recent examples will then be presented of the use of reciprocity in investigations of sound radiation from vibrating bodies, sound transmission through aircraft fuselage walls, performance of acoustic screens and radiation of sound from ventilation ducts. Possibilities for exploitation of reciprocity in other noise control problems, particularly inside vehicles, will be discussed.

A two-microphone technique for measuring acoustic impedance in the free field: effects of sample area and microphone positioning

D C Waddington and R J Orlowski
University of Salford

To predict accurately the sound field in an enclosure, particularly if the sound field is not diffuse as in a factory building for example, it is necessary to have accurate data on the acoustical absorption of the various surfaces. This includes the variation of absorption with angle of incidence. To enable such data to be obtained, a free field method has been developed using a two-microphone transfer function technique to obtain detailed information on the acoustic impedance of a surface.

Taking the approximations to calculate the spherical reflection coefficient for a locally reacting boundary as presented by Madry and Fricke, the impedance of the surface is obtained by an iterative process from the transfer function between the two microphones, and from the geometry of the microphones, source and sample.

The measurement accuracy is determined by three factors: (i) the phase mismatch between the two microphone channel instrumentation systems; (ii) the accuracy of measuring the distance of the microphones from the sample; and (iii) the diffraction of sound waves from the edges of the sample, which is related to sample area.

In this paper we are particularly concerned with the effect the sample area has upon the measured result. To date a number of sound absorbing layers have been measured based on glasswool. These have included the following configurations: air backing, hard backing, covering with a thin membrane, and covering with a perforated panel. Measurements have also been made on soft grassland. In all cases, the results have agreed well with accepted theory.

C2 WARNING SIGNALS AND BEHAVIOURAL RESPONSE

Auditory warnings for fixed and rotary wing aircraft

G M Rood
Royal Aerospace Establishment, Farnborough

Research carried out by RAE Farnborough, MRC Applied Psychology Unit, Cambridge and ISVR, University of Southampton has culminated in a series of recommendations that allow audio warning parameters to be accurately set to ensure complete detection and classification of a warning in noise. Audio levels may be determined and set by taking into account the environmental noise levels, type and acoustic performance of the hearing protector, telephone response of the protector communication earpiece and level of communications and communication load, in addition to using a computer model to predict the noise masked threshold of the subject.

Using the same computer model the ideal spectral distribution of the warning sound may be determined for a particular set of circumstances – which in many cases may be carefully, but successfully, generalized – for instance, over a number of different types of helicopter cabin noise spectra.

An audio warning philosophy has also been determined for aircraft use and this involves the construction of audio warning attensons which have the correct perceived and relative urgency, that are not able to be confused with each other and have an acceptable number of warning priority rankings.

The paper discusses the implementation of audio warnings into helicopters and fixed wing aircraft and the laboratory and simulator research and development phases leading to this implementation, with some indications of future research.

The effects of spectral, temporal and musical parameters on the perceived urgency of auditory warnings

J Edworthy, S Loxley, E Geelhoed and I Dennis
Department of Psychology, Plymouth Polytechnic

Advanced auditory warning design allows a certain degree of matching between the subjective response to the warning and the situation which it is signalling. One important dimension along which matching can take place is that of perceived urgency, such that situations of low priority can be signalled by low urgency sounds and high priority situations can be signalled by high urgency sounds. Many different sound parameters affect the urgency of a warning. This paper presents a systematic study of the effects of many of the spectral, temporal and musical parameters on subjective assessments of urgency. Parameters investigated include harmonic series, amplitude envelope, speed and rhythm, pitch range and pitch contour. The data indicate the nature and the strength of the effects of individual sound parameters on perceived urgency, the consistency of response both within and between subjects, and correlations between responses. Sets of warnings varying in their degree of urgency were designed on the basis of the results and when tested, a highly significant correlation between prediction and result was obtained. This indicates the applicability of the findings to the design of auditory warnings. Ways in which the findings can be applied are proposed in the conclusion to the paper.

The specification of a site-wide toxic alarm system for a large chemical complex

G Taylor
ICI plc

This paper describes the work carried out to determine the specification of a site-wide toxic alarm system for a large chemical complex.

The outdoor sound propagation characteristics of stationary and rotating high power alarms were measured on site and the results used to determine the layout and philosophy of the site system. Tests carried out after installation confirmed the validity of the work.

Auditory icons

W W Gaver
Rank Xerox, Cambridge

Auditory icons are everyday sounds meant to convey information about computer events by analogy with everyday events. Sets of auditory icons can be used to create a relatively continuous, intuitively accessible auditory environment for users. This requires that auditory icons be relatively unobtrusive so as not to distract or annoy users, in contrast to audio alerts which are designed to be noticed. The concept of auditory icons presented in the paper is based on the observation that people listen to the world in order to gain information about the events occurring in it, and the notion that sound can be used in computers as it is in everyday life.

These ideas are instantiated in the SonicFinder, which is an auditory interface developed by the author at Apple Computer. In this interface information is conveyed using auditory icons as well as standard graphical feedback. The paper discusses how events are mapped to auditory icons in the SonicFinder, and illustrates how sound is used by describing a typical interaction with this interface. Finally the paper speculates about the future of such interfaces.

A3 OUTDOOR SOUND PROPAGATION

Acoustical characterization of ground surfaces

H M Hess, K Attenborough and N W Heap
The Open University

In recent years short range measurements of excess attenuation when used in conjunction with semi-empirical formulae for impedance frequency characterization have been advocated for acoustical characterization of ground and as a basis for predicting ground effects at longer ranges. An alternative method is described for determining acoustical properties of ground surface including sands, soils and snow from iterative least squares fitting of the level difference spectrum between a pair of vertically separated microphones. The method is based on a three parameter model for the surface normal impedance as a function of frequency together with well established formulations for propagation from a point source above either local or extended reaction surfaces. The three parameters are porosity, effective flow resistivity and tortuosity. Independent (non-acoustic) measurements of porosity compare tolerably well with the acoustically-determined values for soils that are homogeneous to several centimetres depth. For such soils, fitting comparisons reveal the superiority of the three parameter impedance model to the single parameter semi-empirical model. Where there are obvious surface crusts a double layer model based upon a two parameter approximation for the characteristic impedance of each layer is found to give better agreement with short range propagation measurements than the three parameter homogeneous approximation. Finally the feasibility is discussed of deducing the acoustical properties of the ground directly from parameters measured non-acoustically.

The prediction of sound from a panel radiating over an impedance plane

K Attenborough, N W Heap and K M Li
The Open University

Previously ground effect has been predicted only for point or line sources. On the other hand theories for propagation from a radiating panel have excluded ground effect. By using well-established representations for propagation from a point source above an impedance boundary and for a grassland-type impedance as a function of frequency, and by numerical integration assuming coherency of panel elements, the sound field in front of a panel radiating either uniformly or in simplest mode shapes over grassland is predicted. It is found that only the vertical distribution of particle displacement on the panel has a significant effect on the predicted sound field. At certain frequencies depending on panel height and the ground impedance considerable departures are predicted from the expected decay per distance doubling in the absence of the ground plane.

Reverberation and attenuation by trees; measurements and models

W H T Huisman
University of Nijmegen

In summer 1987 extensive measurements of vegetation structure, micro meteorology and sound transmission were made in a pine forest. Sound transmission over 100 m appeared remarkably constant during a full week, whereas a ray tracing model that neglects tree scattering predicts considerable variation as a consequence of sound speed profiles. This leads to the conclusion that within the forest the tree scattering dominates over meteorological effects.

A stochastic ray tracing model has been formulated that neglects meteorology and ground but accounts for scattering by trunks and air absorption. The predicted pulse responses were integrated to give attenuation and summed over time to give the response to a source on/off sequence.

Measured source off responses and attenuation are explained tolerably well by fitting the effective scattering diameter and reflection coefficient of the trunks. The relationship between this work and that by others on propagation through scatterers is discussed.

Creeping wave theory applied to impulse propagation in the atmosphere

C G Don and A J Cramond
Chisholm Institute of Technology, Victoria, Australia

A residue form of creeping wave theory has been applied to a comprehensive set of impulse propagation data taken over grassland in the presence

of wind and temperature gradients. While the theory copes with changing the geometry and ground impedance, significant discrepancies occur in the predicted excess attenuations of the impulse amplitudes deep inside the shadow zone when a linear sound speed gradient is used. Moreover, the calculated impulse waveforms suggest that fast risetimes remain beyond the boundary, negating a suggested technique for locating the boundary. An empirical method of using the measured non-linear sound speed gradient has resulted in a markedly improved agreement with the experimental results.

Pulse propagation into the acoustic shadow produced by wind speed and temperature gradients close to the ground

M West, F Walkden and R A Sack
University of Salford

An improved formulation of the residue series solution for creeping wave propagation together with the use of computed micrometeorological data as input to a precision ray tracer has enabled prediction of pulse propagation into a shadow zone caused by a non-linear sound speed gradient close to a high impedance ground. The resulting predictions give tolerable agreement with measured wave forms and attenuations out to horizontal ranges of 500 m.

Measurement of acoustic propagation through the atmosphere

P J Soilleux
Royal Signals Research Establishment

There is great interest in measuring the attenuation of low frequency sound at ranges of several kilometres. Static experiments are difficult and laborious to carry out but the line spectra associated with helicopters moving at constant velocity and altitude can be used to give such information very rapidly.

Such experiments indicate the problems of reproducibility due to anomalous effects produced by the atmosphere, the topography and range.

The best indicator of range for particular meteorological and topographical conditions seems to be OASPL.

The prediction of noise from construction sites

R Wentang and K Attenborough
The Open University

The sources and characteristics of noise from construction sites, including frequency spectra, duration and movement of noise sources, are quite different from those of other sources.

This paper reviews typical Sound Power Level (Lw), Directional Index (DI) of major noise sources in construction sites and identifies four quite different construction phases: (i) preparation, (ii) construction of base, (iii) erection of structure and (iv) installation of equipment and building phase. This provides the basic information for predicting noise from construction sites.

The next problem is to predict the noise level at the boundary of construction sites since it is the level at the boundary which is controlled by environmental authorities in most countries.

In addition to sound source power and directional characteristics, the effect of reflections from the ground and from surrounding buildings, excess attenuation of barriers (including typical thick barriers – building) and other factors are taken into account in the prediction scheme.

B3 AIRCRAFT NOISE

An asymptotic theory of propeller noise in the near-field

N Peake and D G Crighton
Cambridge University

The advent of the Propfan as a means of powering the next generation of passenger aircraft has led to intense interest in noise issues relating to high speed propellers. However, conventional analysis often leads to complex formulae, which yield little insight into any of the underlying physics, and are time consuming to compute numerically.

Considerable simplification is possible when the number of blades, B, is large. We study the most basic problem of deriving the thickness (monopole) noise in the plane of a stationary propeller, when r_0/D, the observer distance divided by propeller span, is order unity. Acoustic pressure is expanded as an asymptotic series in inverse powers of mB, where m is the harmonic of blade passing frequency.

The first terms in the series are calculated for both supersonic and subsonic tip rotations, and turn out to be uniformly valid for any observer position, even into the far-field. In principle, a high degree of accuracy can be achieved from such formulae, even for only moderate B.

Previous work has demonstrated that in the far-field the principal source of noise for supersonic rotation is at a point corresponding to the Mach radius, whilst for subsonic rotation it is the tip contribution which dominates. This also proves to be the case in the near-field, but different scalings on mB and r_0/D occur, which are compared and contrasted at each stage. The effects of chordwise noncompactness are also considered.

A study of annoyance due to general and business aviation noise

J B Ollerhead
Loughborough University of Technology
I D Diamond, J G Walker and S A Bradshaw
University of Southampton and
J B Critchley
Civil Aviation Authority

The application of conventional airport planning guidelines to areas affected by noise from General Aviation aerodromes has been questioned because of concerns that different operating patterns, lower background noise levels, and the repetitive nature of training flights which typically occur around GA aerodromes, may give rise to lower thresholds of annoyance than around large commercial airports. A study is reported that was designed to investigate the particular conditions specific to GA operations, in six areas around five GA aerodromes.

The study shows that although the relationships between annoyance and aircraft noise level are similar for commercial and GA traffic, GA noise is more annoying. However, this finding must be viewed with some caution because the GA regression is based on very few points.

In general, however, GA noise alone appears to account for little of the variation in annoyance. It is clear that non-acoustic factors play an important role in determining annoyance due to GA noise. Higher annoyance is related to feelings that the aerodromes are bad with respect to low flying, community relations and in handling complaints; with feelings that the aircraft may crash; and with opinions that leisure flying is unimportant. In addition, respondents who are annoyed tend to be older and more likely to be owner occupiers than their less annoyed counterparts.

These results reinforce the need for caution when predicting annoyance from aircraft noise levels alone; neglect of other, non-acoustic, factors may give rise to signficant errors.

Ground noise at Heathrow's Terminal 4

J E Griffiths
Travers Morgan Planning and
J Simson
London Scientific Services

No Abstract available.

Practical measurement of aircraft ground noise and its implications on prediction techniques

P Henson
Bickerdike Allen Partners

Noise arising from aircraft activities on the ground at an airport is a problem that is becoming increasingly more important. Pressures for development on land close to airports is ever increasing. In addition, with the advent of 'quieter' aircraft, the building of airports within the heart of cities is now becoming a reality and likely to increase in the years ahead.

To predict ground noise exposure at points around an airport, allowances must normally be made for: (i) distance attenuation; (ii) local topography; (iii) aircraft operational procedures, i.e. route, type and durations of activities; (iv) reference noise levels; (v) weather conditions.

By way of practical examples, this paper identifies some of the difficulties that can arise in measuring ground noise exposure around an airport. The five categories given above are discussed and the implications of differences that can occur between measurement and prediction techniques reviewed. Suggestions for improved methods of prediction will be presented on the basis of experience gained from extensive field measurements.

Video film of aircraft will be used to illustrate points raised in our presentation.

Insulation of mobile homes subjected to military aircraft noise

D M Bexon and R J Weston
RAF ICOM
S M Dryden and P Moore
W S Atkins Engineering Sciences

This paper reports the study carried out by the Ministry of Defence and W S Atkins Engineering Sciences into the sound attenuation qualities of existing mobile homes when subjected to military aircraft noise. A subsidiary aim of the study was to determine the absolute low frequency noise levels experienced inside the homes from a variety of aircraft manoeuvres.

Four airfields/mobile home sites were chosen for the study. A sample of 20 homes were selected to represent four construction types, at least three homes of each construction being included in the sample.

Measurements were taken in ⅓ octave frequency bands in the frequency ranges 100 Hz–4kHz and 25 Hz-100 Hz. Levels were obtained at three positions in each of the two largest rooms, as well as one position outside. Reverberation times were also measured in each room in ⅓ octave bands.

The Ministry of Defence currently offers grants for sound insulation in the form of acoustic secondary glazing for homes of traditional construction near to military airfields which are

subject to noise levels of at least 70 dB $L_{Aeq, 12h}$. Since there is no known means of providing effective sound insulation for mobile homes at a reasonable cost, grants are not presently available for this type of home. However, should the study identify a practical cost-effective means of providing sound insulation, mobile homes will be included in the Ministry's noise insulation package.

Experience in the measurement of noise from military aircraft

W Stubbs and R B Gillham
Wimpey Laboratories Limited

In December 1987 Wimpey Laboratories Limited were appointed by the Ministry of Defence to carry out noise surveys over a four year period at 28 airfields in England, Wales, and Northern Ireland. The Ministry of Defence provides grant assistance for noise insulation at properties exposed to noise levels of 70 $dBL_{Aeq, (12\ h)}$ from military aircraft. The aim of the noise surveys is to validate computer predicted noise contours produced by the RAF. Measurements of noise levels of individual aircraft are made at locations around the computer contour in terms of SEL and L_{AMAX}. Predicted numbers of movements are provided by the RAF, and the final noise contour is provided from the data. The $L_{Aeq, (12\ h)}$ contour is calculated from the formula: $L_{Aeq, (12\ h)}$ = Average SEL + 10 log N − 10 log 12 × 60 × 60. L_{AMAX} values are used to establish the 82 dBL_{AMAX} contour as an indicator of night time annoyance at airfields where there is significant night flying.

This paper describes the procedure for the noise survey, with four personnel in the field, in communication with a fifth member of the team in the control tower. The problems involved with certain types of airfield are also discussed. Examples of typical aircraft noise contours are discussed.

In-flight measurement of boundary layer noise and its vibration effects

D Sims
British Aerospace (Dynamics) Ltd

Equipments carried externally on military aircraft are subjected to vibration that is primarily induced from the surrounding turbulent boundary layer. In order to establish data for equipment design and testing it is necessary to measure the characteristics of noise and vibration derived from all flight conditions within the performance envelope of the aircraft. This data is subsequently reduced to provide test specifications for the total system and its components. These specifications then contain the natural vibration characteristics of the equipment and enable the application of realistic test conditions using high intensity noise as the primary vibration source. This in turn results in a more effective reliability and qualification test programme.

C3 STUDENT SESSION 1

The influence of airflow resistance on the acoustic absorption properties of polyurethane foam

G Rodwell
Sheffield City Polytechnic

No abstract available.

Air absorption in acoustic scale models and the substitution of nitrogen

P Wright
University of Salford

Acoustic scale modelling is a useful tool for assisting the design of buildings with specific acoustic requirements. A major problem in the modelling process, however, involves the correct scaling of air absorption. For perfect scaling a linear increase of air absorption with frequency is required whereas the actual increase is considerably faster than this. As a result, large corrections must be applied to measurements made in air, and the range of measurement is restricted.

One well-established method of overcoming this problem has been to reduce the air absorption to the desired level by de-humidifying the air in the model: an expensive process. Nitrogen has been proposed as a cheaper alternative and has been adopted by several researchers.

Tests have been carried out in a 1:10 scale model reverberation chamber using nitrogen. The results indicate the suitability of nitrogen as a medium for modelling full-scale air absorption. Tests are now being conducted in the model in order to gain an insight into changes in the absorption of people at various packing densities.

The effect of loading on the impact sound insulation of concrete floors with a floating raft on a resilient layer

M Stewart
Heriot-Watt University

In testing concrete floors of new or converted houses and flats for impact sound insulation, much has been said on the suitability of resilient materials. However, little is known on how well these materials will be able to stand the test of time. A floor which has been tested and found to pass the Building Regulations on impact sound may, if tested in a year's time, fail due to compression of the resilient layer reducing the coupling loss between the floating floor and the concrete floor underneath.

Research sponsored by the SERC is currently being undertaken at Heriot-Watt University to assess how commonly used resilient materials will behave after a period of time. Small test samples are being loaded and left for 6 months to see if creep deflection is noticeable. Data will be extrapolated from this to show the expected deflection for longer periods. The load is in accord with values in BS 6399 for normal occupancy dwellings. Also variable load measurements will be undertaken on other samples to give an indication of the load/deflection characteristics of each material. Finally, impact sound measurements on a 3 m × 4 m floor will be carried out in unloaded condition (typical of a new floor) and a number of different loaded conditions (determined by the previous data) which we hope will show how the impact sound insulation changes with time (if at all).

Annoyance and impulsivity judgements for environmental noises

C Swift
ISVR, University of Southampton

This study formed part of a project to determine a suitable penalty for impulsive environmental noise. Recorded environmental noises were rated by 40 listeners, to explore the relationship between subjective annoyance and subjective impulsivity. Ratings were correlated with various physical measurements to search for an objective predictor of the subjective quantities. Twenty sounds, ranging from steady to highly impulsive, were played, forwards and backwards, at an L_{Aeq} of 55 dB. Annoyance was rated on a scale of 0 to 9, 'not annoying at all' to 'extremely annoying', as referred to 'indoors at home'. The impulsivity question asked if the sound was 'clearly impulsive', and required a YES/NO response. Twenty listeners rated all 40 sounds for impulsivity; the sounds were then replayed and rated for annoyance. The remaining twenty rated annoyance first and then impulsivity. Annoyance ratings were unaffected if the subject had previously rated the sounds for impulsivity. Impulsivity ratings were lower if the subject had first rated the sounds for annoyance. There was very little relationship between annoyance and rated impulsivity. Playing the sounds forwards or backwards made little difference to the annoyance. Sounds played backwards were generally less impulsive. This experiment did not uphold the hypothesis that the difference between a 'psuedo-L_{Aeq}, measured using an impulse time-weighting, and the true L_{Aeq} might be a useful predictor for annoyance or subjective impulsivity.

Loudness of low frequency impulses

C W Dilworth
University of Salford

An investigation was made into the loudness of low frequency blasts, such as those generated by quarry blasting. A sealed booth, suitable for the simulation of impulses with a low frequency content, was available for the testing. The booth was shown to be extremely susceptible to reflections and resonances within it. To try and eliminate these, the booth was lined with an absorbent. A test method was devised whereby the effect of varying the delay between the individual impulses which make up a blast on the blast's subjective loudness could be investigated. The method used a paired comparison technique, and required a reference with which the test blasts were compared. Due to the nature of the booth and the signals under test the reference signal chosen was a 20 Hz triangular wave. A level in phons could not readily be attached to this. Therefore a separate set of subjective tests was carried out, equating the reference to a sinusoidal wave, for which a level could be found. The results obtained from the testing enable a set of equal loudness curves to be constructed. These show the effect of varying the peak overpressure and the delay between individual impulses on the loudness of a low frequency blast.

Quantification of environmental noise levels

D R Moore
ISVR, University of Southampton

The concept of 'background noise level' has variously been incorporated into planning and other standard procedures for the assessment and prediction of annoyance due to specific environmental noises. However, there is currently much debate on how such a specific (or offending) noise should be measured and compared with the 'background noise level'.

The project was split into three parts

(i) A review of the various specifications and definitions of 'background noise level'.
(ii) An analytical phase using case studies and noise measurements to pinpoint possible areas for further analysis.
(iii) An experimental phase concerned with on-site field measurements at a variety of locations.

Preliminary results using data obtained for the Environmental Protection Agency (Washington

Office) seemed to suggest that there was stronger correlation between L_{Aeq} and L_{95} than between L_{Aeq} and L_{90}. So far, the experimental phase of this study has not led to the same conclusion. Exploration of the idea that tape editing, to remove the offending noise and hence allow examination of the percentile levels of the background noise directly, may reveal more relevant results.

These data will allow comparison of the various methods suggested in BS 4142 (1967) and BS 4142 (Draft Revision 198X) for the evaluation of the complaint potential of a noise to be compared.

Analysis of the amplitude statistics of random signals

A Shadbolt
University of Salford

Random signals can be specified in terms of time averaged quantities such as the mean value or the mean square value. Ideally to measure a mean value one would want to average over an infinite period of time to obtain the true value. Practically, a finite averaging time must be used and a range of values will be measured.

This investigation has looked at the statistics of the mean square values of random signals averaged over finite periods of time. The statistics have been found through digitizing signals into a home computer and calculating the probability density function of the mean square values for different averaging times and varying bandwidths of signals.

For many random signals a Gaussian distribution of values will be found and the software developed allows this to be tested. The theory that for such signals the variance of the values is dependent on the averaging time and the bandwidth of the signal has then been checked.

By establishing that a random signal has a Gaussian distribution of values allows an averaging time to be specified such that the accuracy of a measured value will, for example, be within 10% of the true value with a probability of 95%.

A hemispherical cap array for noise source location

M H D Santer
ISVR, University of Southampton

With the advancement of underwater acoustic signal processing, noise and its reduction has gained increasing importance. Clearly, to reduce noise in an efficient manner it is imperative that the location, intensity, and frequency content of the sources are identified. This paper concerns an array used to measure noise sources induced by fluid flow past an axi-symmetric body, in the frequency range of 1000 Hz to 50,000 Hz in air.

Theory using the Rayleigh Integral indicated that an appropriate design was a hemispherical spiral array, in which the spacing between each turn of the active element decreases towards the centre of the array. This shading effect enabled good directivity to be obtained with a limited length of piezoelectric cable over a wide frequency range.

The theoretical calculations were compared with experimental results taken in a large water tank using a spark source.

An expert systems approach to understanding signals and systems

A M Raper and J K Hammond
University of Southampton and
C A Mercer
Prosig Computer Consultants

No abstract available.

A4 VIBRATION AND HUMAN RESPONSE

Groundborne vibration generated by HGVs – effects of vehicle, road and soil parameters

G R Watts
Transport and Road Research Laboratory

This paper describes results from a programme of research aimed at quantifying the vehicle, road and soil parameters that significantly affect groundborne vibration levels at building foundations and result in disturbance to occupiers. Eight HGVs with widely different suspension systems were driven over a number of artificial profiles at speeds of up to 80 km/h under different load conditions on the Laboratory's research track. The resulting ground vibrations were measured with triaxial geophone arrays and peak particle velocities were computed. In order to generalize the results to other site conditions, the transfer function for an impulsive force applied to the road surface and the resulting ground vibration at various distances up to 50 m was measured for a wide variety of soil types ranging from peat to chalk. The response of building foundations was also determined using the same technique. By determining the average effects of these factors it was possible to estimate the likely range of vibration levels at foundations under a given set of conditions.

The wayside vibration from trains

T M Dawn
British Railways Board

The generation and propagation of ground vibrations and the response of wayside buildings to them are all part of a complex process in which the characteristics of track and vehicles, the properties of the intervening ground and the foundations and structure of the buildings can be expected to intervene.

Much of the overall problem remains yet to be resolved, but it is nevertheless possible to examine the characteristics of the measured wayside vibrations, and discuss the factors which have been found to bear on the level and spectrum of the observed effects. Particular reference is made to the influence of ground type, train speed and traffic category.

Response of domestic buildings to ground vibration

R Randell
ISVR, University of Southampton

BS 6472, 1984, 'Evaluation of human response to vibration in buildings (1 Hz to 80 Hz)' offers a method of assessing complaints from occupants of buildings subject to vibration. For planning purposes, however, it is necessary to predict the potential vibration levels in proposed buildings well in advance of their construction. To this end, it is necessary to know the relationship between the vibration levels in the completed building and ground vibration levels on the green field site prior to construction.

A programme of measurements has been carried out under the sponsorship of the Department of the Environment and monitored by the Building Research Establishment to help establish this relationship. Vibration measurements were made on several green field sites subject to railway vibration and followed up with vibration measurements in the domestic dwellings subsequently erected. This programme enabled relationships between ground and upper floor vibration spectra due to passing trains and the vibration spectra on the original site to be established.

Comparative annoyance from railway noise and building vibration

H J Woodroof
Institute of Naval Medicine

A social survey was conducted amongst residents living within 100 metres of railway lines in Scotland. The survey's primary aim was to investigate community response to railway-induced building vibration but information was also sought about the effect on the residential environment of other influences due to the railway. These included noise.

The survey was conducted on a population of 720 adults selected by a multi-stage, pseudo-random, area sampling procedure which incorporated stratification by distance from the railway. The sample population was clustered at 24 sites. Interviews were obtained from 459 of the sample population (a 64% response rate).

Data are presented from respondents living at 12 of the 24 sites. Of the 257 residents interviewed at these 12 sites, 133 noticed railway-induced building vibration within their homes and all these individuals were questioned about other sources of annoyance asociated with the railway (e.g. noise, maintenance work). The two most commonly mentioned sources of annoyance associated with the railway were noise from passing trains and noise and/or lights from maintenance work at night. Numerous other sources of annoyance with the railway were mentioned by between 1% and 5% of those questioned. Respondents were asked to make a qualitative judgement as to which was more annoying: the building vibration or each of the other sources of annoyance which the respondent had identified. Replies indicated that building vibration was considered amongst the least annoying aspects of a railway's presence in a neighbourhood.

B4 ENVIRONMENTAL NOISE

Neighbourhood noise disturbance

W A Utley and E C Keighley
Building Research Establishment

Research by the Building Research Establishment has shown that neighbourhood noise is now the most widespread source of noise disturbance. The very large increase in the number of complaints about noise from domestic premises indicates that the problem may be getting worse. This paper describes the results of research aimed at giving a better understanding of the nature of the problem. It was found that while some of the most important sources of disturbance also featured highly on the list of sources causing complaint other disturbing sources caused relatively few complaints. The various sources showed distinct characteristics in regard to factors such as position, type of dwelling and time of day when disturbance occurred. More than half of those who are bothered by this type of noise take no action to reduce the noise. Those who do take action are rarely successful in stopping the disturbance. The incidence of disturbance is not spread homogeneously throughout the community and it is possible to identify high and low risk sub-groups of the general population.

A method for predicting environmental noise levels in the UK

Suzie J Baverstock and R Pocock
W S Atkins Engineering Sciences and
K Attenborough
The Open University

Area based prediction methods are developed for the noise indices L_{eq}, L_{10} and L_{90}. The prediction depends upon the relationships between these variables and a number of key demographic predictor variables. The demographic variables considered include: traffic density, road network density and land use.

Data from a noise survey of Milton Keynes, Bexley and the West Midlands and noise data supplied by Open University undergraduate students studying the course T234 'Environmental Control and Public Health' have been used to calibrate and test the proposed theoretical prediction models partially. Two forms of prediction model are presented, namely prediction matrices and linear multivariate regression models.

The main findings of the research are: (1) that L_{eq}, L_{10} and L_{90} can be predicted using industrial land use and traffic density but that there are regional differences in noise which are unaccounted for by these variables; and (2) that the variability of noise (L_{10}–L_{90}) is related to traffic density.

The suitability of A-weighted sound power for labelling domestic appliances

J R Brooks and K Attenborough
The Open University

In 1986 the EEC published Directive No. 86/594/EEC recommending the labelling of household appliances, using A-weighted sound power level (L_{WA}). Concern was expressed that the chosen label should take into account the subjective reactions of people. This paper describes research to determine the relationship between subjective judgements of domestic appliance noise and a variety of noise indices e.g. L_{WA}, L_{Aeq}, L_{AX} etc.

Subjective rating experiments were carried out, whereby 24 volunteers were asked to rate the noise levels of 30 domestic appliances. The sequence of presentation of appliances was determined by a balanced Latin Square design. L_{WA} measurements were made according to BS 4196 Part 1: 1981, and measurements of L_{Aeq}, L_{AX}, L_{Amax}, L_p, L_{pA} and L_{pD} were made in the subjective experimental test location. Statistical analysis indicated that subjects were not able to rate appliances according to the magnitude of L_{WA}, and that measures of L_{Aeq}, L_{AX}, and L_{Amax} correlated more successfully with subjective noisiness ratings than L_{WA}.

Practical use of single number rating

R Weston
RAF ICOM

No Abstract available.

C4 STUDENT SESSION 2

The propagation of explosively generated shockwaves in shallow water channels and their effect on massive structures

N Hogwood
ISVR, University of Southampton

Underwater blasting using high explosives in close proximity to quays and jetties is a common occurrence in civil engineering operations. Damage to the structure must always be avoided, yet criteria for damage are empirical and not fully understood analytically.

The aims of this project are to establish the structural response of a massive structure when impinged upon by an explosive shockwave. Of particular interest is the peak structural velocity, since this has been shown to be related to the likelihood of damage occurring.

The investigation estimates the peak velocity of a structure modelled as a simple limp mass, which is exposed to an underwater blast. Changes in the energy spectrum occurring due to the presence of the water surface and seabed are also estimated. Discrepancies between this simple model and measurements are presented.

The effects of bubble curtains on underwater shockwave propagation

S Boyle
ISVR, University of Southampton

Large quantities of explosives are detonated underwater in enlarging harbour draughts by removing the hard bedrock which cannot be dredged, and many other civil engineering operations. Usually this blasting occurs in close proximity to structures that may be damaged by the waterborne shockwave e.g. divers, jetties, and quays. Although much is understood about deep water explosions, there is a lack of fundamental information regarding how the shockwaves from explosives interact with and damage these structures in shallow water. This limitation of knowledge results in the blasting company having to incur severe financial penalties due to the need either to use small charges or to enforce large exclusion zones both for the divers and the general public, in order to ensure complete safety.

Bubble curtains (that is streams of bubbles produced from compressed air cylinders positioned at depth in the water) have been used to some effect in reducing the levels of waterborne shock. This investigation aimed to produce an analytical formulation of damage prevention mechanisms using these curtains of bubbles, and test them by experiments using scaled explosions in the laboratory. These results were then compared against measured data.

Auditory hazard to divers from underwater explosions

C Herbert
ISVR, University of Southampton

The sea is a noisy environment, but only recently has the need to introduce hearing guidelines for underwater blasting been recognized. In many places, divers and swimmers are explosed to explosive sources, such as compressed air-guns, which are used for seismic explorations, and explosive stud guns.

The initial aim of this project has been to investigate hearing underwater by carrying out audiometric tests in air and water. Knowledge of the resulting threshold shift can then be used, together with data from research into the auditory hazard from airborne blasts, to estimate the hearing damage caused by underwater explosions.

Very little is known about the mechanisms of hearing underwater, and no experimental studies have been carried out to assess the effects of underwater blasting on divers' hearing.

By investigating the auditory hazard from underwater explosions, a set of guidelines for hearing conservation, including safe stand-off distances, can be established.

The acoustic loading of enclosures on loudspeakers

D R Philip
Department of Applied Acoustics, University of Salford

In the use of electrical circuit analogies for low frequency loudspeaker system design, the electrical and mechanical components have long been quantifiable. However, acoustic components representing the loudspeaker's acoustic loading are not easily measurable, generally being assumed from theoretical values based on the loudspeaker performing as a flat rigid piston. This report serves to establish and critically evaluate a proposed method of measuring the actual acoustic loading on a loudspeaker.

Since the acoustic loading makes a very small contribution to a loudspeaker's total electrical impedance, it was proposed therefore that two closely matched loudspeakers used in an impedance bridge would allow a change in acoustic loading to one to become measurable. During development of the proposed method a requirement for the 'reference' loudspeaker to perform consistently was noted. Thus a further proposal that it be placed in a vacuum to minimize variations in acoustic loading was implemented.

With the method established measurements were undertaken with the 'test' loudspeaker mounted in specific acoustically controlled environments: in an infinite baffle approximation and in the end of a closed tube. Both cases approximate to real design conditions for which theoretical solutions exist, thus providing a useful starting point for evaluation of the method. Critical comparisons are made between measured findings and theoretical values, suggesting further work leading on from this report.

Viewing of loudspeaker modes by laser speckle

M Brooke
Department of Physics, University of Wales

The paper describes the use of the misfocusing method of speckle shearing interferometry to view the resonant modes of loudspeaker cones.

Two types of modes are discussed, namely asymmetric and axisymmetric. It is shown that only the latter affect the speaker's frequency response. Three experimental techniques were used to detect these modes and their resonant frequencies: (i) frequency response measurement using a close microphone; (ii) using a microphone to record the speaker's impulse response and subsequently performing a fast Fourier transform on the data obtained; (iii) direct viewing of the modal speckle patterns in laser light.

Experiments with the misfocusing method yielded fringe patterns which depicted the displacement derivatives of the vibrating cone. These patterns were subsequently found to be in agreement with predicted mode shapes and frequencies calculated by use of the finite element method.

A5 VIBRATION AND HUMAN RESPONSE

Improved operator performance from reduced vibration

J A Lines and R M Stayner
AFRC Engineering

No Abstract available.

Active engine mounts for improving vehicle comfort

C F Ross, G P Eatwell, A J Langley and C M Dorling
Topexpress Ltd

This paper relates to improving the comfort in vehicle cabins. As the mass of the body and structure of cars is reduced in order to improve fuel economy, the combined mass of the engine and gearbox becomes a proportionately larger part of the total mass of the car. The dynamic behaviour of the car body is thus altered substantially by the degree to which these two masses are coupled. Increasing the effective mount stiffness increases the coupling of body and engine, and generally this is advantageous. The space required for the engine and gearbox in the engine compartment can be reduced if the engine is not expected to move relative to the car body, and this can be achieved by stiff mountings.

The engine produces vibrations which are transmitted to the car structure through the mountings, and these vibrations disturb the comfort of the passengers. It is therefore desirable to reduce this disturbance by isolating the engine from the car body. This isolation is normally achieved by mounting the engine on rubber blocks which are resilient and allow the engine to move in such a way that its inertia balances the forces on the engine. The transmission of vibrations to the car structure is thus reduced.

These two objectives are in conflict with each other: on the one hand, the mountings should be stiff (ideally rigid) in order to tie the engine to the car body and thereby reduce the relative movement of the engine; on the other hand, the mountings should be compliant and allow the engine to move freely in order to provide good vibration isolation.

This paper will describe a solution to the problem and its experimental demonstration.

Speech variability as a function of low frequency whole body sinusoidal vibration

M R Taylor
National Physical Laboratory

This paper examines the effects of whole-body vibration on speech production and outlines the rationale behind vibration experiments recently completed within the Human Engineering Department of the UK Royal Aerospace Establishment Farnborough.

The experiments required ten adult males to recite digit lists and connected speech passages whilst under whole-body vertical sinusoidal vibration. The vibration frequencies used in the experiments ranged from 8 Hz to 25 Hz at acceleration levels between 0.05 g(rms) to 0.25 g(rms) in 0.05 g(rms) increments. During the experiments acoustic speech and Laryngograph Lx waveforms were digitally recorded in synchronization with displacement signals monitored by accelerometers attached to the vibration platform.

Subsequent analysis of the Lx data has enabled mean fundamental frequency to be computed for each subject over a 7 month period. Percentage deviations from long term mean fundamental frequencies have also been computed for every subject at each of the 90 vibration conditions. The results of these computations are presented in the paper together with normalized response curves indicating percentage F_o, voicing and overall duration changes as a function of vibration frequency between 8 Hz and 25 Hz at 0.25 g(rms).

Whole-body vibration exposure: a comparison of standards

A W James
Sound Research Laboratories Ltd

In recent years, the acoustic consultant has been able to choose from a steadily expanding range of standards and guidelines on the measurement and evaluation of human exposure to whole-body vibration. Some standards, although not formally adopted in this country, have been widely used even after the introduction of ISO 2631-1974 'Guide for the evaluation of human exposure to whole-body vibration'. With the gradual revision of ISO 2631 beginning in 1985, and the introduction of BS 6841 in 1987, we are now faced with an array of widely differing and occasionally contradictory standards.

This paper charts a brief history of the development of national and international standards on vibration, compares some of the more commonly used ones and presents numerical results for some theoretical vibration histories. Particular attention is paid to different frequency weightings, and to the use of Vibration Dose Values to evaluate intermittent vibrations. From the results, some suggestions as to the consultant's choice of standard can be made, as well as predictions of how the field of vibration measurements might be expected to develop over the next few years.

Measurement and analysis techniques for the evaluation of human exposure to vibration and motion

C M Nelson
ISVR, University of Southampton

The measurement and analysis of vibration and motion with respect to its effect on humans can be complex. The characteristics of the vibration (e.g. magnitude, frequency, direction), other environmental factors and subject differences all play a major role in determining the resulting effects on people. The effects of vibration exposure may be purely subjective (e.g. discomfort in vehicles, annoyance in buildings), physiological (e.g. seasickness, back pain, vibration-induced white finger) or related to performance (e.g. impeded vision, manual performance). Several standards have been evolved to provide guidance for those wishing to measure and evaluate human exposure to vibration and motion. These include BS 6841, BS 6842, BS 6472, ISO 2631 and ISO 5349. These documents define frequency weightings and time dependencies which can put many investigations beyond the scope of a simple r.m.s. meter.

The recent availability of compact, portable and affordable computers has made possible the digital recording and analysis of vibration in the field. Complex mathematical operations, such as spectral analysis and true integration, may be carried out on digitized time histories which may also be permanently stored for further analysis. An investigation of the vibration in a building due to passing trains is described as an illustration of the use of a portable computer-based vibration analysis system.

Survey of exposure to hand-arm vibration in Great Britain

K Kyriakides
Health and Safety Executive

It is well established that regular exposure at work to vibrating tools, machinery or workpieces is connected with various patterns of disease affecting the hand and forearm. The best documented and most easily observed condition is vibration white finger (VWF) the symptoms of which are blanching, pain and numbness in the exposed fingers. If exposure is severe and continued, more serious conditions may develop. VWF is now a prescribed industrial disease and is reportable under the Reporting of Injuries, Disease and Dangerous Occurrences Regulations 1985.

This paper presents the results of an investigation, carried out between 1984 and 1986, into the number of people in selected sectors of manufacturing industry, the public utilities, agriculture, forestry and construction using powered tools asociated with the incidence of VWF. The data provide an indication of the likely extent of the problem in Great Britain and the areas where attention might be focused to evaluate and control the hazard.

B5 ENVIRONMENTAL NOISE

The Noise Council Survey of clay pigeon shooting noise

H G Leventhall
Southbank Polytechnic

No Abstract available.

The work of the Noise Council in relation to motorcycle noise

TBA

No Abstract available.

Industrial claddings: sound absorption and transmission

N J H Alexander, D E O'Connor and R J Orlowski
Department of Applied Acoustics
University of Salford

When EEC legislation for limiting exposure to noise at the workplace is introduced in 1990, it will be the responsibility of the employer to ensure that the design and construction of factories is such that the risks resulting from exposure to noise are reduced to the lowest level reasonably practicable. This will result in greater importance being attached to the prediction of noise levels inside and around industrial buildings at any stage of their design or construction. Theoretical models are being developed to predict these noise levels but their accuracy relies on the provision of accurate values of absorption coefficient and sound reduction index of the construction materials, in particular the lightweight claddings favoured by today's industrial architects.

The paper presents measured values of absorption coefficient and sound reduction index of profiled single-skin and double-skin claddings and composite sandwich panel claddings. The measurements were carried out in a reverberation suite conforming to international standards. Wherever possible the mounting of the cladding samples replicated the normal construction methods used.

In addition to measuring the acoustic characteristics of the claddings, a theoretical explanation of their acoustic behaviour is being explored. Most claddings exhibit two greatly different bending stiffnesses across perpendicular axes and hence are assumed to be orthotropic. The measured values will be compared with theoretical results obtained using the theory of an infinite orthotropic plate.

Sound power division at duct branches

M Turner
Ove Arup and Partners and
D M Fairhall
South Bank Polytechnic

This paper reports the results of measurements of the division of sound power at air duct branches. Square shoe branches for combinations of three duct sizes are considered. Results are presented showing the reduction in sound power between the approach and exit ducts.

Where the exit duct is in line with the approach duct the reduction in sound power level is found to be in proportion to the cross sectional area of the exit duct, as stated in various design guides. Where the exit duct is at right angles to the approach duct the measured behaviour exhibits a further reduction equivalent to the attentuation of a mitred bend of similar dimensions to the exit duct.

Environmental noise considerations of gas turbine power generation

B C Postlethwaite
Acoustic Technology Ltd

No Abstract available.

The new course in Acoustics and Noise Control in Sheffield City Polytechnic

R B W Heng
Sheffield City Polytechnic

The new course in Acoustics and Noise Control in the Sheffield City Polytechnic leading to the award of the Diploma of the Institute of Acoustics commenced in Autumn 1986. This is a paper recording the experiences of the author as one of the two course leaders involved in the initiation and implementation of the course.

This paper looks into the various aspects encountered in the setting-up of the course and publicity and recruitment of candidates to ensure the necessary numbers for viability of the new course. It also reports on problems that had to be overcome on the teaching, examination and overall administration of the course. This is compared with a similar course previously set up by the author in the National University of Singapore.

It is felt that the paper would be of interest to staff of other institutions looking into starting a similar course who could learn of some of the difficulties encountered and some of the ways these were overcome. The experiences and opinions of some of the participants in the Sheffield course are also reflected together with some changes made in the course structure to accommodate their particular requirements. In these days of cost efficiency, this aspect of course administration would be of interest to those wishing to improve on their own courses or to increase participant numbers.

C5 OPEN SESSION

Computerized auto-testing of sound level meters

C P Stollery
Cirrus Research Ltd

As a result of increased sales of sound level meters it has become not only attractive but necessary to implement an automated test procedure for the production of sound level meters.

To fully test a sound level meter to all the parameters in IEC651 or IEC804 takes a prohibitive amount of time and effort. At present only a representative sample of a batch is fully tested and only with auto-testing techniques is it possible to fully test each manufactured unit.

This paper describes a method of auto-testing applied to sound level meters and aims to show how the international standards relating to sound level meters lend themselves to the method of computerized auto-testing.

The effect of flanged joints on noise and vibrational transmission

S Ming and G Stimpson
ISVR, University of Southampton

Flange type bolted joints occur commonly on many types of machinery structure, typically being used to attach oil sumps, water tanks or couple pipework, etc. For the prediction of noise from such structures using an SEA type analysis it is necessary to know coupling factors through the junctions. Recent work has been undertaken to investigate vibrational transmission through flanged joints including the effects of gasket materials. Experimental and theoretical results will be presented and information for minimizing vibration through these joints discussed.

Transmission of noise through rubber–metal composite springs

A H Muhr
Malaysian Rubber Producers' Research Association

The design principles of vibration isolation mounts are well known, and a great variety of such mounts are available. Each type of mount offers a particular combination of damping and force-deformation behaviour (in the various directions) which makes it appropriate for a given vibration isolation requirement. However, the implication of such design details for the transmission of audio-frequencies is often less certain. Although the general principles of audio-frequency transmissibility are available (e.g. Snowdon, 1968) the current emphasis on reducing noise requires more care be taken about design details. This is particularly true for the automotive industry, since the trend towards lighter structures exacerbates the problem of noise.

In this paper an investigation of the dynamic properties of several types of spring by both theory and experiment (up to 1000 Hz) will be presented. The emphasis is on wave effects and the interaction of rubber and metal components in composite springs.

The use of time reversed decay measurements in speech studios

B Rasmussen
Brüel & Kjær, Denmark, and
J H Rindel
Technical University of Denmark

In speech studios with reverberation times around 0.1–0.2 s it is not possible to use traditional measuring technique because of the ringing of ⅓ octave filters. A new measuring technique, which is based on a time reversed analysis, has been used in three speech studios at the Danish Radio, and the results have been compared with traditional methods. Both interrupted noise and the integrated impulse response from a pistol shot have been used.

Sound generation in a duct with a bulk-reacting liner

A Cummings
University of Hull

Aerodynamic sound generation in ventilation ductwork is an important aspect of the acoustics of building services. In ducts without internal acoustic linings, a knowledge of the aerodynamic noise source characteristics would enable estimates of noise generation to be made if the duct walls could be assumed rigid. In the case of acoustically lined ducts or package silencers, however, the situation is complicated by the fact that the sound absorbent is usually in the form of continuous layers of a porous material, and does not present a locally reacting impedance surface to the sound field within the duct. In this situation, difficulties arise in writing an eigenfunction expansion for the sound field in the duct: the eigenfunctions are not orthogonal, in the usual sense, on the duct cross-section, and it is therefore not straightforward to prove their completeness. Of course, calculation of the sound field radiated by sources in the duct suffers from these problems too. Some progress may, however, be made with this problem if the air-flow speed in the duct is negligibly small. In this paper, the two-dimensional problem is discussed and some results are presented.

A study of stick slip for selected materials

G J McNulty, G R Symmons
Sheffield City Polytechnic and
Zhang Ming
Chengdu University, China

Several selected materials were tested for stick-slip motion as part of a long-term investigation into the source of acoustic output and its associated friction relationship. Published work provides tentative relationships between stick slip and acoustic output. However, no definite reason why some material combinations have an acoustic output can at this juncture be rigorously postulated.

This paper concentrates on the specific details of the relationships between friction torque, friction and stick-slip velocity for several material combinations in stick-slip motion. A new development is the study of the piston loads and driving speed on the stick slip. Thus a description of how the parameters of torque, friction and slip velocity affect the energy available for stick slip and consequently the acoustic output is presented.

The materials combinations in stick-slip motion described here are: Perspex on steel, lead on steel, aluminium on steel and three different commercial brake fibre materials on steel.

A brief outline of the stick-slip apparatus is given for completeness.

Conference Organizers

Please remember to send Abstracts of your Conference to the *Bulletin* Editor for publication, at the earliest possible date. (Send to: 14 Witney Road, Long Hanborough, Oxon OX7 2BJ.)

A WOMAN IN ACOUSTICS?

Jennifer Zarek

I get rather annoyed by this sort of thing. I'm tempted to enquire what is so odd about 'a woman in acoustics'. But I suppose in all honesty there aren't that many, and perhaps we should be pleased that others are interested in a minority. But I'm not sure that we are all that interesting. Is being a woman in acoustics any different from being a man in acoustics? By definition, I don't know. But I find it very difficult to identify any difference which is related to being 'in acoustics'.

For a start, I should state my view of the Women In Engineering question. In the ILEA – my current employer – issues of gender and race (not to mention age, disability, and sexual orientation) are vital. The argument runs as follows. Women should want to be engineers; few girls choose to study science or enter engineering; therefore we may conclude that women are disadvantaged in technological education and discriminated against in employment; therefore Something Should be Done About It. However clear the facts may be, I have never found any evidence to support the argument of causality. Statements to this effect during a Cert. Ed. course earned me minimal marks from my (female) tutor in the first year, and 10 out of 10 from my (male) tutor in the second.

The point is this. It is clearly true that most women do not choose engineering; it is possibly true that some women are discouraged by upbringing, education and stereotyping; it may be true that women would have better employment prospects with technological training; but it is not necessarily true that more women *should* wish to be scientists or engineers.

So, disappointing though it might be to readers, my career in acoustics is more differentiated by personal eccentricities than by anything relating to the fact of being female. Education at an all-girls school left me firmly ignorant of all electronics (it is still a matter of luck if I identify the hot end of a soldering iron correctly). Cambridge still discriminated 10 to 1 against women in all subjects (no nonsense about mixed colleges) and by the third year of Natural Sciences there were 2 women and 64 men studying physics.

At this point, I acquired my only experience of real sexual discrimination. A 'milk round' interview with the BBC required me to answer such questions as: 'We find that we can't ask women to hump cables around studios because they ladder their tights; how would you cope?' (Answer: wear trousers); and 'It is difficult sending women on outside broadcasts because if a camera falls down a cliff, you can tell a man to go and get it, but you can't say that to a woman, can you?' (Answer: If you can't, that's your problem, not mine).

I reported it all to an acquaintance who was giving evidence to the House of Lords committee on sex discrimination. But in all honesty, on the strength of my interview performance I don't think I'd have employed me either, even if I'd been male. It is much more fun to be, now, in the back row of the BBC Chorus (if they want sopranos and contraltos, they have to have women) observing the male – and female – studio managers wrestling with the acoustics of the trickier studios.

I can't remember exact numbers on the MSc course at ISVR, but I think I was the only woman doing the Sound and Vibration option, although there were several in Audiology. It is with glee that I now remember, when using B&K's impedance hammer, that I always said that when physics got too difficult I became an engineer so I could ''it things with 'ammers'. Around this time one of the characteristic occurrences of my life began; the kind men who offer to carry bits of equipment for me. When I refuse, it is rarely out of affronted feminism; I am not the smallest of people with the slightest of builds, and if *I'm* having difficulty with a BFO (MSc students got the old style B&K equipment with the wooden cases) or – nowadays – a large tape recorder, most men have equal trouble. But it always happens! Now I just remark that if anyone is going to drop however-many-thousand-pounds-worth of my equipment, it had better be me. Of course, the one time that I would have welcomed assistance – parked outside the engineering building, struggling with wheel nuts on finding a flat tyre – I was studiously ignored!

I seem to remember that when I arrived in the Building Engineering department at Liverpool I was declared an honorary man for staffroom purposes; I can't remember whether I bothered to declare *them* all honorary women. But that is the full extent of the significance of being female. I did once protest to the local garage because all the cartoons in their reception area depicted women being silly; but some were really quite funny ('please can I have a new dipstick, this one doesn't reach the oil any more') and it had nothing to do with acoustics. And as I've said, present employment by the ILEA does not permit prejudice.

So where does all this leave the matter of being 'a woman in acoustics'? I really don't know. Certainly, there is a tendency for telephone callers to assume that I am the department secretary – although as I have rather a deep voice, the eccentricity of the switchboard equally deceives them into addressing me as 'Mr'. And there is one secretary in B&K with whom I don't bother to argue; she doesn't believe that I am worth communicating with and I know that it is quicker to walk the length of the building to fetch my junior (male) colleague than to attempt persuasion. The occasional Cathedral canon has been disconcerted to find that the 'Dr Zarek' who is turning up to discuss his sound reinforcement is female (and wearing a Movement for the Ordination of Women

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THE ACOUSTIC CONSULTANT – Role, Responsibility and Risk

A one-day meeting was held on 1 March 1989 at the Institute of Physics jointly with the Association of Noise Consultants, aimed at those members who are consultants. Bearing in mind the narrow subject the meeting was well attended with 34 participants. The format of the meeting was unusual in that there were five invited speakers – only one of them an Institute member.

The meeting was opened by Professor John Large who discussed the role of the acoustic consultant. From small beginnings, acoustic consultancy now covers an enormous breadth of subject matter and this is not reflected in different types of qualification. There is nothing, for example, to tell a client whether he is choosing an expert in hearing aid design or one in ventilation noise. We are now dealing with highly specialized subjects and we will have to become more compartmentalized.

He outlined the problems of establishing a contract when many jobs start with a telephone call or a briefing meeting, no statement of final objectives, and usually without the client knowing what he wants or what he is going to get.

Sarah Webb, a solicitor in private practice with Russell, Jones and Walker, was able to answer some of Professor Large's concerns and advise us what contractual arrangements we should at least be aiming at. She discussed such matters as who is the client, what constitutes a contract and the obligations of both the consultant and the client. Agreement to a detailed brief is always advisable and if only an initial report is asked for then it must be made clear that your obligations cease after that.

While it does no harm to put exclusion clauses into a contract, it should be remembered that they may not be effective – the courts will look at what is reasonable in each particular case.

Jeremy Hyne of the Excess Insurance Company was the last speaker of the morning and gave us the underwriters' view of the professional risks we face. We were glad to hear that the Acoustic Consultant has had little history in the Professional Indemnity market. The main factors that companies took into account in assessing the risk were the history of the firm and its principals, the overall fee income and whether there had been any previous problems. In engineering generally many claims were the result of poor supervision of staff.

Michael Lukey from BSI Quality Assurance opened the afternoon session by telling us how quality assurance can help reduce our risk. Quality assurance (QA) is simply a management system which is approved by an independent body – BSI. Its aim is to identify the management disciplines needed to ensure that the service consistently lives up to the clients' expectations. It was generally thought that firms employing QA could eventually expect to see lower premiums for professional indemnity in the future, but it seemed unlikely that would happen very quickly.

The final speaker was Stephen Dunmore from the Construction Industry Directorate at the Department of the Environment. He explained the implications of the Single European Market. The immediate effect will be to create a domestic market of 320 million people and a construction market of 250 billion pounds.

An EC directive will list and define professions which are approved by the state or by a chartered body. The host state could impose either a period of supervised practice or an adaptation test on anyone wishing to take up employment there. On liability and professional indemnity the indications are that there will be no directive to oblige member countries to adopt similar arrangements.

The discussion following the invited papers brought some experiences from members of the audience – particularly difficulties with contracts and with obtaining payment from clients.

Our warm thanks are due to the invited speakers who gave up not only a day of their time to speak and to answer questions but a great deal of time prior to that to prepare their talks. Delegates came away from the meeting with much to think about and perhaps some questions answered.

Dick Bowdler

Letter to the Editor

Environmental Noise
Hong Kong's Noise Control Ordinance

Your readers may like to know that Hong Kong now has its first ever comprehensive legislation to provide statutory controls to restrict and reduce the annoyance caused by environmental noise. The Noise Control Ordinance was passed by the Legislative Council on 20 July 1988, after intensive deliberation within government and careful consideration by the law makers. The control provisions attracted widespread interest during the public consultation period prior to the enactment of the legislation.

The Noise Control Ordinance deals with the following forms of noise:

(a) noise from domestic premises and public places (i.e. general neighbourhood noise);
(b) noise from construction activities (including piling);
(c) noise from places other than domestic premises, public places or construction sites (for example, noise from industrial or commercial premises); and
(d) product noise (i.e. noise from individual items of plant or equipment).

The Ordinance enables Regulations and Technical Memoranda to be made which introduce detailed control criteria, measurement procedures and other technical matters. Three Technical Memoranda (two on construction noise and one on industrial type noise) are now in place to deal with the unique local situation whereby a large percentage of the metropolis' built up area is under the influence of numerous construction and industrial activities. A pragmatic approach is being adopted to recognize the need for particular activities and hence the different criteria to be used in the three Technical Memoranda.

The provisions of the Ordinance are enforced by the Director of Environmental Protection (the Noise Control Authority) and the police and implementation of different provisions will commence in stages starting early in 1989. About 40 additional posts at the professional and technical levels have been created in our Department to cope with the anticipated enforcement activities.

From Raymond Chan, Principal Environmental Protection Officer, for Director of Environmental Protection, Hong Kong Government.

Copy for the *Bulletin*

Contributions and information for the October issue of *Acoustics Bulletin* should reach Marjorie Winterbottom at 14 Witney Road, Long Hanborough, Oxon OX7 2BJ, no later than Tuesday, 22 August.

ACOUSTICS AND THE INTEGRATED BUILT ENVIRONMENT

The Building Environmental Performance Analysis Club (BEPAC) initiative began in the summer of 1987. The aim of BEPAC is 'to improve the quality of building performance by encouraging the use and development of environmental prediction methods for buildings'.

BEPAC is about environmental modelling in its widest sense, including acoustics, air movement and lighting as well as thermal and energy simulation. Indeed, it is hoped that BEPAC will be instrumental in progress towards the integration of these individual specialist topics to produce a complete environmental model for real buildings.

BEPAC receives support from the Science and Engineering Research Council and the Building Research Establishment. The Chairperson of the BEPAC Committee is Steve Irving, Managing Director of Facet Ltd (one of the Oscar Faber group of companies). The secretary is Eric Keeble of the Environmental Systems Division of BRE.

BEPAC seeks to achieve its aims through a number of activities. The key element is the promotion of information exchange between users, developers and researchers and the effective dissemination of this to the membership. Such activities will assist the definition of future research needs, and encourage the development of appropriate standards in terms of benchmark input data sets, documentation and data sets.

To get the work under way Task Groups are being established to concentrate on five areas of specific interest to BEPAC – acoustics, air movement, controls, lighting and standards. An Acoustics Task Group is now being formed. Although the first meeting of this group will define its tasks experience has shown that activities might typically include:

List of major UK facilities.
Review of current research activities.
Catalogue of relevant design and computational computer packages.
Identification of user needs.
Identification of longer term needs for design tools and analysis procedures.

The Acoustics Task Group will endeavour to provide a forum for the cross-disciplinary exchange of ideas and thus representation from both research and practice is sought. All parties interested in hearing more about the Acoustics Task Group please contact:

Dr John Roberts, Institute of Environmental Engineering, South Bank Polytechnic, London SE1 0AA.

INAUDIBILITY – A CONCEPT IN THE ASSESSMENT OF NOISE NUISANCE

One-day Meeting held on 8 March, 1989 at the Shire Hall, Reading

Organizer, G A Parry, Southern Branch

This meeting, held at the Headquarters of Berkshire County Council, was attended by 55 enthusiastic members of the Institute and others.

The meeting was opened by Mr R Clarke, the Director of Highways and Planning, who welcomed the members to the prestigious Council Chamber and explained that it seemed quite fitting that a meeting on inaudibility should be held there as the Chamber was more frequently noted for the excessive noise of heated debate. Mr Clarke reminded the audience of the role of Berkshire in taking on a large amount of growth over the past decade and the difficulty in planning terms of keeping noise to a minimum; with this in mind Berkshire County Council had employed a team of acoustic engineers for the last 15 years. Mr Clarke extended his opening address whilst an overhead projector was hastily located for which I am especially grateful. (Note to contributors – please tell the meeting organizer your exact requirements prior to arrival!)

The opening speaker of the day, Ken Dibble of the Sound Practice, explained his experience in the assessment of entertainment noise and the mechanics of problems of evaluation with the particular difficulty encountered in designing in order to ensure inaudibility. No sooner had Ken finished his presentation than a swarm of hands went up with a resultant barrage of questions.

This experience was repeated during the course of the day and it was only with the greatest of difficulty that the various session chairmen managed to keep to timetable and control the urges of some delegates to turn the day into a personal debate.

There were very distinct differences between the North (Scotland) and the South in how 'inaudibility' should be used as a planning and design tool. The consensus of opinion was that in order to ensure inaudibility then one should design 10-15 dB below background; however, it was recognized that the constraints involved might well mean settling for a lesser standard.

The meeting was finally closed at 1700 h with grateful thanks from the meeting organizer to the contributors, the various session chairmen and especially to Roseanne from the Institute for making the administration of the day run so smoothly.

BRANCH AND GROUP NEWS

North West Branch

Afternoon and evening visit

On a blowing wintry day in March fifteen NW branch members turned out for a fascinating visit to the City of Liverpool to learn something about organ making. Our visit started with a tour of David Wells' Cathedral Works where we observed and experienced the art and craft of organ making. Following the tour David demonstrated his many skills by constructing an organ pipe whilst entertaining us with the history of his small but expanding works. He described the various types of pipe, the materials they are made from and methods of construction, explaining how these factors alter the sound and tone of the pipe. We left David Wells and his colleagues with Ian Fraser the proud owner of a handmade organ pipe. The second half of the visit was at the magnificent Anglican Cathedral. We were greeted by Ian Tracy the cathedral organist, his assistant and the two organ scholars. Here we were privileged to have a personal tour of the largest organ in the British Isles. Henry Willis III built this heroic organ which was started in 1925. It consists of approximately 10,000 pipes, the imposing transept fronts embodying the 32 ft pipes. It was a unique experience to walk through the many tightly packed forests of pipes that ranged from the huge 32 ft pipes to those smaller than a pencil. The pipes need tuning twice a year; this takes approximately three weeks in the spring and again in the autumn. The life of the organ is provided by large blowers which feed the many reservoirs through a labyrinth of pipework built into the building. The nerve centre of this magnificent instrument is the main console which has 5 manuals and over 150 stops and a range of special features. Here we were able to admire the many skills of the organist as well as the organ maker. We also had the pleasure of listening to the organ in the Lady Chapel which has Sir Giles Gilbert Scott's very effective small case. The highlight of the evening was to listen to the rich sound of the cathedral organ which was in tonal proportion to the large resonant requirements of this our greatest modern cathedral. Following the visit several of us enjoyed a good Chinese meal which completed a very rewarding day.

Chris Waites

Phonetic Labelling of Speech Signals

Speech Group Technical Meeting held at University College London on 24 February 1989

This was a well-attended open meeting, with approximately 80 in the audience, including some European visitors. The afternoon was split into two, with four invited speakers, tea, and then a discussion session.

Geoff Lindsey and Bill Barry (University College London), started off with a description of some of the problems and strategies one must take if one is to attempt to assign symbols to regions of a speech signal. Their talk was of 'Coping', and emphasized that traditional word and phonemic labelling oversimplified the content of the signal, and phonetic labelling was a compromise between an identification of common acoustic events and a phonological interpretation.

Mike Allerhand (University of Cambridge) described one class of pattern recognition techniques for generating phonetic transcriptions automatically. These systems must of course be supplied with labelled data for training. It appears that all of the current systems have very similar performance, about 70% for 10 ms labels and 50-60% for phonetic units. Given that it is hard both to label speech and to generate the labels automatically, we must conclude that we are doing something wrong.

John Harris (University College London) introduced some new developments in the study of how speech 'sounds' are organized in language, termed non-linear phonology. The aim here is to dispense with the idea of a linear transcription at a phonological level, to recognize that the construction of words and syllables need not be described left-to-right in a linear way, and that more parsimonious descriptions can be obtained by a hierarchical analysis. John proposed that 'the phoneme is dead'.

John Local (University of York) took the idea of non-linear phonological analysis a stage further by demonstrating the possibility of linking the hierarchical phonological description directly to a set of acoustic parameters, bypassing the traditional linear segment sequence model. John has developed a non-linear speech synthesis system, and he explained some of its operation.

The discussion session set out to answer the following questions: 'At what level should we annotate speech?' and 'Should we use linear or hierarchical labels?' Of course no definitive answers could be obtained, but the discussion was wide ranging. Jim Hieronymous (CSTR) described the acoustic-phonetic label inventory used in the US speech database. He described the shortcomings and proposed a slightly modified set for UK use. Discussion here was related to the phonological bias to the symbols – which were neither acoustic nor phonemic. The question as to whether in all practical circumstances the proposed symbol set would preclude some kinds of phono logical model in a speech recognition system was talked around rather than answered. Laurie Moye (STC) suggested that this type of labelling was quite the wrong thing to do in any case, that the labels one puts on the signal should be simply the labels you want the speech recognizer to output, usually words. Adrian Fourcin (UCL) proposed that labelling could be performed on

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Letter from the Vice-President Groups and Branches

The idea I outlined in the last *Bulletin* about improving communications with overseas members has gained some support. Unfortunately at the time of writing, this support has come from UK members who wish to hear about events abroad, not from overseas members wishing to divulge the information. *Please* can I have some response from around the world? There are approximately 122 members spread amongst 30 countries, not counting the members in Hong Kong.

Activities in that part of the world appear to have been somewhat limited over the past couple of years. I hear, however, that an attempt will be made to revive the branch with a meeting this summer. Mr Daniel Chan, a senior lecturer in Hong Kong Polytechnic, has taken on the task so Hong Kong members please contact him if you don't hear anything. There are 82 members there so I see no reason why we shouldn't have a viable Branch. We all hope that the present political unrest in the region will not adversely affect the wellbeing of this unique Branch.

Meanwhile I would like to hear from members whether at home or abroad with ideas about improving links overseas.

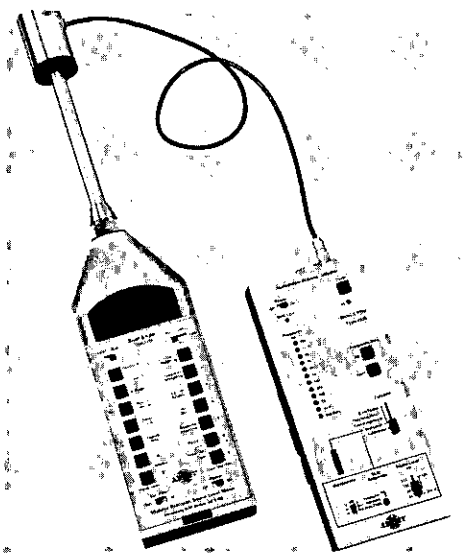
Geoff Kerry

New Products

Submissions for inclusion in this section should be sent direct to J W Sargent, Building Research Establishment, Garston, Watford WD2 7JR.

Omnidirectional hydrophone B&K 8105
The 8105 hydrophone is a spherical transducer which is omnidirectional over 360 degrees in the x–y plane and 270 degrees in the x–z plane over its entire frequency range. The unit is designed for waterborne sound measurement over the frequency range 0.1 Hz to 160 kHz with a receiving sensitivity of −205 dB re 1V/μPa. the piezoelectric effect of the sensing element is reversible, so that the unit can also be used as a sound projector. This small robust unit, which has no exposed metal parts, can be used down to 1000 m ocean depth. The internal construction guarantees mechanical and electrical isolation of the sensing element, and the shield of the integral low-noise cable is connected to the internal support structure to provide electrical shielding. Each hydrophone undergoes an extensive ageing and temperature stabilization procedure prior to individual calibration traceable to NBS.

Multifunction acoustic calibrator B&K type 4226
The Type 4226 multifunction acoustic calibrator not only performs normal sound level calibration of microphones and sound level meters but also checks frequency response, time weighting and crest factor capability. The frequency response of microphones and instruments can be checked from 31.5 Hz to 16 kHz in octave steps. Stability of test frequencies is guaranteed by a crystal oscillator, and accuracy of calibration by a compressor loop driven by a reference microphone. Insertion of a built-in correction network into the compression loop enables simulation of a free field or random field for microphone calibration, while in the absence of a correction network a pressure response is obtained. A built-in timer accurately defines noise dose for dosemeter calibration. In addition connection is provided for an external generator and an output signal is available for checking instruments without an acoustic input.



Bruel & Kjær's multifunction acoustic calibrator Type 4226

Further details are available from Bruel & Kjær (UK) Ltd, 92 Uxbridge Road, Harrow HA3 6BZ. Telephone: 01-954 2366. Telex: 934150 BK UK G. Fax: 01-954 9504.

Acoustic Editor
Acoustic Editor is a new acoustical processing program for IBM compatible computers. Data are taken from a Sound Level Meter or Data Logging L_{eq} Meter such as the CRL 2.36 and stored as a series of data elements on the computer's disk. Acoustic Editor will allow the data to be examined in many ways and plotted out in many different forms. The calculations in Acoustics Editor are of sufficient accuracy to meet the requirements of the Laboratory grade of IEC 651 and IEC 804 type 0. Acoustic Editor can plot the variation of sound level against time and all the parameters such as dynamic span, time, resolution etc. can be varied. The plot can be of any length from 1 second up to several years with a resolution from 5 msec up to about 24 hours. The dynamic range is from −10 dB to 190 dB, the limit being set by the Sound Level Meter used to acquire the data. If a Cirrus CRL 2.36 data logging unit is used for acquisition, the measuring span is from about 20 to 140 dB.

Not only can the Time History of the noise be plotted, but the data can be *coded* in colour. Thus any particular noise event can be separated out from the rest of the data and viewed or measured without unwanted noise influencing the results. Both the normal and cumulative histograms can be presented with a resolution of 0.1 dB or greater, using all or part of the stored data. Thus a series of histograms can be plotted showing the time variation of the noise distribution, giving a total picture of the variation of the acoustic climate over time. Not only that, but the coded data of individual events can be plotted as well. Any statistical level from L_1 to L_{99} can be listed with any chosen time period both overall and between each listing.

Acoustics Editor was designed to operate with Cirrus Research meters, however special programs are available to interface almost any currently available professional sound level meter using a Cirrus interface card. It is also possible to export data from Acoustic Editor files to standard database or spreadsheet programs such as Lotus 123, Symphony or Smart allowing the calculations to be put into a standard report as part of the text without having to retype the data.

For further information please contact Dudley Wallis, Cirrus Research Ltd, Bridlington Road, Hunmanby, North Yorkshire YO14 0PH. Tel: 0723 891655.

R 1000 oscilloscope
This new oscilloscope can capture waveforms and store them on disk for recall at any time. The Rapid Systems R1000 is a PC based outboard peripheral including 'turn-key' digital oscilloscope software. There are four input channels, each with its own 500 kHz, 8-bit A/D converter and 32 kbyte buffer memory. The instrument offers analog and digital trigger facilities, fully programmable gain, and the flexibility of pre- and post-trigger acquisition for transient capture applications.

All manipulations and control of acquisition and display are by menu commands, while display features include zoom, scrolling, grid, plus cursor readout of time and voltage. An 'autoslave' feature allows automatic capture and store for unattended operation, with the waveform labelled for storage on hard or floppy disk.

The instrument is housed in a compact case, with standard BNC input and external trigger connectors for ease of hook-up, while connection to the PC is via ribbon cable terminated with a proprietary PC-bus interface card.

A detailed data sheet for the R1000 oscilloscope can be obtained from Data Laboratories Ltd, 35 Bury Mead Road, Hitchin, Herts SF5 1RT. Tel: 0462 422411.

Flanking Transmission in a Ventilation System

Simon J. Lovell

Over the years it has been noticed that engineers involved in the design of heating and air conditioning systems do not fully appreciate the additional noise problem associated with flanking transmission. This problem can, of course, apply to all forms of noise control if the correct procedures are not checked and adhered to, but in this instance the reference is purely to ventilation ductwork.

'Flanking transmission' simply means to pass around the side of a functional item, e.g. a silencer, and pass back into a critical region, i.e. the ductwork or adjacent area.

The standard practice of silencer selection for reducing ductborne fan noise to a specified criterion may not always be achieved. This sometimes is due to the lack of consideration in silencer positioning. If attenuators are installed in a plant room at a distance from the wall there is a likelihood of airborne fan or motor noise breaking back into the system after the silencer. In some instances, should the silencers be installed above a critical area external to a plant room, the airborne noise level emanating from the duct before the silencer can affect the target design level achieved at grille or diffuser positions.

Another example of flanking is via an externally situated vent system serving a theatre/studio or the like. Traffic, factory or aircraft noise may be audible above the artificially low ambient condition, having bypassed the attenuators and discharged to the served area. Ideally silencers should be installed within the duct at exit or entry from or to the plant room or served area. However, it is always advisable to check the noise break-out figures from the silencer casing and, if necessary, increase the casing gauge of material being used. In extreme cases it will be imperative to externally acoustically insulate silencers, but whatever the application consideration of the problem should be given importance.

Generally, silencers are assumed to be internally acoustically lined on all faces; however, this is not the case in rectangular units. Two of the four faces will be lined and approximately 60% of each of the remaining faces will be protected by the splitter top and bottoms, so this does not ensure that noise will not break in via the silencer airways. In order to achieve maximum attenuation through external cladding it is necessary to effect discontinuity between the ductwork and insulation membrane. This is normally achieved with a heavy density mineral fibre slab, ensuring adequate thickness in order to clear all protrusions, such as flanges or hanger brackets liable to transmit vibration. After adhering the slabs to the ductwork, aluminium or similar corner angles are applied and secured with galvanized wire strapping, affording further support for this heavy material. Finally, a pre-selected membrane, affording the calculated transmission loss, is fixed. Should calculations show the silencers are not necessary for ductborne fan noise attenuation, but breakout noise before the grille or diffuser exceeds the design criterion, it is possible to line all four ductwork surfaces internally with a suitably dense mineral fibre to a calculated distance. However, it should be noted that consideration must be given to the air velocity as in some instances additional static pressure and noise regeneration will be effected, possibly invalidating the treatment.

The majority of heating and air conditioning systems require thermal insulation and silencers are often excluded to ensure a competitive insulation price. As already mentioned, they are not fully protected and will emit the same chilled or heated air as the ductwork, giving rise to condensation resulting in ductwork corrosion.

It seems obvious, therefore, that duct-mounted silencers require insulating in line with the ductwork system, not only to ensure continuous thermal insulation, but also to provide acoustic properties that will alleviate minor flanking problems. The parameters for selecting barrier materials are (a) high mass and (b) low stiffness, such as lead and PVC impregnated membranes.

As we know, when the mass is doubled so is the performance. In logarithmic terms this is equal to a maximum constant addition of 3 dB per frequency. To improve upon this mass law it is necessary to isolate each barrier from itself via a mineral fibre or like material. This will reduce and absorb the reflected noise between each barrier. It should be noted that the greater the barrier cavity depth the greater the improvement in noise reduction.

When applying this treatment every care must be taken to ensure discontinuity between each mass and that all joints are staggered and overlapped. On this layer system it is known that low frequency noise will be transferred via the airborne path in the cavity. At mid and high frequency noise will be transferred via the structural/mechanical connections; therefore, the bulk of noise reduction is achieved at frequencies of 500 c/s upwards.

It should be noted that all materials have resonant frequencies. These sometimes occur when a noise wavelength is exactly equal to the distance between the duct surface and the treatment surface. Should this be effected on the frequencies being considered the attenuation applied will be reduced due to the increased loudness of the resonance.

CALLS FOR PAPERS NON-INSTITUTE MEETINGS

International Congress on Recent Developments in Air and Structure Borne Sound and Vibration

Auburn University, Alabama, USA, 6–8 March 1990

The programme will consist of invited and contributed papers covering theoretical and experimental research in the following areas: sound intensity; modal analysis; statistical energy analysis; passive damping; boundary element methods; diagnostics and condition monitoring; material characterization and non-destructive evaluation; active noise and vibration control; sound radiation and scattering; finite element analysis.

Abstracts (200 words) must be received no later than 15 September 1989 by the Congress Secretariat, Department of Mechanical Engineering, 201 Ross Hall, Auburn University, AL, 36849-3541, USA. Tel: (205) 844-4820; Fax: (205) 844-3307.

SYMPOSIUM ON PHYSICAL ACOUSTICS – Fundamental and Applications

Kortrijk, Belgium, 19–23 June 1990

Contributed papers should not exceed 15 minutes and are invited on the following topics: acousto-optical and photo-acoustical problems; surface-acoustic waves; reflection, refraction and scattering of acoustic waves; inhomogeneous and heterogeneous waves. Please address correspondence to: Professor O. Leroy, Katholieke Universiteit Leuven Campus Kortrijk, E. Sabbelaan, B-8500 Kortrijk, Belgium. Tel: (056) 21 79 31; Telefax: (056) 22 89 20.

NON-INSTITUTE MEETINGS

1989

16–18 August	*Noise and Vibration '89,* to be held in Singapore. Details from: The Secretariat, International Conference Noise and Vibration 1989, c/o School of Mech. and Production Engineering, Nanyang Technological Institute, Nanyang Avenue, Singapore 2263.
19–22 August	International Symposium on Musical Acoustics, Planegg, FGR.
24–31 August	*13th ICA Congress,* International Commission on Acoustics, Belgrade, Yugoslavia.
4–6 September	*Symposia:* Dubrovnik on *Sea Acoustics*; Zagreb on *Electroacoustics*. Details: Secretariat, Sava Centar 11076, Belgrade, Yugoslavia
4–6 September	COMADEM 89 International, *Condition Monitoring and Diagnostic Engineering Management,* at Birmingham Polytechnic. Conference Organizer: Dr Raj B. K. N. Rao, Faculty of Engineering and Computer Technology, Birmingham Polytechnic, Birmingham B42 2SU. Tel: 021-331 5441. Co-sponsored by the IOA.
5, 6 and 7 September	5th International Meeting on *Low Frequency Noise and Vibration,* at Trinity College, University of Oxford, Oxford, UK. Sponsored by *The Journal of Low Frequency Noise and Vibration*. Information from: Dr W. Tempest, Chairman, Organizing Committee, Multi-Science Publishing Co Ltd, 107 High Street, Brentwood, Essex CM14 4RX, England.
12-13 September	*R & D Design and Manufacturing,* Manchester Business School; to be held in Ghent, Belgium.
13–14 September	IMechE Conference on: *Sizewell 'B': the first of the UK PWR Power Stations,* at Ramada Renaissance Hotel, Manchester. Details from: IMechE on 01-222 7899.
26–28 September	*Eurospeech '89,* European Conference on Speech Communication and Technology, Paris. Details from: Secretariat, CEP Consultants Ltd, 26-28 Albany Street, Edinburgh EH1 3QH. Tel: 031-557 2478.
3–6 October	28th Acoustical Conference on Physiological Acoustics: *Acoustics of Speech and Music.* Details: Secretariat, House of Technology, Eng. L. Goralikova, Škultétyho ul.1, 832 27 Bratislava, Czechoslovakia.
4–6 October	IEEE/UFFCS Ultrasonics Symposium, Montreal, Canada. Details: Allied-Signal Inc., Attn. H. van de Vaart, PO Box 10221R, Morristown, NJ 07980, USA.
23–27 October	ISVR-METRAVIB-TPD-Course, Noise Reduction of Machinery Installations by Vibration Isolation, Noordwijkerhout, The Netherlands.
24–26 October	*Sensors & Systems '89.* Test and Transducer Conference at Wembley Conference Centre. Details from: Norma Thewliss, Conference Secretary, Trident International Exhibitions Ltd, 21 Plymouth Road, Tavistock, Devon PL19 8AU. Tel: 0822 614671.
27 November–1 December	Meeting of Acoustical Society of America, St Louis, USA. Details: Murray Strasberg, 500, Sunnyside Blvd, Woodbury, NY 11797.
4–6 December	Inter-Noise 89, Newport Beach, CA, USA. Details from: Internoise '89, Institute of Noise Control Engineering, PO Box 3206, Poughkeepsie, NY 12603.
December	European Symposium on Transportation Noise, Braunschweig, FGR. Details from: Deutsche Gesellschaft für Luft- und Raumfahrt e.V., Godesberger Allee 70, D-5300 Bonn 2.
5–7 December	BMUS 21st Annual Scientific Meeting & Exhibition, The English Riviera Centre, Torquay. Contact: The General Secretary, British Medical Ultrasound Society, 36 Portland Place, London W1N 3DG. Tel: 01-636 3714.
11–12 December	Third International Noise Seminar, Rio de Janeiro, Brazil. Contact: Organizing Committee, Laboratoria de Acustica e Vibracoes, PEM-COPPE/UFRJ, C.P. 68503, 21.945, Rio de Janeiro, Brazil. Tel: (021) 280 8832 R/412.

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February	*Fourth Conference on Hydro- and Geophysical Acoustics,* Rostock, E. Germany.
6–8 March	International Congress on *Recent Developments in Air and Structure Borne Sound and Vibration,* organized by the Dept. of Mechanical Engineering, 201 Ross Hall, Auburn University, AL 36849-3541, USA. Abstracts (200 words) by 15 September 1989. Details from Congress Secretariat.
20–22 March	IMechE International Conference on *Engineering – A Quieter Europe,* at the Centennial Centre, Birmingham. Details from IMechE on 01-222 7899.
10–13 April	First French Conference on Acoustics. Details from: Congrès Français d'Acoustique, I.C.P.I. Lyon, 25 rue du Plat (or 31 Place Bellecour) 69288 Lyon Cedex 02, France.
21–25 May	Meeting of the Acoustical Society of America, State College, Pennsylvania.
6–8 June	16th World Congress of the International Association against Noise, AICB, hosted by The National Society for Clean Air, at the Brighton Conference Centre. Details from: National Society for Clean Air, 136 North Street, Brighton, BN1 1RG. Tel: 0273 26313.
19–23 June	Symposium on *Physical Acoustics, Fundamental and Applications,* at the Catholic University Leuven Campus Kortrijk in Belgium. Details from: Prof. O. Leroy, Katholieke Universiteit Leuven Campus Kortrijk, E. Sabbelaan, B-8500 Kortrijk, Belgium. Tel: (056) 21 79 31.
1–6 August	Internoise '90, Goteborg, Sweden.
8–10 August	International Tire/Road Noise Conference, Gothenburg, Sweden. Details from: U Sandberg, Swedish Road and Traffic Research Institute, S-581 01 Lønkoeping, Sweden. Tel: +46-13-115200.
October	*29th Acoustical Conference on Room and Building Acoustics* – Czechoslovakia.
26–30 November	Meeting of the Acoustical Society of America – San Diego, California.

Information relating to meetings of possible interest to readers should be with the Editor at the address on page 1 no later than four months before the date of the meeting.

A Woman in Acoustics – cont'd from p. 30

badge), but is usually more affronted to find that I suggest revision of his liturgical arrangements as well as loudspeakers. Now, if you'd asked about the position of women in the Church . . . acoustics really doesn't do so badly!

At the recent seminar on The Acoustic Consultant, one speaker – Professor *Large* – commented that in terms of consultancy practice, acousticians are small. This interested one of the shorter delegates. With the exposé of *heightism* in the *Times Higher Education Supplement* of 7 April, perhaps a future issue of *Acoustics Bulletin* should be devoted to small people in acoustics?

Speech Group meeting – cont'd from p. 33

tiers related to the articulation, and these in turn could be related to the output of physiological sensors. The utility of the modern phonological theories was debated, and Geoff Lindsey (UCL) summarized by noting that even the phonologists used a linear phonetic description as the base for their analysis.

M. Huckvale
Organizer

Institute of Acoustics Meetings

1989

14 September	SG	Digital Speech Coding	Engineering Dept., Cambridge University
25 September	M	PC Programmes in Acoustics (One-day Meeting)	Zoological Gardens, Regents Park, London
23 October *(Note new date)*	L	Planning and Noise (One-day Meeting)	Regent's College London
2–5 November	M	**Reproduced Sound 5**	Windermere
23–26 November	M	**Autumn Conference – Industrial Noise**	Windermere
27 November	M	Hand–arm vibration	Windermere
11–13 December	UAG	Sonar signal processing	Loughborough University
12 December	BAG	Noise within Buildings	To be announced

1990

27–30 March	M	**Spring Conference – Acoustics '90**	University of Southampton

Key

M = Meetings Committee Programme
BAG = Building Acoustics Group
ING = Industrial Noise Group
MAG = Musical Acoustics Group
PAG = Physical Acoustics Group
SG = Speech Group
UAG = Underwater Acoustics Group
LB = London Branch
EB = Eastern Branch
EMB = East Midlands Branch
NEB = North East Branch
NWB = North West Branch
SB = Southern Branch
ScB = Scottish Branch
SWB = South West Branch
YHB = Yorkshire and Humberside Branch

Further details from:

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