

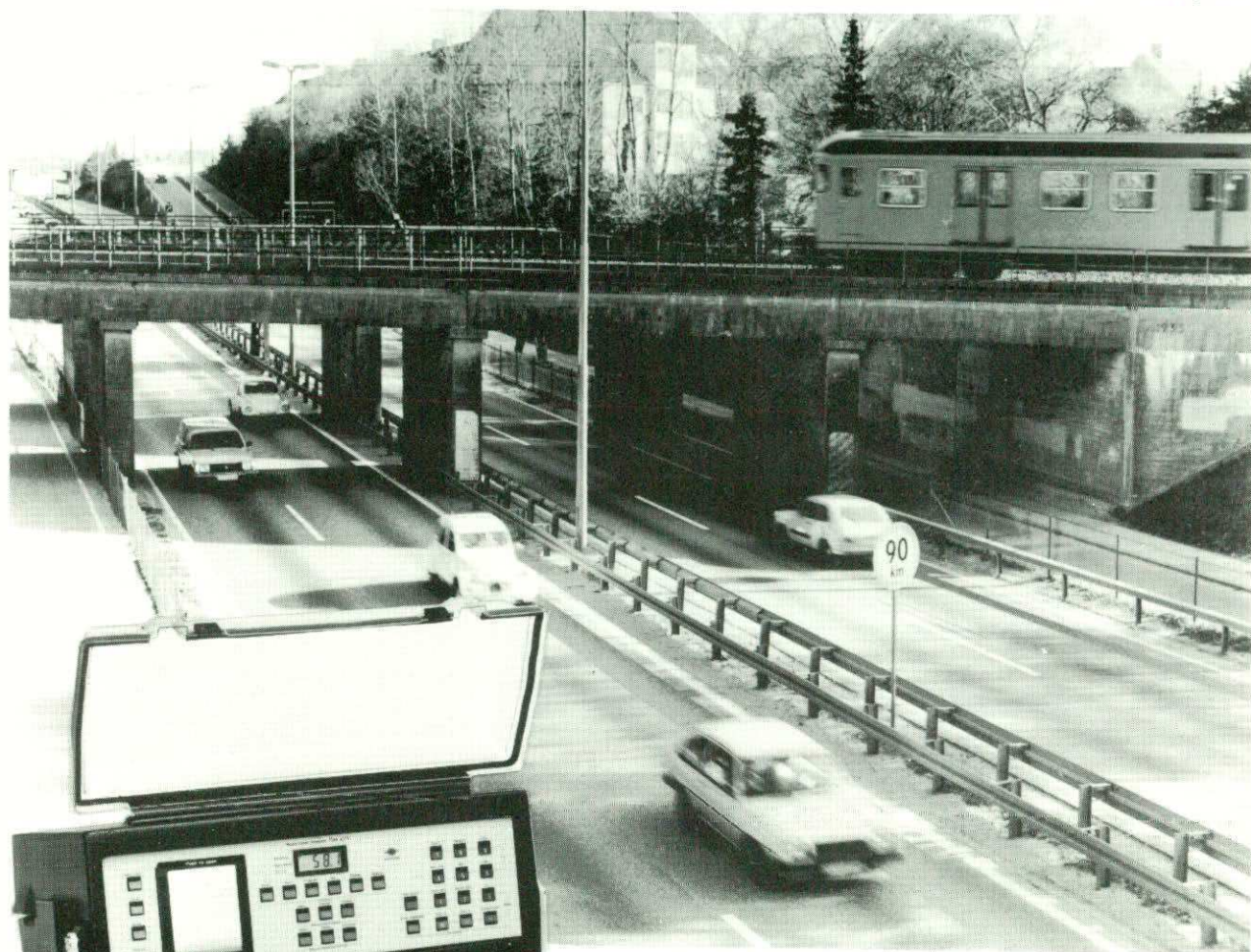
# Acoustics Bulletin

January 1985    Volume 10    Number 1

INSTITUTE OF ACOUSTICS

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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 of The Institute of Acoustics

Membership of the Institute is generally open to all individuals concerned with the study or application of acoustics. There are two main categories of membership, Corporate and Non-corporate. Corporate Membership (Honorary Fellow, Fellow, Member) confers the right to attend and vote at all Institute General Meetings and to stand for election to Council; it also confers recognition of high professional standing. A brief outline of the various membership grades is given below.

## Honorary Fellow (HonFIOA)

Honorary Fellowship of the Institute is conferred by Council on distinguished persons intimately connected with acoustics whom it specially desires to honour.

## Fellow (FIOA)

Candidates for election to Fellow shall normally have attained the age of 35 years, have had at least seven years of responsible work in acoustics or its application, and have made a significant contribution to the science or profession of acoustics.

## Member (MIOA)

Candidates for election to Member shall normally have attained the age of 25 years, must either (a) have obtained a degree or diploma acceptable to Council and have had experience of at least three years of responsible work in acoustics, or (b) possess an equivalent knowledge of

acoustics and cognate subjects, have had experience for not less than seven years of responsible work in acoustics or its application, and must have been a Non-corporate member of the Institute in the class of Associate for not less than three years.

## Associate

Candidates for election to the class of Associate shall have attained the age of 18 years and (a) be a graduate in acoustics or a discipline approved by Council, or (b) be a technician in a branch of acoustics approved by Council, or (c) be engaged or interested in acoustics or a related discipline.

## Student

Candidates for election to the class of Student shall have attained the age of 16 years and at the time of application be a bona-fide student in acoustics or in a related subject to which acoustics forms an integral part. Normally a student shall cease to be a Student at the end of the year in which he attains the age of 25 years or after five years in the class of Student, whichever is the earlier.

Full details and membership application form are available from: The Secretary,

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## Presidents Letter

### **Institute of Acoustics**

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*Dear Member,*

*We now have a Code of Ethics, which was approved by Council at its December meeting. Two members responded to the request for comments on the Code, which was published in draft form in the July Bulletin. This limited reaction is, we hope, an accolade to the drafting of the Membership Committee, rather than a measure of apathy! The points raised by the two members were on the precise meaning of a particular paragraph and on the more general point of members' responsibility to safeguard human life, whereas their employment might assist destruction of life. The Membership Committee carefully discussed these points but could not find an alternative wording which did not itself produce other problems of interpretation. Consequently, the final form of the Code remains the same as that published in the July 1984 Bulletin.*

*Members will be aware that a Physical Acoustics Group has been formed jointly with the Institute of Physics. The motivation for this came from the Institute of Physics, within which an informal group of physical acousticians has been meeting for several years. Our own Institute has been caused to look inwards at itself by the realisation that it has failed to satisfy the needs of a significant group of acousticians, although they may consider themselves to be physicists first and acousticians second. We are ensuring that the new Group is run as a joint effort, but this can only continue into the long term if our contribution to the Group matches that of the Institute of Physics.*

*Subscriptions have not been increased for 1985. This is an act of both faith and confidence. We anticipate increased expenditure, but intend to raise additional revenue by other means eg conferences, sales of publications, new members, etc. To achieve these aims, we need the help of all present members through their involvement in the activities of the Institute. Do not miss out on the Spring Meeting at York. It will be a good one!*

*Yours sincerely,*

# 1984 Autumn Conference

2-4 November, Hydro Hotel, Windermere

**Conference Organiser: Roy Lawrence (Liverpool Polytechnic)**

This was the first time the Institute had held one of its major conferences during a week-end, although the third time an Autumn Conference had taken place at the Hydro Hotel. The technical programme commenced at 2.20 pm on the Friday and finished at 3.40 pm on Sunday. The hotel was completely full and all available rooms offering similar facilities in the Windermere area were also used. One hundred and forty-eight delegates attended along with forty spouses and ten children. At the Conference Dinner the dining hall and the adjacent grill room were completely filled. The numerical success of the Conference was generally attributed to an excellent technical programme which had been assembled by diligent session organisers together with the attractive financial terms, free of any form of penalty clause, offered by the hotel management.

Seven organisations exhibited at the conference. These were Messrs Bruël and Kjær (UK) Ltd, Computer Engineering Ltd, GenRad Ltd, Gracey and Associates, Loughborough Sound Images Ltd, Masscomp (UK) Ltd, and Scientific Atlanta Ltd. The exhibition

was given a greater sense of visual unity through the use for the first time of blue table covers carrying the Institute's insignia. Also on view was the Institute's recently acquired Marler-Hayley stand which is designed to be transported to technical meetings so that the Institute's publicity may be presented in a more professional manner than has hitherto been the case. The technical programme was arranged in two parallel sessions. The Speech Research sessions ran throughout the conference in the hotel ballroom whilst the lecture theatre was used for the Building Acoustics and Privacy, Ship and Diesel Engine Noise, and Open sessions. To accommodate an intensive programme sessions commenced at 8.40 am on the Saturday and during the conference the 1984 Tyndall Medal was presented to Professor R G White, Director of the Institute of Sound and Vibration Research, University of Southampton, who gave the Tyndall Medal lecture entitled *Structural Dynamics and Vibration Control*.

The conference handbook was the first to be produced in the revised format with its larger page size and restyled cover.

## SHIP AND DIESEL ENGINE NOISE

**Organiser: A Corkill (ICI Acoustics Ltd)**

The ship and diesel engine noise technical sessions were divided between Friday afternoon and Saturday morning with some ten papers being presented by authors from France, Denmark and Singapore as well as the UK. The international flavour of the sessions clearly demonstrates the high regard in which the overseas community holds the Institute.

There was much variety in the range of papers presented, with something in each session to interest most delegates. Perhaps particularly outstanding were those papers reporting the results of the latest research into the propagation of acoustic and vibrational energy through liquid and solid structures. Whilst this work has had traditionally a strong theoretical and analytical basis, the reported experimental work on full and part scale models, together with some of

the experimental techniques that researchers had adopted, clearly proved to be of great interest to the delegates.

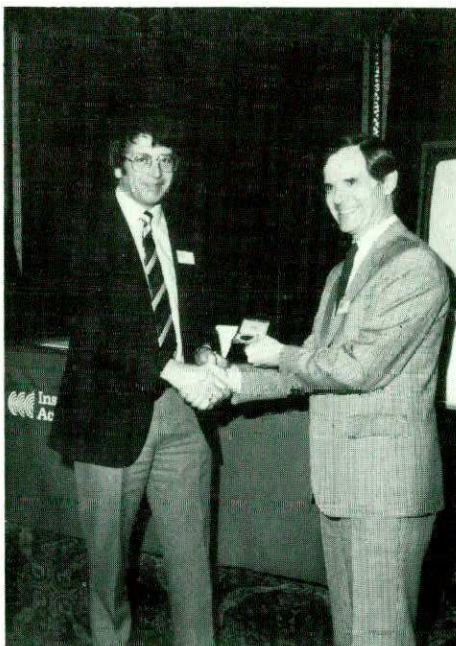
The sessions were not exclusively taken up by papers dedicated to fundamental research; interest extended into development of prototype noise and vibration control systems such as the Active Mount from the University of Essex and the Quiet Heavy Vehicle Project (QHV 90). This latter paper was most ably and speedily delivered by John Tyler who at one point, because of the inevitable shortage of time, managed to make a series of consecutive slides showing the QHV noise control hood dropping into position, appear like a movie.

The final group of papers were concerned with noise control in practice. Having previously listened to papers describing the complex mechanisms involved in noise and vibration and the developed engineering solutions to such problems it was quite apparent that the practitioners were emphasising the vital importance of the acoustician having some influence at the earliest stage in an engineering project; this being the best, the cheapest and the most effective means of noise control. The problem of the acoustician being sufficiently influential in an engineering project, and acoustics, noise and vibration being a serious consideration to Engineers and manufacturers of equipment, are perhaps peculiarly British problems. It is perhaps at conferences such as those organised by the IOA that researchers and industrialists can develop a better sort of empathy.

## SPEECH RESEARCH

**Organiser: W Ainsworth (University of Keele)**

The first session, held on Friday afternoon, consisted of eight papers in the area of speech analysis. The title covered both the acoustic analysis of speech and phonetic analysis. The session began with two papers on acoustic analysis. P R Alderson *et al* (IBM) described a speech analyser based on a personal computer. The more computationally intensive signal processing, however, was performed on a large host computer. R K Moore *et al* (RSRE)



*Professor Bob White receives the Tyndall Medal from former IOA President Brian Clarkson*



*The well attended exhibition must rank as the tidiest the Institute has ever staged!*

introduced a new concept, 'acoustic flow', which enables patterns of change in a speech signal to become more apparent.

There then followed four papers on methods of analysing text as a prerequisite for synthesis. S G C Lawrence *et al* (IBM) described a rule-based system for the phonetic transcription of text, and this was complemented by G Knowles (University of Lancaster) who showed how a knowledge of historical sound changes could be useful in such a system. B J Williams (IBM) described a method of assigning lexical stress in English, and D R Miller and S D Isard (University of Sussex) showed how to align speech waveforms with text using a phonetic analysis. C G Henton (University of Oxford) gave a sociological interpretation of data she had obtained by measuring the fundamental frequencies of vowels spoken by male and female speakers with different dialects, and R A W Bladon (University of Oxford) discussed theories concerning speech processing during spectral change.

The next session took place on Saturday morning. It consisted of no less than twelve papers on automatic speech recognition, and was chaired by J N Holmes. This large number of papers reflects the growing interest in this topic at the present time.

J S Bridle (JSRU) began by pointing out the relationship between two popular techniques for automatic speech recognition: stochastic modelling and template matching. M J Russel *et al* (RSRE) described how the effect of template choice affected the performance of an automatic speech

recogniser, and R I Damper and S L MacDonald (University of Southampton) discussed the use of template adaptations in speech recognition. W A Ainsworth *et al* (University of Keele) showed how knowledge of the speaker of the template could be used to improve the performance of a multispeaker system, and J S Bridle *et al* (JSRU) described a technique for compensating for the noise which is inevitably present in the acoustic signal in a practical situation.

Some new approaches to the problem of speech recognition were introduced in the next three papers. J S Bridle (JSRU) and R K Moore (RSRE) described a pattern processing network known as a Boltzmann machine. A computer simulation of such a system was also demonstrated at the conference. G D Tattersall and R D Johnston (BTRL) described a self-organising array based on a neural network, and M J Carey (Mitel) showed how such a self-ordering network could be used for classifying phonemes.

The theme of networks continued in the next paper. M A Huckvale (University College, London) proposed a scheme for applying phonology in ASR by incorporating this knowledge in acoustic-phonetic networks. D Lindsay (University of Keele) then showed how intonation contours could be analysed and classified automatically. P D Green and A R Wood (North Staffs Polytechnic) described their method of representing speech signals as a 'speech sketch', and the session concluded with a paper by S J Young (University of Cambridge) on the problems encountered in connected word recogni-

tion and a way of solving these by generating multiple solutions.

On Sunday morning C Scully chaired a session on speech perception. It began with two papers by Dutch visitors. F J Koopmans-van Beinum *et al* (University of Amsterdam) described the influence of response categories on the identification of vowels excerpted from conversational speech, and L C W Pols *et al* (University of Amsterdam) discussed the role of formant transitions in vowel recognition. W A Ainsworth and D Lindsay (University of Keele) described some experiments relating to the identification and discrimination of Halliday's primary tones, and D R Scott and S D Isard (University of Sussex) and B de Boysson-Bardies (CNRS, Paris) showed that there are no differences in the perceived rhythm of English and French when assessed by a tapping task.

The remaining two papers in the morning involved visual perception of speech. G A Foster (University of Sussex) demonstrated the McGurk illusion and described some new experiments on feature interaction, and M McGrath and Q Summerfield (IHR, Nottingham) and M Brooke (University of Lancaster) discussed the roles of lips and teeth in lipreading both natural vowels and ones produced by a facial synthesiser.

After lunch two papers on speech production were presented. B Cranen and L Boves (Nijmegen University) discussed the use of ultra-miniature pressure sensors for investigating the aerodynamic aspects of voice production, and C Scully (University of Leeds) described speaker-specific patterns for articulating speech synthesis. J Laver *et al* (University of Edinburgh) showed how various vocal fold pathologies could be predicted by acoustic analyses of voices, and L Boves and R van Bezooijen (Nijmegen University) discussed the relations between acoustic measures and perceptual ratings of voice quality. R L Pratt (RSRE) described the facilities available at RSRE for the assessment of speech intelligibility. Finally, K Silverman (APU, Cambridge) presented some data on FO perturbations in various contexts. This last session was chaired by L Moye.

The sessions were very well attended, with an audience of about one hundred. The speakers are to be congratulated on their time-keeping, which enabled such a large programme to be presented efficiently. The only adverse factor during the weekend was the weather, which was beyond the control of the organisers!

## BUILDING SOUND INSULATION AND PRIVACY

**Organiser: R Galbraith (Sandy Brown Associates)**

On Friday afternoon, R Galbraith and R Bussell (Sandy Brown Associates) opened the session with *The sound insulation of access (computer) floors*. In this paper they described the results of laboratory measurements of the room-to-room insulation of ten different types of access floor, and investigations into the effect of carpets, floor-void firebreaks, and services penetrations.

In the second paper, *Planning guidance for sound insulation of flats formed by conversion*, B Whittaker (Bolton MBC) described the problems of Environmental Health Officers in dealing with increasing numbers of complaints. Using the example of flats formed by house conversion, he explained how planning law was used to impose sound insulation requirements, and to try to prevent conversions which created sound insulation problems.

C Walker (British Gypsum) continued with a paper on *Timber framed separating walls in traditional houses* which described his work on the introduction of timber framed separating walls into otherwise conventionally built masonry houses. He gave details of the treatment of potential flanking paths, and described the solution of the problem of back-to-back gas flue systems within the thickness of the wall. Field sound insulation results, which met Building Regulations requirements, were given.

G Kerry (University of Salford) and C Inman (Pilkington Glass Ltd) then presented *Improving the sound insulation of glazed partitions*. They emphasised the effect of the density and effectiveness of the mounting seal, and described the importance of the damping layer material in laminated glass.

The Friday session was concluded by P Lewis (UWIST) with his paper on the *Comparison of the steady state and dynamic characteristics of sound insulation with the intelligibility of transmitted speech*. This paper questioned the validity of relying upon the steady state sound insulation of partitions when evaluating speech privacy. A comparison with speech intelligibility in auditoria suggested that consideration should be given to the time domain, and the proportions of early and late energy arrival at the listener. The results of experiments using computer simulation were given in support of this hypothesis.

M Burgess (University of New South Wales) bravely started Sunday — the 'morning after' — with *The effects of current reverberation times in British living rooms* in which she reviewed RT measurements carried out by various workers in this country over the last twenty years or so, including recent measurements, and compared these with the values used for normalising sound level differences.

X Bohineust (ITBTP-CATED Paris) and P Wagstaff (Université de Technologie de Compiègne, France) followed with *Evaluation of the sound insulation properties of 40 types of timber frame walls under laboratory conditions*. Their investigations shed light on many of the things we all want to know about light-weight walls: The effect of mechanical ties, studs, double versus triple walls, etc. In addition they successfully dispelled the notion that the overhead projector is an audio-visual 'poor relation' by illustrating the paper with beautifully produced transparencies.

In the paper *Rapid sound insulation calculations*, which concluded the session, P Allaway (Grootenhuis Allaway Associates) described his use of a micro-computer for simple building acoustics calculations. In a departure from the printed paper, he went on usefully to question the validity of equations commonly used for building acoustics calculations.

## DISCUSSION OF UNRESOLVED ISSUES IN BUILDING ACOUSTICS

A general discussion on *Unresolved issues in building acoustics* took place at midday on Sunday, and was chaired by P Lord (University of Salford). For many this was a highlight of the conference.

N Spring (Sandy Brown Associates) described the difficulties in ensuring that clients get the kind of building performance that is specified and expected. This was in part due to the standard form of building contract which absolves the contractor of design responsibility and to the difficulty in predicting field performance from laboratory data. He spoke of the pressure which must sometimes be applied to force manufacturers to provide acoustic data, and described cases where the data eventually supplied either was obtained from another superseded product or was falsified.

B Day (University of Bristol) described how a floor construction, which provided good sound insulation in the

laboratory, failed when included in houses in a large development.

P Allaway spoke about similar problems in the field of mechanical services noise control, and the difficulties caused by the lack of design data.

R Galbraith followed by warning of the increasing incidence of litigation against those providing building acoustics consultancy. He spoke of cases (in which Sandy Brown Associates were advising the plaintiffs!) in which claims ran from ten million pounds, down to ten times the consultants' fee.

Finally, the ineffectiveness of the current Building Regulations was discussed at length, and worries were expressed about the possible shortcomings of the proposed revisions.

## OPEN SESSION

**Organiser: R Lawrence (Liverpool Polytechnic)**

There was a more than usually interesting miscellany of papers in the session and this was rewarded with good attendance from delegates.

John Goodchild (Liverpool Polytechnic) reported audiometric measurements made under less than ideal conditions on seventy-eight competitors at clay pigeon shooting competitions held at agricultural shows in the UK. Evidence was presented of significant hearing loss among the majority of the subjects, particularly the younger age group. Preferential loss was found in the more exposed ear, that is in the left ear for right-handed shooters. Measurements of the propagation of shot-gun noise as a function of distance for different wind conditions were also reported.

Mathematical modelling of sound propagation over an inhomogeneous plane was reported in a paper by SN Chandler-Wilde of the University of Bradford. Results of a numerical approach applicable to a strip of finite width embedded in a rigid ground were presented and discussed.

Geoffrey Burrows of Plessey Crypto Ltd presented results of experimental work on the effect of wind turbulence propagation over open grassland.

In an interesting contribution, Peter Wagstaff of the Université de Technologie de Compiègne, France, discussed an investigation of possible effects of inter-microphone interference when making acoustic intensity measurements. The conclusion drawn was that under the conditions of test the effects sought were either negligible or

very small. The need for further work was highlighted.

Bill Grafton of GenRad USA presented background on the intensity technique along with various processing methods utilised to minimise intensity instrumental measurement errors.

Three-dimensional acoustic intensity acquisition and experimental analysis methods were also demonstrated.

## SOCIAL PROGRAMME

There was a strong social programme catering for delegates and their companions. The excellent meals, enhanced by the friendliness and good service of the hotel staff, gave us time to unwind, make new acquaintances and turn to matters other than those dealt with in the lecture rooms — although it was widely claimed by other delegates that the Speech sessions continued non-stop through meals, entertainments and the train journey home. On Friday an evening of music and dance followed the meal, with an Irish harp featuring prominently and two young girls giving an accomplished display of Irish dancing. Delegates who had themselves had to subdue a few nerves before presenting their papers were full of admiration for the calmness with which these young performers went ahead despite a high ambient noise level as people continued discussing decibels and beer. At the Conference Dinner on Saturday, guest speaker Peter Maloney from Liverpool Polytechnic regaled us with a host of anecdotes, including reference to the well-remembered river excursion during the 1976 Spring Conference at Liverpool when he had to abbreviate a similar talk because the land was reportedly sinking! His underlying theme of fellowship and professionalism was most entertainingly presented and we retired to the disco and reduced-price bar in good spirits.

The excursions were well attended and generally little affected by the weather which that week-end made the national headlines. A boat trip on Friday afternoon took one party down Lake Windermere to Brockhole where the geological, social and natural histories of the Lake District were superbly displayed and many reminders of our visit were available. The party then watched glass-blowing at the Adrian Sankey glassworks. The programme for the Saturday trip proved so full that only the Bobbin Mill and Holker Hall were actually visited, both to the great interest of those participating.

It was unfortunate that the Saturday afternoon, left free for delegates, was



*Guest speaker Peter Maloney entertains delegates at the Conference Dinner*

hit by the worst of the weather, as summed up by a brief exchange among three participants in the lounge that afternoon:

Delegate 1 (to Del 2, unrecognisable beneath dripping hair and Kagoul): 'You must have been on the boat trip'.

Del 2: 'No — we were in the High Street'.

Del 3: 'Well you look as if you've been in the Lake'.

In fact one group of experienced walkers, who had arrived at the Conference with brief-cases under one arm and boots under the other, were forced to turn back from their walk over the hills — not so much by the snow as by the buffeting winds. Nonetheless most of us ventured out, many on the arranged excursion on Lake Windermere — which incidentally was prevented from disembarking a party at the Steamboat museum because of the squalls — and saw at least a glimpse of the Lakeland's beauty.

The luckiest people I think were those who visited Wordsworth's two houses, Dove Cottage and Rydal Mount on Sunday morning, for by then the Lake District showed itself at its best: clouds scudding across a blue sky, the lakes white capped from the wind, the autumn colours on the hillsides glowing in the sun and snow on the tops. You are warned to book early in 1985; the Autumn Conference has been fixed for the first weekend in November — at the Hydro Hotel, Windermere! □

# Appreciation

## Dr E A Neppiras

The world of ultrasonics will be sorry to learn of the death of Dr E A Neppiras, a pioneer of British Acoustics (see *Acoustics Bulletin*, April 1979) who passed away in September of 1984 after a series of illnesses following a kidney operation.

Ernest Neppiras graduated from Imperial College with an Honours Physics Degree and subsequently joined the Mullards Ultrasonic Research Group at Salfords (Redhill, Surrey). His flair for experimental work was soon apparent and his physical approach to problems was evident in his collaboration with Dr B E Noltingk in formulating the so-called 'hot-spot' theory to explain the phenomenon of sonoluminescence. On leaving Mullards, Neppiras joined the Acoustics Group at Imperial College for a short period before setting up as an ultrasonics consultant and he quickly acquired a demand for his advice and guidance from companies in the USA and UK. The world of ultrasonics is indebted to 'Ernie' for his services to the Ultrasonics Journal editorial board with which he has been associated since its inception over twenty years ago. He was responsible for initiating a number of articles in sequence by different authors on a particular theme and currently there is such a series on cavitation, an acoustic field in which he was a world leader.

Ernest Neppiras was a keen chess player and his other leisure interests were in soccer and cricket. He will be greatly missed at international meetings on ultrasonics and by his many scientific friends around the world. □

R W B S

## INSTITUTE MEDALS 1986

Anyone wishing to put forward a name for consideration by the Medals and Awards Committee as a possible recipient of the Rayleigh, Tyndall or A B Wood Medal for 1986 should write in strict confidence to the President, enclosing a brief outline of achievements, etc, before the end of February. The 1986 Medals will all be awarded to UK citizens.

Details of the Medals and previous Medallists may be found in the October 1984 issue of *Acoustics Bulletin*. □

# Pioneers of British Acoustics

Alexander Wood MA DSc (Glasgow)

1881-1950

*Alexander Wood's book Acoustics was probably the first comprehensive text-book on sound in which the more embracing title of Acoustics was adopted, although it had been used previously in more specialised publications such as Planning for Good Acoustics (1931) in which Wood was joint author with Hope Bagenal, Modern Acoustics by H Davis (1934) dealing with practical developments and Acoustics of Orchestral Instruments by E G Richardson, which was a small but readable monograph.*

THE AUTHOR of the present volume under review, Alexander Wood, was a Fellow and Tutor of Emmanuel College, Cambridge and University Lecturer in Experimental Physics. This practical aspect of Wood's academic work gives an indication of his general scientific outlook which was revealed in his love of music and found expression in *Physics of Music*, published in February 1944, and which he referred to as the borderland between physics and music. The book was a great success and a fifth edition was published (by Methuen) in the sixth year after its initial publication. After the death of the author in 1950 it appeared in a University series of Paperbacks, this time undergoing revision by J M Bowsher who, while preserving the general style of the original, brought up to date the sections on sonic recording and reproduction and on architectural acoustics. It is noteworthy to record that Alex Wood was most meticulous in all his writings to give credit and acknowledgement to other workers for the use of diagrams and facts obtained; without the need of the exacting formality of present-day regulations.

*Acoustics*, our main focus on Wood's literary efforts, extended to 600 pages and was divided into 19 chapters and it is not perhaps surprising to find three of the longest having topics associated with musical acoustics, namely acoustics of buildings, rods membranes and plates and the ear and hearing. A notable feature of the text is also the space devoted to sound velocity measurements, propagation in all states of matter and over a considerable frequency range being carefully considered. It is interesting to note however that in the 1960 printing, Wood still frequently used the term supersonic wave velocity although on the same page could make reference to 'a beam of ultrasonic waves'. In the text he develops the simple expression for the effect of amplitude on sound velocity but shock waves are not explicitly mentioned anywhere. The book has many

references which are given as footnotes to the pages in which the topics are quoted, and at the end there are about twenty carefully selected volumes giving one or two lines on their particular features. One finds here reference to the other two Woods of acoustical fame, Albert B Wood whose classical work, *Textbook of Sound* (Bell) first appeared in 1930 and the American R W Wood of Brown University, who wrote a popular account of the generation and properties of ultrasonic waves under the title of *Supersonics*, which was published in the first year of World War II.

The popularity of *Acoustics* as a University text-book is revealed by the fact that it underwent six re-printings between 1940 and 1950. In 1960 it was re-issued and the publisher's note (Blackie) given with the preface is worth recording: 'This masterly text-book is now re-printed in its original form, having been first published in 1940. Although there have been major developments since then in the electrical techniques of sound reproduction, these are mainly the province of the electrical engineer. It was felt that a revision by another hand to cover the needs of both engineers and physicists would serve no useful purpose.' How times have changed as regards book publication - I know of one publisher whose general policy is not to publish a re-print of an advanced science text-book.

Alexander Wood was an excellent lecturer and his lucidity in expression and care in presentation were recognised in his University appointments and in the invitation to give the 1929 Royal Institution Christmas Lectures on *Sound Waves and their Uses*, which appeared in print (Blackie) in the following year. He also wrote a short *History of the Cavendish Laboratory* and at the time of his death he was engaged in the last stage of completing the life of the eminent Emmanuel College scientist Thomas Young, which was posthumously published under the title *Thomas Young* (CUP 1954).

This account of the work of Alexander Wood is not complete without a

reference to other aspects of his career. Despite his considerable activity in college life as a tutor, in which he exceeded the normal duties expected of an individual by his personal interest in students, he also took an active part in civic affairs. His skill in lecturing was particularly fruitful in explaining to the general public and to school children in an understandable way the relations between sound, music and noise. He was a Borough Councillor from 1926 until he became Alderman in 1945 and during the last ten years of his life devoted much of his time and energy as Chairman of the Borough Housing Committee, a difficult task requiring sympathetic handling. These various activities were backed by his courageous Christian faith and he was an Elder and a preacher to St Columba's Church. Wood also worked for the Temperance Movement and for the Peace Pledge Union and even those who disagreed with many of his views were appreciative of his sincerity. Finally we must not forget that he was a keen supporter of the formation of the Acoustics Group of the Physical Society. □

RWBS

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## Inter-Noise 85

The fourteenth International Conference on Noise Control Engineering will be held from 18 to 20 September 1985 in Munich, Federal Republic of Germany. The conference covers the following topics: National and international legislation and standards for noise reduction; Noise effects on man; Sound propagation in working areas; Measurement and assessment of noise; Sound intensity measurement; Structure borne noise problems; Noise emission data, data bank systems, labelling; Traffic noise; Noise prediction/prognosis and planning; Noise abatement by design and machine noise reduction.

The working language of the congress is English. There will be a technical exhibition and a pre-conference tour to the most important centres of acoustic research in the FRG.

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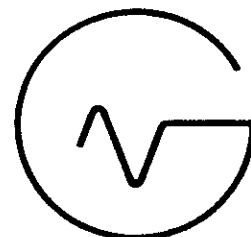
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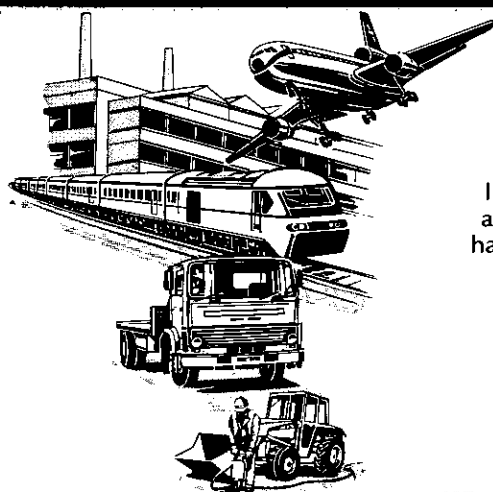
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# Library Facilities for IOA Members

A number of libraries have recently been asked whether resources might be made available to IOA members. There has been an encouraging response and the libraries listed below have agreed to admit members. Some libraries offer only reference facilities whilst others will permit borrowing. The individual conditions vary according to the library rules and a fee may be charged, especially for borrowing.

Members wishing to use a library should make themselves known to the librarian as Institute members and comply with local regulations.

Libraries at which facilities are available are listed below.

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# Building Acoustics

Building Acoustics has become considerably more complex since those days when the ancient Greeks used sounding vases, or echeia, in their open-air theatres. Today's Building Acoustician must have a knowledge of physics, an understanding of building techniques and a familiarity with the principles of site planning. For some types of building project he may need to appreciate the specific requirements of performing artists, while in others he may need to understand the limitations of electronics. He will probably have learnt from bitter experience that a theoretically 'correct' solution to his problem may become quite impracticable when non-acoustic factors such as durability, aesthetics, mechanical services requirements, clients' wishes and cost are added to the equation. Building acoustics is therefore a compendium of many subjects straddling the disciplines of art and science. The absence of mathematics in the following articles should not be interpreted as a leaning towards the former discipline; the 'art' of building acoustics is getting the 'science' right.

|                         |                                         |
|-------------------------|-----------------------------------------|
| Places of Entertainment | M Barron and P Lord                     |
| Public Buildings        | D B Fleming and P Allaway               |
| Domestic Buildings      | L C Fothergill, G M Jackson and R Craik |
| Building Services       | N Spring                                |

This special feature was sponsored by the Building Acoustics Group, and made possible by the efforts of the authors.

G M Jackson

## Places of Entertainment

### M BARRON

Department of Architecture, Cambridge University

### P LORD

Department of Applied Acoustics, Salford University

*Progress in auditorium acoustics must appear slow to those in other disciplines. Reverberation time still looks as ubiquitous as ever and auditoria are still built with their share of acoustic problems. There has, however, been valuable progress during the last 30 years but the problems are now known to be much more complex than previously thought. With multi-purpose halls now becoming the norm, new challenges are arising for the acoustician.*

**T**HE MAJOR realisation in auditorium acoustics research has been the need to base investigations on subjective results, using techniques developed in experimental psychology. However, the path from subjective results to objective requirements via design implications to use in actual auditoria is a long one. At present, several interesting ideas are known to have substance but they remain to be extensively exploited in practice, with the attendant trial and error which that process must involve. On the publication front, a parallel situation exists with two books which give good extensive summaries of recent theoretical and

experimental advances (1, 2), but do not contain the clear cut recipes which the consultant may wish for.

#### Reverberation Time

Attacks on the reverberation time formulae and criteria offer a regular diet to the journal reader. But it is not an area for the faint-hearted author: an article in *Acustica* in 1965 *Do the classical reverberation formulae still have a right for existence?* was thoroughly demolished, which implied an affirmative answer. It has now been convincingly demonstrated that the formulae will give incorrect results when the distribution of absorption is non-uniform,

which is always the case in large auditoria. The reason for this is that the absorbent surfaces receive more energy than the reflective surfaces. On the subjective front, it is now known that a listener judges reverberance on the basis of the early part of the decay, and not over the dynamic range associated with the traditional measurement. So is the continued use of reverberation time valid or just idle expediency? As far as the formulae are concerned, Cremer (1) has frankly admitted that 'the refinements...may contribute more to the physical understanding of the statistical theory of reverberation than they do to the design of good concert

halls'. Since none of the refinements offers a simple modification, use of the traditional formulae seems assured for many years to come. Indeed on a practical level, experience with models of auditoria suggests that significant divergence from theory is generally limited to cases where seating is shadowed by overhanging balconies.

If the reverberation time can be calculated, how useful is it? The subjective characteristics traditionally associated with reverberation time are the sense of clarity and reverberance. Though there are now objective measures which probably relate more closely to each subjective response, we find that in most cases the reverberation time is highly correlated with these new objective measures. So for these halls the reverberation time is a convenient and well understood measure, which relates to subjective response. There are some halls though in which the correspondence no longer occurs, in which for instance the sense of reverberance is lower than one would expect from the reverberation time. In these halls the reverberation time itself can only be appreciated when loud orchestral chords are followed by silence, enabling the full decay to be heard. Since chords followed by silence only happen a few times during a performance, it is not particularly significant for the appreciation of the acoustics. The alternative objective measures have to be considered in these halls. Halls in which surfaces have been oriented specifically to direct sound onto the audience tend to behave in this way; the recently opened Royal Concert Hall in Nottingham is a good example.

### New Objective Measures

Many of these new measures originated from experiments using simulation systems, in which the direct sound and reflections are simulated by feeding a signal into an array of loudspeakers with appropriate delays. The simulation reproduces many aspects but not others. To establish which acoustic characteristics are judged most important it has been necessary to develop the artificial head, so that the acoustic experience at a particular seat in a concert hall can be truly reproduced in the laboratory. Two major studies in Germany and work elsewhere indicate a possible consensus view regarding the most important objective measures. The Early Decay Time (measured over the first 10 dB of the decay) replaces the reverberation time as a measure of reverberance, and the ratio of early to late energy, or alternatively the Centre

Time (the time of the 'centre of gravity' of the squared impulse response), relate to perceived clarity. The novel concern to provide early reflections arriving at the listener from the side can be measured by the Early Lateral Energy Fraction. The final measure is not new at all; in fact Sabine mentions concern for loudness in his publications. Somehow the success of reverberation time has obscured what now appears to be a high degree of sensitivity; changes of only a few decibels to be found within and between halls seem to be important.

The design implications of this multidimensional scenario are only beginning to be appreciated. Design for strong lateral reflections is creating ceiling lines which are far from flat as well as being responsible for attempts to incorporate reverse splays (ie the opposite of fan shape) in plan. This can have adverse effects on other aspects of the sound field which is a typical example of problems inherent in novel designs. The progress offered by these new measures seems likely to be considerable but much more remains to be discovered, including quite probably more new measures.

### Phase Grating Diffusers

The most exciting development in recent years has been the phase grating diffuser, sometimes known as the Schroeder diffuser after its inventor (3).

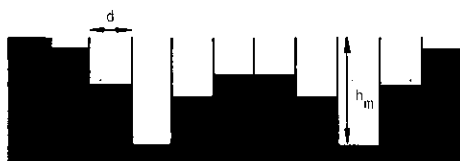


Figure 1 Section through a single period quadratic residue diffuser for the frequency range 210 — 3000 Hz.  $d = 172$  mm,  $h_m = 468$  mm. The individual slots are separated by fins

For the first time it becomes possible to design a highly diffusing surface operating over a specific frequency range. Figure 1 shows a section through a typical diffuser, which consists of slots of different depths following a mathematical number sequence. In this case the depth of the slots follows a readily calculated quadratic residue code, which has the property of a constant amplitude discrete Fourier transform.

As with any new development, the range of use of these diffusers remains to be established. They have been used successfully in a new concert hall in

Wellington, New Zealand which opened last year and are now available commercially in the USA, intended primarily for use in recording studios.

### Theatre Acoustics

The situation with theatre acoustics parallels that in concert hall acoustics in several ways. The inadequacy of a simple reverberation time criterion has been unequivocally demonstrated in certain theatres with speech intelligibility problems in particular seats. Again various objective measures exist which correlate with intelligibility much more precisely than just reverberation time. The measure now gaining notoriety: the Modulation Transfer Function (MTF), already has an established reputation in optics; an instrument to measure it directly in the field is likely to appear shortly. One of the great attractions of the MTF is that in its definition the two principal determinants of intelligibility, the room impulse response and the signal-to-noise aspect, are automatically combined. The MTF is a measure of the degree of distortion of the signal envelope, though not all workers in the area are convinced that the envelope of the speech signal is obviously critical for intelligibility.

In the case of theatres the diagnosis and remedy are simply stated. Problems are frequently associated with seats which receive inadequate early reflections and the situation is generally worse when the actor faces away, which is an inherent characteristic of thrust stage designs, for instance. Good suspended ceiling design to provide strong overhead reflections allows the highest number of seats to be accommodated in theatres of this type.

### Design Aids

The problems of prediction beyond reverberation time have led to models of two types. Computer models have until now not had the success one might have expected. The complexity of acoustic behaviour when a sound wave hits a finite obstacle is still beyond ready computation. Most computer models treat 'sound' as if it were light, ignoring the wave behaviour. This seems a very severe assumption yet those involved with such models are confident of their value. In this computer age one feels that substantial progress must be imminent.

Acoustic scale models have also had a rather chequered career though more for organisational reasons than any limitations in the technique. Acoustic scale models can offer surprisingly accurate reproductions and in comparison

with computer models they automatically accommodate complex wave behaviour. For auditorium work the traditional scale factors for acoustic models have been 1:8 or 1:10. At this scale both objective testing (providing numerical results) and subjective testing, in which music or speech are played through the model, are possible. Until now the value of subjective tests has been limited by the necessarily crude recording systems with just two microphones spaced an appropriate distance apart. However, a brave gentleman in Germany is in the process of reproducing an average ear at 1/10th scale — as luck would have it this average ear used on the new Neumann dummy head is his own!

The expense of construction and the problems associated with housing these large models has led to developments at smaller scales of 1:20 and 1:50, as shown in Figure 2. At 1:50 scale, pioneered at Cambridge, the technique

auditoria in Britain are having to cater for multipurpose use and new buildings are going to become increasingly rare now that central government support is being severely reduced.

The principal conflicts of use are between speech and music but perhaps even more severe between classical and popular amplified music. Variable passive acoustic elements have to be very extensive to provide worthwhile modifications. Absorbent drapes have been used many times in America and are to be found in the new Nottingham Hall. Though further possibilities of variable passive acoustic elements remain to be tried, the acoustic changes they produce are likely to fall short of the demands of the client. Can electroacoustics then solve the multipurpose problem?

Two basic methods of electroacoustic enhancement exist: systems to provide electronic reflections and reverberation

viding for multipurpose use, but the acoustic changes achieved fall short of original expectations. An alternative system based on a large number of broadband microphone-amplifier-loudspeaker channels is now also available commercially from Holland. Experience with any electroacoustic system, including speech reinforcement systems, has shown the need for continual maintenance, a need frequently not appreciated by hall management.

### Requirements for the Future

Certainly as far as the UK is concerned performance spaces will probably come under two headings, the leisure centre providing a large barn of a hall, and old churches, disused theatres etc which may be modified and refurbished. The need to be able to predict the likely acoustical quality of these spaces before committing funds is self-evident. For instance it is important to know whether division into a smaller volume is important, whether the existing shape or possible shape will provide adequate early lateral reflection, sight lines and loudness towards the back of the hall.

The hall in the leisure centre presents much greater temptation for multipurpose use and in so doing presents a multitude of acoustic problems, lack of diffusion, over-reverberant, excessive width, intrusive noise and so on. It will prove an exciting challenge for the acoustician to turn it into a satisfactory performance space for he will not have access to a well tried recipe for success.

The use of electronics to extend the potential of a hall can only be thought of as in its infancy. It has a long way to go before it becomes an automatic choice of weapon from the acoustician's armoury. It is an area of research and development badly in need of financial investment particularly in the UK.

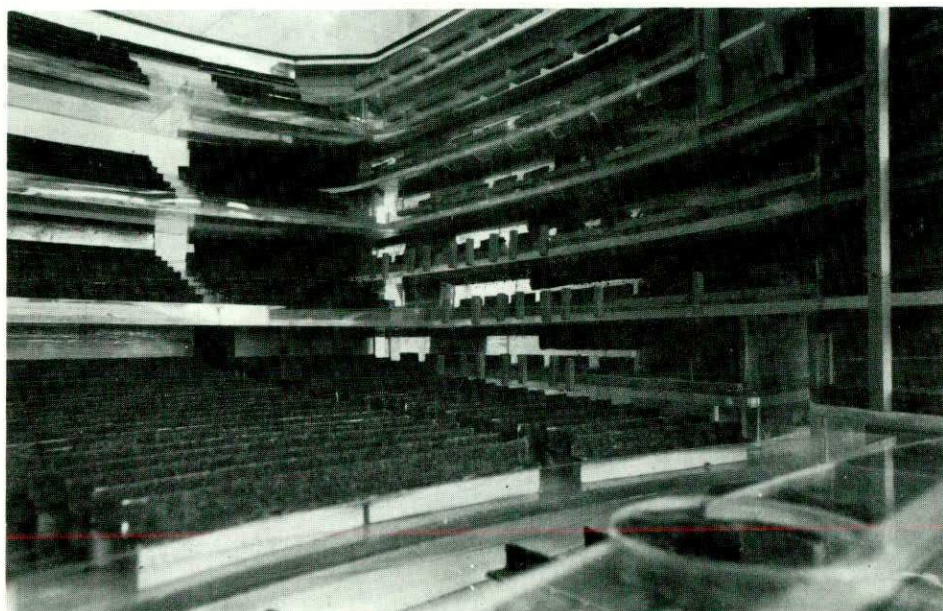


Figure 2 Photograph of the interior of a 1:50 scale acoustic model of an opera house. This model is constructed of Perspex but varnished timber is more common

has proved itself for recent auditoria in England at a cost acceptable to clients.

### The Multipurpose Trend

It is the misfortune of acoustics that it frequently restricts seat numbers before other aspects do and that possibilities for acoustic flexibility are very limited in large spaces. Economic pressures are changing the design requirements before particular auditorium forms have undergone any reasonable process of trial and error. Currently all new

enhancement systems. The big problem with the former is a satisfactory microphone arrangement to collect the sound from the source. A successful system was recently used for a while in a London theatre to provide an electronic reflection to a specific area of seating. Whatever the purists might wish, more use of this type of system is very likely. Reverberation enhancement was first used in 1965 in the Royal Festival Hall and remains in use there to this day. The use of Assisted Resonance to provide variable acoustics has helped in pro-

### References

1. *Principles and applications of room acoustics. Vol I and II.* L Cremer, H A Muller (translated by T J Schultz), Applied Science Publishers, London 1982.
2. *Room Acoustics (2nd Edition).* H Kuttruff, Applied Science Publishers, London 1979.
3. *Progress in architectural acoustics and artificial reverberation: concert hall acoustics and number theory.* M R Schroeder, *Journal of the Audio Engineering (1984) Society* 32, 194-202.

# Public Buildings

Sound insulation and medium scale room acoustics are old coalfields in building acoustics which have not yet been worked out. Taking examples over the last decade from consultancy practice in Music Teaching Rooms and Council Chambers, it seems there are still practical discoveries to be made by ingenious acousticians and inventive architects — if they can avoid the pitfalls.

Similarly with Educational and Hospital buildings there are many acoustic features which must receive the acoustic consultant's attention so as to control external and internal noise and hence provide satisfactory room acoustics. He must appreciate in some detail how these buildings will be used and should be able to accommodate practical and financial constraints inherent in the design of these highly functional buildings, some of which are semi-industrial.

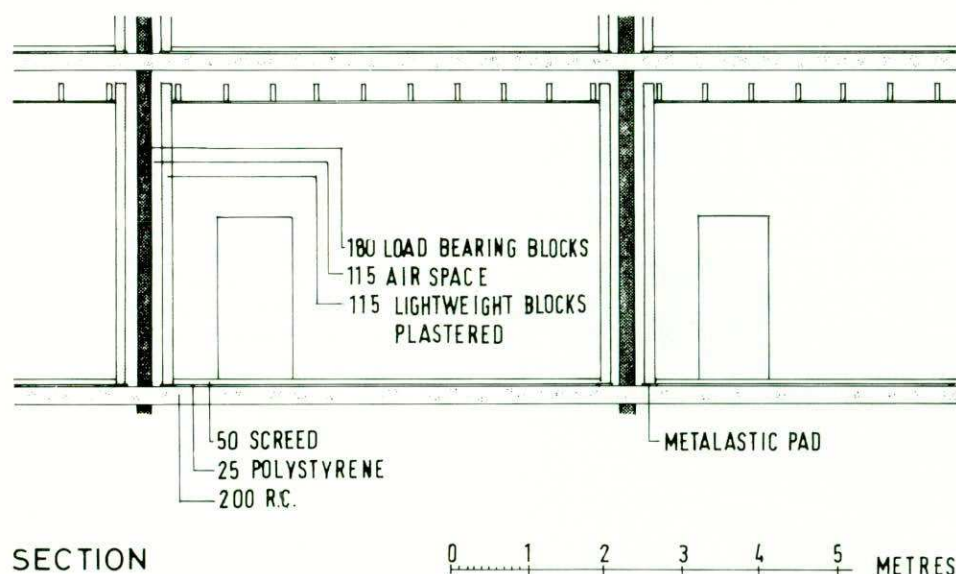
## Music Teaching Rooms and Council Chambers

**D B FLEMING** Bickerdike Allen Partners, London

### Sound Insulation of Music Teaching Rooms

**F**ORMS of construction and sound insulation data above 55 dB are relatively rare in everyday building practice and in the acoustics literature

loadbearing walls were accommodated in a triple wall construction with independent floating walls and floors in each room, Figure 1, which now gives



SECTION

Figure 1 Section of teaching rooms in Birmingham School of Music

mainly because it is at about this point that flanking transmission begins to dominate the overall performance. Success therefore depends on the whole construction which will usually fundamentally affect the structural and architectural design. The object is to achieve satisfactory acoustic privacy by a combination of sound insulation and background noise. Thus, in music teaching rooms, where migrating music moles, a modest level of amorphous noise is by no means malodorous. Ventilation or traffic noise up to 40 dB(A) in student practice rooms or at a level of NC25 in music teaching rooms is usually acceptable. Let's look at some examples from the last decade.

In the Birmingham School of Music which opened in 1973, the 225 mm

59 dB  $\Delta$ SPL (125-2000 Hz) between adjacent rooms and 56 dB  $\Delta$ SPL between rooms across the corridor, Figure 2. These measurements indicate that the compression seals of the solid core doors are no longer as effective as they once were — across the corridor an improvement of 10 dB at 4000 Hz can be obtained by pressing the door firmly against the seals. The gradual deterioration over the years seems to have gone unnoticed though, to my ears, the penetration of woodwind sound is now difficult to ignore even in the background noise of NC25  $\pm$ 5 dB from road traffic and ventilation. The client remains content, even delighted.

Regrettably the same cannot be said of all staff at the Royal Northern College of Music (Figure 3) with 55 dB  $\Delta$ SPL and a background noise of only NC10 in some rooms. The simplest way to improve these would be to increase the background noise to about NC25-30.

In the Guildhall School of Music and Drama the principle of floating rooms was carried to its logical conclusion by resiliently mounting individual rooms on columns along the building facade, giving 36 inch air gaps between each room (in plan). The promise of this design (at least 80 dB  $\Delta$ SPL) has unfortunately fallen foul of some sluggish

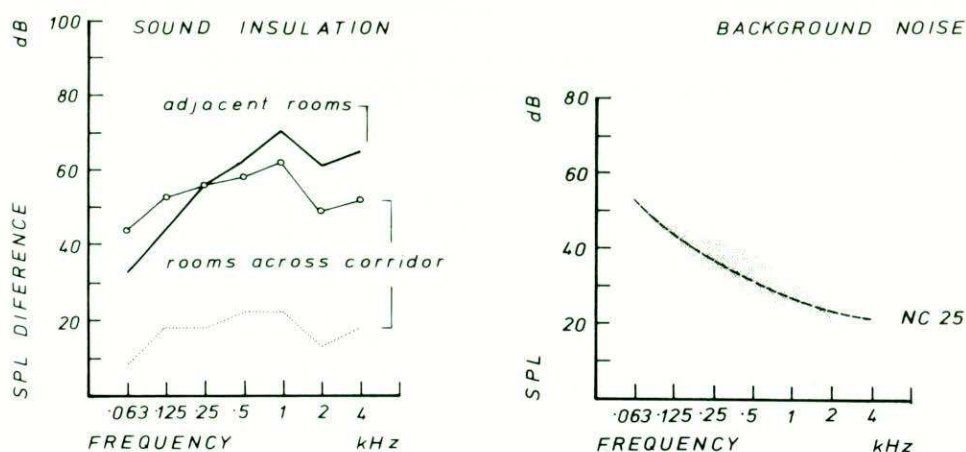


Figure 2 Octave band sound insulation and background noise in Birmingham School teaching rooms. The broken line in the left hand diagram shows the increase in received noise in the room across the corridor when its door is opened

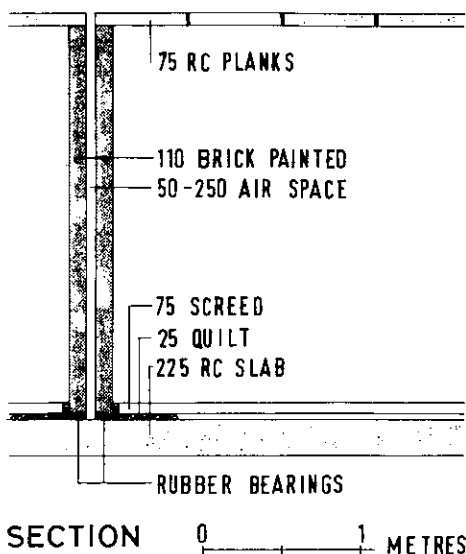


Figure 3 Typical construction of the teaching rooms in the Royal Northern College of Music, Manchester

ironmongery which leaves the doors ajar instead of closing them fully against the compression seals.

Fully floating rooms have also been used internally in the Royal Academy of Music, London (Figure 4) and in the Hong Kong Academy for Performing Arts. In the Royal Academy some of the magnetic seals — required because door latches were forbidden by the fire officer — have been abused; between adjacent practice rooms (Figure 5) sound leakage was evident only six months after completion (Figure 6). Further deterioration is evident now. Fortunately the original high standard of sound insulation (70 dB  $\Delta$ SPL) has been maintained between the percussion room and the electronic music studio,

even tympani are not audible in the studio against a background noise of about NC18 — a surprising subjective result when compared with calculations. The only hazard to tranquillity in the studio is from impromptu baritone performances in the adjacent WC.

The Hong Kong APA is presently under construction using similar floating rooms but with 150 mm thick dense concrete block walls (rendered) separated by at least 150 mm. Promising results have been obtained between two sample rooms (Figure 7), though with an intriguing dip at 250 Hz.

Not all clients can afford fully floating masonry constructions of 70 dB  $\Delta$ SPL or the manufactured metal equivalent marketed by IAC and others; indeed we

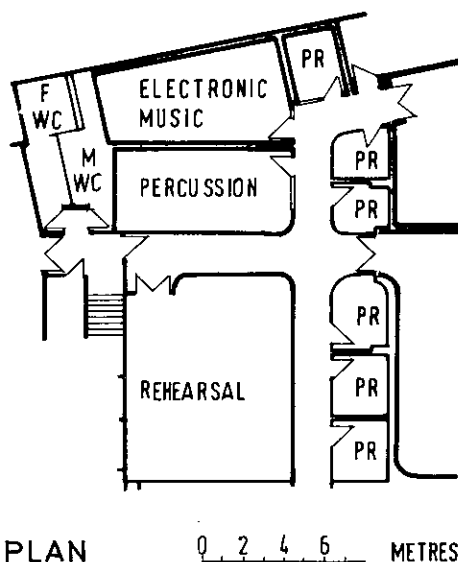


Figure 5 General arrangement in the basement of the Royal Academy

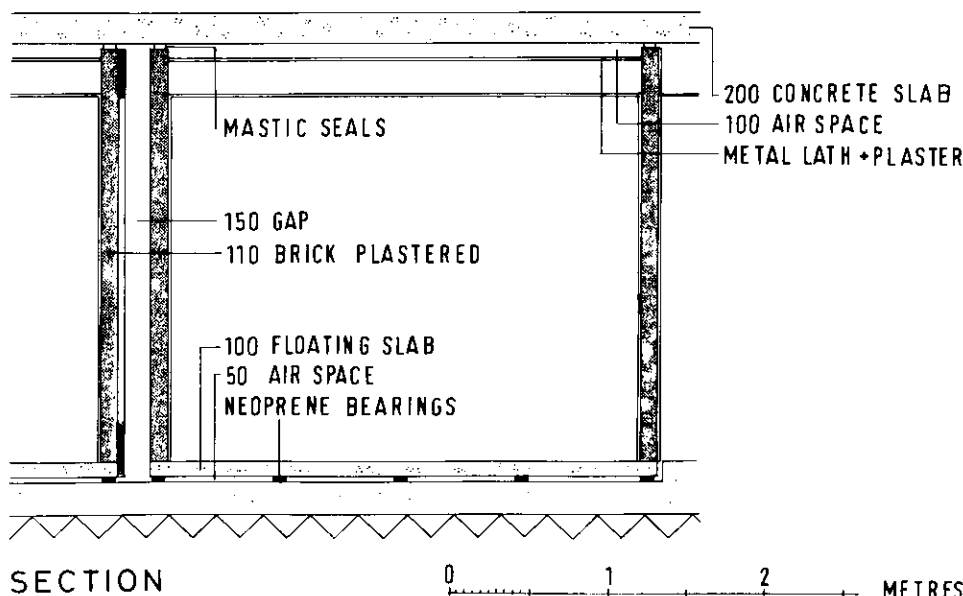


Figure 4 Practice and teaching rooms in the Royal Academy of Music, London

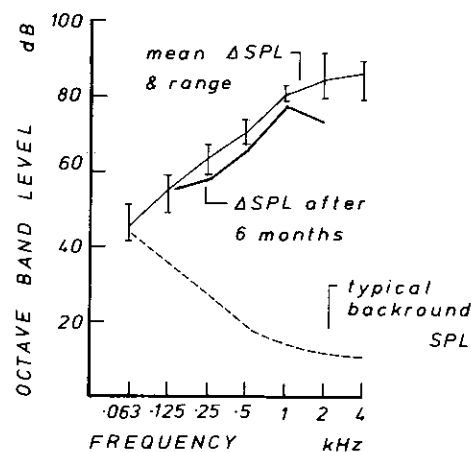


Figure 6 Sound insulation and background noise in the basement rooms of the Royal Academy

might conclude from the examples so far that such a high standard is not strictly necessary for teaching rooms if the background noise can be maintained, but where mechanical services are concerned that is a big 'if'. Recently Hugh Creighton has been exploring the use of orthodox forms of construction, first in Cambridge Music School (Stage 2), a single storey building (Figure 8) and now in the multi-storey Royal Scottish Academy of Music and Drama in Glasgow, which is under construction. The design team is confident because the sound insulation of about 60 dB  $\Delta$ SPL (in a background noise of NC15-20, Figure 9) which was demonstrated to the Scottish client in Cambridge, was considered acceptable for Glasgow and, for Cambridge, has been predicted with remarkable accuracy by Robin Mackenzie in Heriot-Watt University. Are bagpipes on the curriculum in Scotland?

Looking to the future, if 60 dB  $\Delta$ SPL is satisfactory it could radically change the design of music teaching rooms. Double

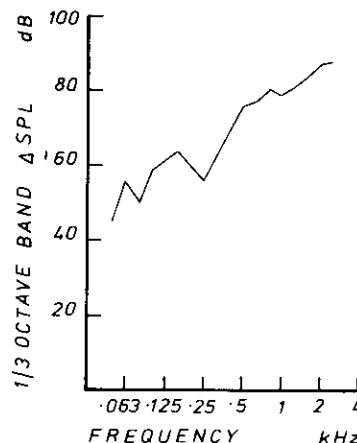
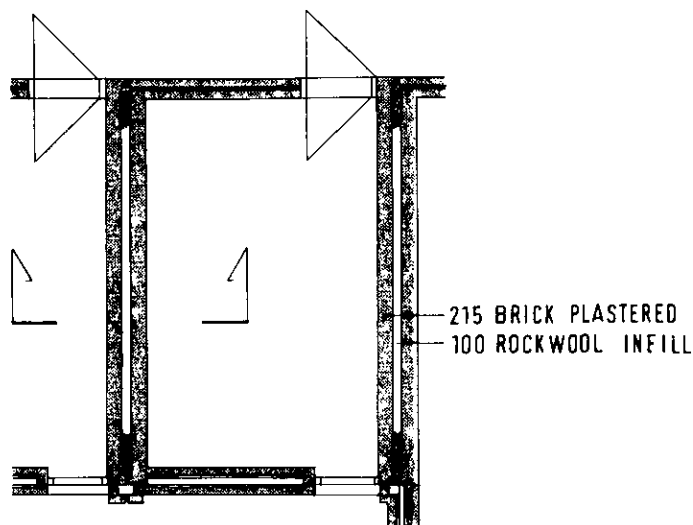


Figure 7 Sound insulation measured between two sample teaching rooms in the Hong Kong Academy for Performing Arts

## PLAN



## SECTION

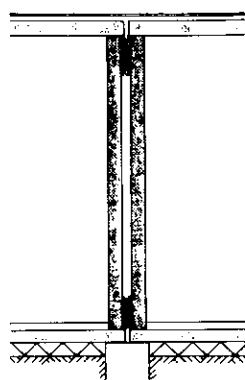


Figure 8 Cambridge Music School Seminar Rooms

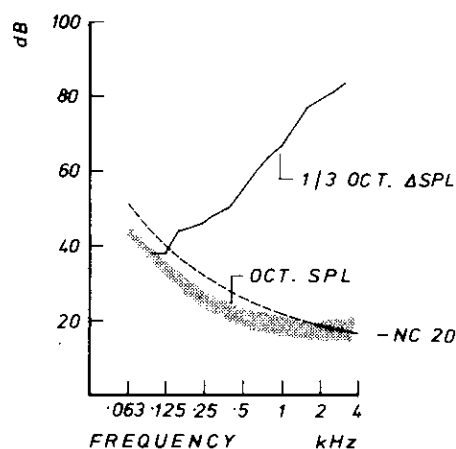


Figure 9 Third octave band sound insulation and octave band background noise levels in the Seminar Rooms of Cambridge Music School

windows to the exterior would not be needed to preserve sound insulation between adjacent rooms so that in some cases background noise from road traffic could be utilised. Double walls and even floors could be lightweight, such as blockwork, timber, woodwool slabs or plasterboard with suitably large airspaces and structural discontinuities. Perhaps the respective manufacturers could analyse the technical problems and costs. As for the doors, it seems the most reliable arrangement, requiring no maintenance, is to use ordinary double doors without seals, in a sound lobby configuration. Further reading on suitable standards of sound insulation and the choice of walls, floor, ceiling and doors to achieve a balanced design, can be found in the article by Klepper *et*

*al*, *Noise Control in Music Teaching Facilities*, Noise Control Engineering 15(2) 71-79 (1980).

## Rooms For Debate — Council Chambers

In a rare departure from their usual measured style Cremer and Müller, Vol I p 119, roundly condemn the mistaken use of absorbent ceilings to reduce reverberation in small lecture and conference rooms and the consequent introduction of sound systems to provide sufficient early energy for speech. Even when this blunder is avoided, council chambers, debating chambers and law courts present particular room acoustic and electroacoustic problems — people may speak from various locations and will not always be trained public speakers. Nevertheless some orientational constraints do apply; in council chambers for instance, debate is regulated by the chairperson and members usually address the Chair.

*continued on page 21*

## WEST GLAMORGAN COUNTY COUNCIL SWANSEA

118  
55  
225

Councillors, Officers & Clerks  
Press & Public  
Floor Area m<sup>2</sup>

## LONDON BOROUGH OF HILLINGDON

102  
125  
500

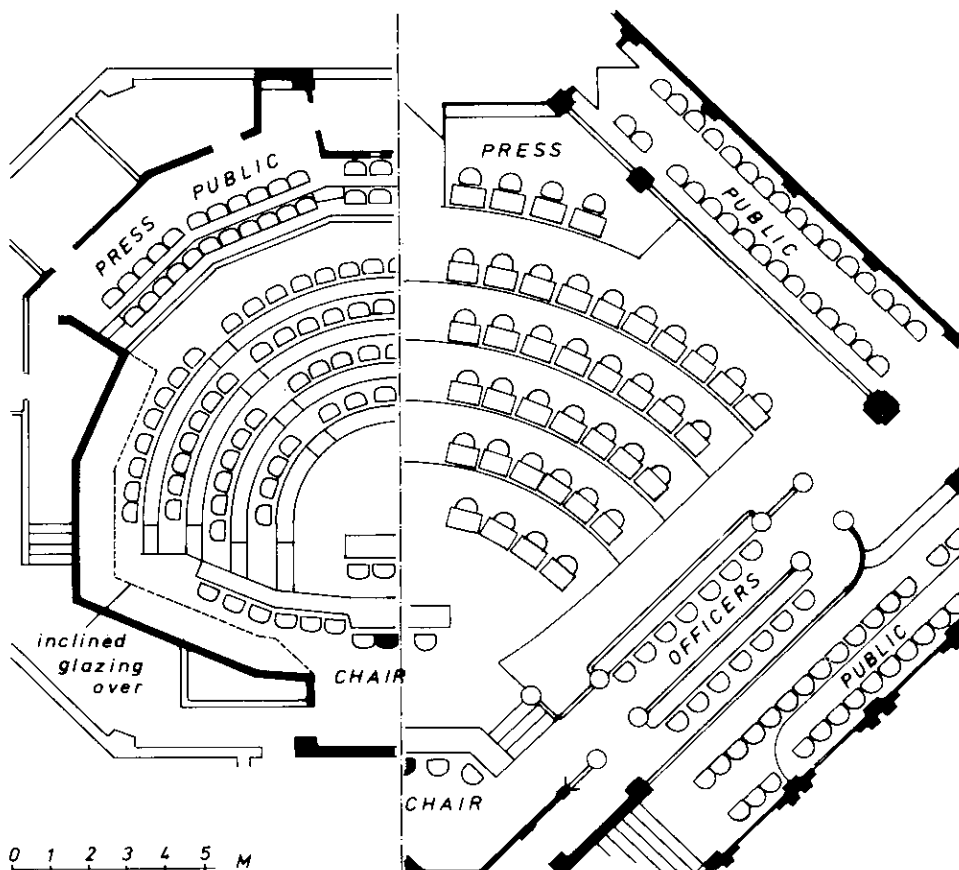


Figure 10 Part plans of Swansea and Hillingdon Council Chambers to the same scale; the acoustic boundaries of each chamber are shown heavily shaded

# Proceedings of The Institute of Acoustics — Abstracts

## Combustion Generated Noise and its Suppression

7 November 1984 at the Midland Research Station, British Gas Corporation, Solihull, near Birmingham

### The Non-linear Acoustic Properties of Flames

D Adams  
CEGB

Observations made on an industrial furnace have led to an interest in the non-linear effects which may occur when a periodic acoustic wave passes through a flame.

This paper outlines the development of a simple model to describe such effects and some initial experimental investigations to confirm their existence. In particular it is found that a flame may act to introduce modulation of the heat and pressure waves given the presence of two (or more) acoustic sources at different frequencies. These modulation products are found to be capable of exciting a furnace system which would otherwise remain quiescent.

The possible importance of these findings to practical problems is discussed briefly.

### The Generation of Noise in External Coanda-type Waste-gas Flares

P W Carpenter and P N Green  
Centre for Industrial and Geophysical Fluid Dynamics, University of Exeter

External-Coanda-type waste-gas flares represent a considerable improvement in terms of combustion efficiency, pollutant emission and noise when compared with the older sonic pipe flares and vents. Nevertheless, despite this improvement in noise level, the environmental restrictions on the design of off-shore platforms make further noise reduction highly desirable. The present study of the noise generated by the Coanda flares has been undertaken as part of a research programme aimed at developing suitable noise-suppression techniques.

Brzustowski and others have discussed certain aspects of external-Coanda-type flares. However, apart from our preliminary results no information on the noise generated by such flares appears to be available in the open literature. The present paper is concerned with the Indair flare which is designed and marketed by Kaldair Ltd. Noise data measured in the field and from model tests are used to assess the relative importance of the various noise sources and to elucidate the main feature of the high-frequency sources.

### On Noise Producing Mechanisms in Turbulent Gas Combustion

B C Dalamagas and N Kidin  
Polytechnic of the South Bank, London

Sound emission from turbulent gaseous combustion has been described macro-

scopically in terms of a random distribution of elementary monopole sources. This paper presents an extension to the currently accepted model of sound generation by these elementary sources which takes particular account of the rate of volume evolution at the terminal stage in the burning of small pockets of a combustible mixture. The model is based on hydrodynamic relationships applied to the elementary volume of combustible mixture which are solved using first-order perturbation methods. Sound emission is then predicted from an estimate of the characteristic time of chemical reaction.

An experimental arrangement is described which has enabled the acoustic pressure from such small isolated pockets of burning fuel to be measured. An open premixed laminar flame is excited to produce small bubbles which undergo uniform surface burning until they experience a small thermal explosion. Schlieren and shadow photographic techniques are used to follow the combustion process to correlate with the acoustic signal. A reasonable measure of agreement is found between experimental findings and theoretical prediction.

### Some Combustion Noise Problems and Countermeasures

P J Foster  
Department of Chemical Engineering & Fuel Technology, University of Sheffield, UK

A stable laminar flame, whether a diffusion or a premixed flame, is not an original source of sound.

In the absence of a flame a turbulent flow is a source of broadband aerodynamic noise. Interrelated fluctuations in velocity, pressure and density act in free flow as quadrupole sources of sound. For free jet flows, the peak wavelength is about 7 times the jet nozzle diameter often with peak frequency in the range 1000 — 4000 Hz in practice.

A turbulent flame emits broadband noise which peaks at a wavelength about 50 times the burner nozzle diameter usually with a peak frequency of 200 — 800 Hz in practice.

In a furnace, a flame is one element of a system comprising the combustion chamber, fuel and air supply lines, the burner, and the flue gas duct. Fluctuations of pressure in the combustion chamber can vary the fuel or air supply rate. When the corresponding variation in the heat release rate possesses a component in phase with the chamber pressure, an oscillation can be sustained in accord with Lord Rayleigh's dictum. Reported system oscillations have a specific low frequency often in the range 4 — 70 Hz and sometimes a factor of up to 10

times less than the natural acoustic frequencies of the combustion chamber at the hot gas temperature. In addition, the natural frequencies of the ducts and chambers are liable to excitation by broadband noise.

These phenomena and the combinations of interaction between them provide a rich variety of sound producing phenomena which are often difficult to diagnose and to remedy owing to the wavelength variation in atmospheric air from about 17 m at 20 Hz to about 34 mm at 10 kHz which encompasses plant dimensions.

Sound is a form of energy which once produced can only be removed by conversion into thermal energy by viscous dissipation in fluids or internal friction in solids. When a source of noise is identified there are two basic approaches to deal with it:

- reduce or eliminate the source itself,
- insulate the source from its environs and absorb the sound energy produced.

### Active Control of Noise caused by a Flame in a Duct

Maria Heckl  
Department of Engineering, University of Cambridge

I have used the Rijke tube as an elementary model for combustion instabilities involving the propagation of longitudinal pressure waves in ducts. The stability behaviour can be explained by energy considerations. Acoustic energy is gained at the heat source and lost at the tube ends. There is instability if the energy gain is larger than the energy loss.

The noise of a Rijke tube can be reduced and even cancelled completely by the following feed-back system. A microphone at one end of the tube picks up the sound which consists mainly of the fundamental frequency of the tube. The microphone signal is filtered, phase-shifted, amplified and fed into a loudspeaker at the other end of the tube.

The Rijke tube can be made quieter or noisier by varying the phase-shift and the amplification. This is because the loudspeaker at A changes the boundary conditions so that the energy loss at A becomes larger or smaller respectively. By appropriate choice of the phase-shift and amplification the energy loss at A can be made so great that the total energy loss is more than the energy gain, in which case the noise is cancelled completely.

Unlike other active systems, this method is not sensitive to errors in phase-shift or amplification. A phase range of 60 degrees is

## Combustion Generated Noise

acceptable so long as the amplification is sufficiently high.

A balance equation for the acoustic energy in the Rijke tube and feed-back system has been developed. This equation is analysed numerically to show how the phase-shift and amplification influence the stability behaviour.

### Combustion Induced Vibration in Industrial Boilers

**D J Irving, W J G Little and J S Wharmby  
Babcock Power Limited**

Incidents of combustion induced pulsations have caused problems on gas and oil fired boilers throughout the world in recent years. The pulsations are caused by fluctuations in furnace pressure coupling with oscillations in heat release rate, according to the Rayleigh Criterion. Sustained vibration, which is usually diagnosed during commissioning, can lead to severe damage to the plant and long outage periods while repairs are carried out.

The policy of rapidly assessing the control parameters for redesign by direct measurements on actual plant, has enabled Babcock Power Ltd to be successful in solving a number of cases of combustion induced pulsation problems on a wide range of plant size.

A number of investigators have built up mathematical models of the combustion region, in terms of flow velocities, local pressure, flame temperature etc, in an attempt to fully define the coupling between the heat release pulsations and the combustion chamber dynamic pressure. Although there is agreement that the principle of Rayleigh's hypothesis is valid, many aspects of the flame behaviour are still open to discussion. This paper describes some features associated with excitation mechanisms and the Rayleigh Criterion and summarises some of the recent investigations into combustion induced vibration on industrial boilers.

### On the Coupling of an Anchored Flame with an Acoustic Field

**A C McIntosh  
College of Aeronautics, Cranfield Institute of  
Technology, Cranfield, Bedford**

The interaction of an anchored flame with a low-level acoustic field is considered. The flame is considered to be 'held' by a gauze through which the reactants are allowed to flow. Small perturbations in velocity in the combustion zone are linked upstream and downstream with order  $O(M)$  acoustic disturbances at large distances from the source (where  $M$  is the flow Mach number). This matching process yields a frequency condition governing the flame vibration and preliminary results for emitted acoustic waves are presented.

### Measurements of Acoustic Stability Parameters in Combustion Systems

**M Macquisten, M Vuillermoz and J Roberts  
Polytechnic of the South Bank, London**

The occurrence of combustion driven oscillations can be a disadvantage in the operation of most combustion systems. This problem can be observed in most combustion systems ranging from a small domestic unit to much larger industrial installations. A novel sound probe technique

has been developed using a pulsating arc discharge which has been used to investigate the phenomenon.

The paper describes the technique as a means for predicting acoustic instabilities in combustion chambers. This involves the measurement of the acoustic impedance in the chamber using the probe as a constant velocity source and measurement of the relevant transfer terms which describe any acoustic amplification brought about by the combustion process. Particular reference is made to the impedance matching between the pulsating arc as a sound source and its surroundings, and the results of the impedances measured along the axis of a model combustion chamber which are shown to be in general agreement with theoretical predictions.

The above investigation has been limited to a modulated DC arc in a laminar flame system and for frequencies generally higher than those encountered in practice. The natural extension will be its application to combustion driven oscillations in turbulent flames. In most combustion systems turbulent mixing is employed for greater efficiency. An experimental programme aimed at overcoming these limitations will be discussed, involving the use of a radio frequency arc in a turbulent flame system.

### Design of Low Noise Industrial Premixed Burners

**B Mugridge and D Whitman**

An empirical formula for the broad band sound power output of a simple premixed natural gas flame has been developed. An experimental evaluation of more practical burner designs has been carried out, and a comparison made with a conventional design. Utilising this data, a graphical technique has been developed for the design of lower noise burners. The technique seeks to optimise reduced mixture exit velocity, and port diameter and number, so as to achieve lower noise levels while avoiding combustion lightback problems.

A burner incorporating an array of 114 small mixture ports, with a small flame stabilised on each, has been built, which gives a 14 dB noise reduction, compared with a similarly rated burner of conventional design, and exhibits very stable combustion.

Details of this burner development will be described, together with its application in the industrial gas market, and some information given concerning the occurrence of combustion driven oscillations which can be experienced with flames of this type.

### Diagnosis of Oscillations in a Large Swirl Burner/Furnace Combination

**N Syred, C Curtis-Thomas and T C Claypole  
Department of Mechanical Engineering &  
Energy Studies, University College, Cardiff**

This paper describes some experimental work carried out to determine the mechanism of low frequency oscillation occurring in a swirl burner/furnace combination for burning and recovering heat from low calorific value gases. The mechanism is identified as excitation of a fundamental Helmholtz oscillation of the system by a naturally occurring three dimensional time-dependent instability of swirling flows, called the Precessing Vortex Core. The problem arises from the technique used to simulate low calorific value gases in

the laboratory (ie by dilute mixtures of air and natural gas) and the resulting need to prevent flashback by the addition of a large centre body to the swirl chamber.

### The Acoustics of a High Intensity Combustion Chamber

**R Turner  
Blue Circle Industries PLC**

The acoustic behaviour of a high intensity combustion chamber was investigated in order to illuminate the causes of unacceptably high operational noise levels.

In use the combustion chamber is a direct steam generator and is liquid fuelled. Simulation of the combustion noise produced was attained by replacing the liquid fuel by an air/natural gas mixture. Acoustic measurements were taken of the combustion noise produced by just the burner alone and by the complete combustion system. Further measurements were carried out on the complete combustion system by examining the variation of acoustic impedance with frequency at the burner port by a standing wave technique.

The results from all the tests conducted indicate that the unacceptable noise is generated by 'combustion roar'. However, more details of the precise operating conditions of the device would be required before the most appropriate remedy for the reduction of the excessive noise levels could be recommended.

## Proceedings

Copies of the Proceedings for the meetings on Combustion Generated Noise and its Suppression and on Underwater Acoustic Calibration and Measurements may be obtained from IOA Headquarters in Edinburgh.

Contact:

Mrs C M Mackenzie  
IOA  
25 Chambers Street  
Edinburgh  
EH1 1HU  
Tel: 031-225 2143

# Underwater Acoustic Calibration and Measurements

13 - 14 December 1984, Bracknell

## A Review of Underwater Acoustic Fluctuation Measurement

D E Weston

Admiralty Research Establishment, Portland

A brief survey indicates the considerable extent of the published measurements of ocean acoustic transmission fluctuations. Many different mechanisms are responsible and it is useful to classify the results accordingly. Important measurement techniques include the use of coded transmissions, the provision of compact displays, and the employment of very long measurement periods. The several advantages of the latter are illustrated. Fluctuation of variability is of significance for many reasons, and one demonstration shows effects on a reverberation display of fish.

## Limitations on Performance of Doppler Sonar Systems for Vehicle Velocity Estimation

Jean Boulton

Cambridge Consultants Ltd

The performance of a doppler sonar system to be used for vehicle velocity estimation is limited by the nature of the environment in which it must operate. For example, variations in the velocity of sound through the insonified water column, and changes in seabed scattering strength over the footprint, lead to inaccuracies in the estimation of vehicle velocity. These and other effects generate both zero mean and bias errors. Zero mean errors may be reduced by averaging techniques, but bias errors are more difficult to overcome.

The causes of limitations in performance of doppler system sonar velocity sensors will be discussed, and ways in which system performance may be optimised will be suggested.

## Calibration and Inherent Errors of a Two Hydrophone Sound Intensity Measurement System

P S Watkinson

Plessey Marine, Templecombe, Somerset

The ability to measure sound intensity has been identified as a useful tool in the study of noise radiation from ships with regard to the ship's hull as a complex noise source. The paper will discuss design criteria, inherent measurement errors and calibration of the 'two hydrophone' method of sound intensity measurement.

The 'two microphone' method of measuring sound intensity in air is well documented and all the fundamental principles transpose over to the 'in water' case: sound pressure and particle velocity are approximated at a point mid-way between two transducers by the sum and the integrated difference of their signals. There are numerous errors associated with this technique and those

pertinent to the application of the method with a two channel Fourier analyser will be reviewed. One error can be particularly limiting: that associated with a phase mismatch between the two measurement channels. A technique will be described for determining this mismatch 'in water' and how this information can be used to significantly increase the range of measurement of an inherently band limited technique. Also described will be a parameter which quantifies the quality of a particular intensity measurement system as a function of frequency and how this parameter can, under some circumstances, be used to estimate measurement errors. Example results for these techniques will also be presented.

## A Comparison of Prony and Nyquist Sampling for the Measurement of Short Pulses in Acoustic Calibration

W P Hereward

British Aerospace PLC

The need to simulate free field conditions in tanks and other confined spaces is introduced and the technique of using short pulses to achieve this is briefly discussed. The problems inherent in making actual measurements of these pulses are described.

The principles of the Prony (Coherent sampling) system are explained and the techniques of oversampling, undersampling and compound sampling are described. The Prony system developed by Brown & Luckey of USRD is briefly described and the figures for the accuracy of the system, as measured by them, are quoted.

The limitations of the Prony system are explored, in particular the difficulties in measuring pulses from integrated systems, due to the need to synchronise the sampling device with the transmitted signal.

The principles of the Nyquist (Random Sampling) technique are explained and the relationships between sampling frequency, signal frequency, pulse length and accuracy are explored.

Some commercially available equipment is described with the relevant manufacturers' specifications. A possible calibration system based on one of these devices is briefly described.

The conclusion is drawn that the very fast random sampling devices now available make the increased complexity of the Prony system largely redundant, except for certain specialised applications.

## Calibration of Hydrophones

H A J Rijnja

TNO, The Netherlands

Abstract not available.

## Underwater Acoustic Calibration and Measurements in HSEI

He Zuo-yong

Haerbin Shipbuilding Engineering Institute, China

In the present paper, some interesting work about calibration and measurements is introduced.

### I Calibration of a hydrophone under high static pressure:

The method of absolute calibration of a hydrophone under high pressure in a coupler had been improved. Here, the transducers were made with a U-form PZT ceramic sensor. It will ensure them for shielding, waterproof and a satisfying rigid boundary condition. Furthermore, the reciprocity parameter of calibration in the coupler was derived theoretically with different formulae from those conventionally used. Then, the calibration frequency range can be extended.

The comparative calibration was made in a noise field at high pressure. In a steel tank, the statistic uniform distribution noise field established up to 5 kHz with uniformity about  $\pm 1$  dB.

### II Near-field complex number sound pressure measurements:

In order to estimate the influence of a baffle on the acoustic behaviour of the sonar array, we had to resolve the method for measuring the distribution of scattering sound pressure nearby the baffle of the array. The pressure was detected by measuring it twice: the first time, the hydrophone was in the free-field and the second, it was in the same point near a baffle.

We have also measured complex sound pressure along a spherical surface enclosing an arbitrary elastic shell body which was excited by an electro-mechanical ceramic exciter. Then, the far-field angular distribution and directivity pattern can be calculated by computer. Thus, the behaviour of sound radiation of an underwater structure may be expected to be studied in a tank.

## A Technique for Measurements of Acoustic Properties of Materials using a Delay Rod

G A Steel et al

University of Birmingham

Abstract not available.

## Absolute Calibration of Hydrophones in the Frequency Range 0.5 MHz to 15 MHz

R C Preston, A J Livett and D R Bacon

Division of Radiation Science and Acoustics, NPL, Teddington

The absolute calibration of piezoelectric hydrophones in the frequency range 0.5 MHz to 15 MHz will be discussed with the emphasis on the techniques which are routinely used and are under continual development at the National Physical

## Underwater Acoustic Calibration and Measurements

Laboratory. Both reciprocity and planar scanning techniques will be described with particular reference to the sources of uncertainty. Results of comparisons between these two techniques will be presented. Emphasis will be placed on the calibration of membrane hydrophones although the techniques may be applied to other devices at the expense of reduced accuracy. The development of optical interferometry to measure absolutely the acoustic displacements in a high frequency field will be described and preliminary results of calibrations of hydrophones will be presented.

### Tungsten Carbide Calibration Spheres

**D N MacLennan**  
Marine Laboratory, Aberdeen

Tungsten carbide spheres are used for the calibration of fishery echosounders. The target strength may be calculated from well established theory to an accuracy that depends upon knowledge of the sound velocities and density within the sphere. Resonance experiments show how the sound velocities vary with density, thus the target strength may be calculated as a function of the density alone. Experimental comparison of sphere target strengths indicates more variation than would be expected from theory, possibly caused by small quantities of gas trapped in the webbing support around the sphere. Experimental and theoretical results are presented from which confidence limits are derived for the target strength of spheres used to calibrate 38 kHz echosounders.

At the close range of the reference target in most applications, the time varied gain changes significantly over the pulse duration. Errors associated with this effect are discussed. They may be eliminated by correct choice of the time delay before the start of the time varied gain ramp.

### A Method for the Accurate Measurement of Target Strength

**J R Dunn**  
Department of Electronic & Electrical Engineering, University of Birmingham

One method of calibrating sonars used in fish stock assessment is by the use of standard targets, and this paper describes a method of calibrating such targets to a good degree of precision without individual calibration of the transducers used in the measurements. The basis of the method is the comparison of the echo from the target with that from the surface of the water acting as an ideal plane reflector, the actual measurements being of a ratio of voltages and of the ranges of the target and the surface from the transducers. Because the measurements were made at relatively close ranges, small corrections were made to the directly measured ranges to account for the effective centres of spreading not being exactly at the face of the transmitting transducer nor at the nearest point of the spherical target. The target strength of ping-pong balls was measured at 30 and 38 kHz, and it was proved that these balls are not suitable as standard targets; tests were also made on tungsten carbide balls for target strength and for resonant frequency.

### Calibration Practices in the USA

**J E Blue**  
USRD NRL Orlando, Florida, USA

Abstract not available.

### Digital Automatic Measurement of Underwater Sound Transducers

**Yuan Wenjun**  
Hangzhou Underwater Acoustics Institute, China

A digital measuring system that is used for calibrating evaluating and testing underwater sound transducers has been set up in HUI. By the help of a computer and with the use of a two channels transfer function analyser, some essential performance characteristics of underwater sound transducers, such as electrical impedance (or admittance), transmitting response, receiving sensitivity, input electrical power and efficiency, may be quickly measured and recorded. It also provides a convenient technique for measuring and testing high power transducers.

Some examples of results are given, and the measuring system and method are described.

### Microcomputer-controlled Transducer Calibration Facilities at the Defence Research Establishment Atlantic

**G W McMahon and C V Sheffer**  
Defence Research Establishment Atlantic, Dartmouth, Nova Scotia, Canada

**D R Chang**  
Evans Computer Applications, Halifax, Nova Scotia, Canada

The underwater acoustic calibration facilities at DREA include a 180 kl tank and a 300-tonne barge moored in sea water 42 m deep. Both facilities are equipped with identical microcomputer control systems based on the DEC LSI-11/23 CPU with up to 256 kbytes of memory. Each system includes digital-to-analog and analog-to-digital converters, vector array processor, parallel and serial I/O lines, and a 9 Mbyte Winchester/floppy unit. Peripheral devices such as frequency synthesisers and filters are controlled through an instrument bus controller. Graphic results are displayed on a terminal or a digital x-y plotter.

A user-interactive software package has been developed to perform the common transducer calibration tasks including receiving and transmitting responses, reciprocity calibrations, directivity, and electrical admittance/impedance. Conventional tone burst or CW calibrations cover the range from 20 Hz to 450 kHz and a pseudo-Gaussian noise method is available for hydrophone calibration from 5 Hz to 50 kHz. Sampled tone bursts are analysed by a DFT process, or, if extended low frequency observation is needed, a modified Prony analysis technique is available.

### An Off-the-shelf, State-of-the-art, Acoustic Test System

**C Ledoux**  
NUSC, Rhode Island, USA

Abstract not available.

### An Instrumented Semi-automatic Acoustic Calibration System and Attachments Thereto

**L W Lipscombe**  
DBE Technology Group PLC

A computer controlled system for acoustic measurements is described. The system comprises a number of standard and special purpose instruments communicating with a

desk top computer and plotter. In addition to the normal measurements of sensitivity, polar patterns and impedance in large tanks of water, it can accommodate inputs from a mechanical 'dunking machine' calibrator, and an air-water pistonphone. Typical results will be shown in the presentation.

### Use of BBC Microcomputer for Synthetic Aperture Measurements

**J W R Griffiths and A S Gida**  
University of Technology, Loughborough

In a study of high resolution systems to provide detailed information about targets, use has been made of the synthetic aperture technique. The platform which carries the transmitting and receiving transducers is controlled from a BBC microcomputer and the received signal after processing to provide the amplitude and phase information is fed into the BBC microcomputer and subsequently stored on a floppy disc.

Reconstruction of the image is carried out either on the BBC microcomputer itself, which is rather slow, or on one of the main campus computers. In the latter case the BBC microcomputer acts as a terminal to the main computer and can download the data directly and then receive the processed data back again.

### Precise Calibration Technique for Echosounders used in Fish Stock Estimation

**E J Simmonds, I B Petrie and F Armstrong**  
DAFS, Marine Laboratory, Aberdeen

The paper describes the calibration procedure used by the Marine Laboratory, Aberdeen for a 38 kHz sounder system. The procedure consists of three separate measurements.

(1) The Time Varied gain function which compensates for range dependence is checked using a computer controlled range gate. A signal source is adjusted to give constant output at each range point. The average error between the required function and the measurement gain is computed and errors are recorded for the later correction of acoustic survey data.

(2) The Transducer Equivalent Beam angle is measured using a high precision computer controlled motorised gimbal table. The technique is described and the errors are discussed.

(3) The 'on axis' sensitivity measurement is described in more detail. This is a standard target calibration using a tungsten carbide sphere as the reference target. Alignment of the target and the transducer acoustic axis is achieved using a computer controlled three wire suspension system. This is attached to the towed body transducer housing during the calibration procedure. The three wires are adjusted to move the target through the sounder beam in two planes approximately at right angles. Data from scans are collected and curves fitted to compute the position and amplitude of the maximum signal.

**Material for the April issue of Acoustics Bulletin should reach Mrs F A Hill at 25 Elm Drive, St Albans, Herts AL4 0EJ, no later than Tuesday 26 February.**

## Building Acoustics — continued

In common with theatres, the fundamental problem is to accommodate as many people in as compact an arrangement as possible; typically in council chambers up to 100 councillors and 50 observers at about 1.5m<sup>2</sup>/seat can usually be provided for without recourse to a sound system. That said, it will be essential to take full advantage of a compact, raked, circular seating arrangement, with early reflections from the walls and ceiling preserved, echoes suppressed and sufficient reverberation making the space comfortable to encourage members to speak up.

Although these principles are not always consistent with the aspirations of some local councils, examples can be found in Bedford, Hillingdon, Reading and Swansea where they have been applied with some success. Part plans of the Hillingdon and Swansea council chambers in Figure 10, show different approaches partly resulting from different occupancy. Both have reverberation times of about 1.0 second and background noise levels in the range NC25-30. In Swansea, elevated inclined glazing and a profiled ceiling are used to strengthen the early sound, whereas in Hillingdon the approach is to use dado height walls on risers, dividing the space, and a largely diffusing ceiling highlighting the structure.

Although the intention to provide good natural acoustics for the councillors was realised in both cases, sound systems were not avoided altogether. As a precaution in Swansea, provision was made for gun microphones in front of the Chair directed towards the front rows of councillors, feeding loudspeakers in the press and public gallery at the rear; these were found to be unnecessary and are never used but a microphone for the chairperson is occasionally used to bring the public

gallery to order! In Hillingdon, quiet spoken councillors and the sometimes boisterous behaviour of their colleagues, have led to unforeseen intelligibility problems in remote seats in the back benches and in the public galleries. The solution has been to install two sound systems, one with microphones at the dais feeding column loudspeakers behind (which also provides for audio-visual presentation in the chamber) and the other, with voice activated members' microphones, one between two, feeding loudspeakers distributed at the interface between the debating area and the public galleries. By dividing this system, left and right, with appropriate time delays for each side, natural sounding speech reinforcement has been achieved.

Clearly where a sound system is necessary and works well, without placing undue constraints on the user, it is to be applauded (but discreetly please). However, the experience of these and other debating chambers suggests there is still scope for refining the natural acoustic design, for example by using 1:50 scale acoustic models which are cheap and quick to build. We must also beware of the public seduction wrought by the illusory ease with which microphones are used in radio and television.

### Acknowledgements

Gentle reader, we are indebted to Hugh Creighton for the lowdown on Music Schools in Birmingham, Cambridge, Glasgow and The Guildhall and to AIRO for the same in respect of Hillingdon Council Chamber. I must also thank Hugh and his wife for some delicious apples from their orchard and Theodore Schultz for his translation of *Principles and Applications of Room Acoustics*, Vol I by L Cremer and H A Müller, published by Applied Science, 1982, which is still being digested.

## Educational Buildings and Hospitals

### P ALLAWAY

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#### Educational Buildings

**M**ANY schools are built, or are already situated, in urban centres and therefore have to contend with noisy external conditions from road traffic and the many noise sources in a busy town or city. Even those schools in country areas may face noise from road traffic, from airports, from agricultural machinery and local industry.

Regardless of the external acoustic environment, teaching areas must be provided with sufficiently low intrusive noise levels to permit good communication which is, of course, a fundamental requirement of teaching and learning. Within the teaching areas, the room acoustics have to be of a quality appropriate to the subjects taught. For instance, most classrooms will require acoustic conditions which favour the

understanding of speech but some areas, such as music rooms, will require a quite different quality of acoustics and other areas will require high levels of sound absorption in order to reduce reverberant noise levels. Kitchens, internal swimming pool halls and gymnasiums may have room acoustics which are more 'lively' than are strictly desirable because the acoustic considerations may be overruled by considerations of hygiene, durability and life of room finishes.

The Halls of schools, colleges and universities, though generally used for speech, are of multipurpose usage and room acoustic design will generally be a compromise between the ideal conditions for speech and those for small scale music making. Many schools have strong choral traditions and, if this is the case, some acknowledgement of this may be made in the design of room acoustics for the Hall though the optimum conditions for speech and choral music are quite different.

Because of the frequently noisy external conditions, sound insulation requirements for the facades are likely to impose the use of quite heavy construction. Openable windows should be placed, whenever possible, on an elevation to a quiet area such as a quadrangle or courtyard. Only in unusual cases will money be available for air conditioning so that sealed windows could be used in unfavourable external conditions.

Noise insulation between classrooms and other teaching areas will ideally be of a standard to prevent the easy perception and understanding of speech in adjacent rooms.

Quiet floor finishes, such as rubber or vinyl tiles, are to be favoured though, again, considerations of material life may prevail. Sound absorption in the finishes of communication areas such as corridors is desirable.

Craft rooms such as woodworking, metalworking and so on, may require special treatment and preferably will be placed far from the hall and classrooms.

Modern teaching techniques frequently involve the use of audio visual aids and it is a general experience that sound levels tend to be higher than for natural speech. Consideration of this point should be included in the selection of sound insulation standards and building layout.

#### Hospitals

It is surprising to many people to realise the extent to which hospitals are substantial industrial installations. Even if a hospital is not fully air conditioned,

some areas will be air conditioned for reasons of bacteriological control. These will include operating theatres and the ancillary areas. However, all hospitals built to today's standards include massive heating installations, medical gases, medical vacuum and waste disposal systems. Very deep ceiling voids are frequently required for the location of these services and care has to be taken that noise is not radiated from pipes and ducts in that ceiling void to critical areas below.

Hospital services plant rooms must work twenty-four hours per day and 365 days per year. Their location in relation to noise sensitive areas within the hospital and to neighbouring properties is critical to a successful installation. Large boiler plants can produce very low frequency noises which may disturb patients, staff and residents in nearby property, especially at night.

As with educational buildings, there is frequently a conflict between the optimum use of sound absorbing

materials, in order to control reverberant noise, and considerations of hygiene and material life.

Standardised hospital building design is intended to facilitate the provision of high quality hospital buildings at sensible costs but the use of the lightweight internal partitions in such designs may give rise to noise insulation problems between public areas and wards for instance. Consulting rooms are an obvious area where good acoustic privacy is essential.

## Domestic Buildings

*Converting large, at one time single-family homes into multi-occupancy dwellings has highlighted problems of inadequate noise and vibration isolation. Extensive survey work of the acoustic privacy in a wide range of domestic buildings has been done and methods for improving the transmission loss developed. Relatively less dramatic noise improvements have been achieved by most of the manufacturers of domestic appliances, some of which remain excessively noisy. The continuation of relevant research into noise and vibration transmission in buildings should lead to the cross pollination of ideas and ultimately an improved domestic noise environment.*

### Sound Insulation in Domestic Buildings

**L C FOTHERGILL**

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**I**N domestic buildings the main job of the acoustician is to provide the occupants with adequate protection from intrusive noises emanating from sources outside and inside the building. The main sources of external noise are road traffic, aircraft, industry and construction work. Reducing noise at source can be the best solution but this may only be practical for some industrial and construction sources so that improved insulation provides the most convenient solution in many cases. The solution to a problem may involve liaison with a local authority, assessing the acceptable internal noise level and specification of insulating element(s).

External noises often vary with time and may contain tonal components which increase the annoyance and so simple dB(A) measurements may be inadequate. Different descriptions have been devised to suit the main sources of noise and they are validated by results from social surveys. For aircraft noise the Noise and Number Index (NNI) is used and it takes account of both the noise level of a flyover and the number of flyovers. Contours of NNI may be drawn around airports for planning purposes. For traffic noise the 'A' weighted level exceeded for 10% of the time has been found useful. The equivalent continuous noise level  $L_{Aeq}$  (ie the level of a steady tone having the same energy as the fluctuating noise of

the same duration), and the simple dB(A) reading from a sound level meter are also widely used.

When the sound reaches the building it enters by the weakest part of the facade which is usually the windows. Fitting double windows is the most common solution. The advantage of a double window over a heavy single pane is only achieved above the mass-spring-mass resonance frequency caused by the panes of glass vibrating at a frequency related to the stiffness of air between them. Much work has been done to evaluate the effects of cavity width, mass of panes, gas between panes, damping of the panes and their edge conditions. The insulation of a typical double window installation is about 35 dB(A) against traffic noise but the insulation expressed in dB(A) is very dependent on source spectrum.

Noise generated within dwellings is becoming an increasing problem, not least because of the proliferation of high power audio equipment. There is little the acoustician can do to protect the occupants of a flat from the noise of an all-night party in the flat above, but a reasonable degree of privacy can be achieved between households pursuing more restrained activities. Sound insulation requirements for new dwellings have been included in the Building Regulations for nearly 20 years and this

has reduced the incidence of very poor performance and eliminated the more bizarre constructions seen before this time. However, building design is not static and changes to other aspects of design can have adverse effects on sound insulation. The insulation between a pair of dwellings depends on the properties not only of the party wall or floor but also of the flanking construction. Masonry party walls rely on their high mass to provide sound insulation and use of lightweight concrete materials in the external walls to improve thermal performance has been found to degrade sound insulation under some circumstances. Lining walls with plasterboard instead of wet plaster has also been found to have an adverse effect on the performance of some wall types. Interest in prefabricated, thermally efficient buildings has led to the increasing use of timber framed construction. Here, party walls made from

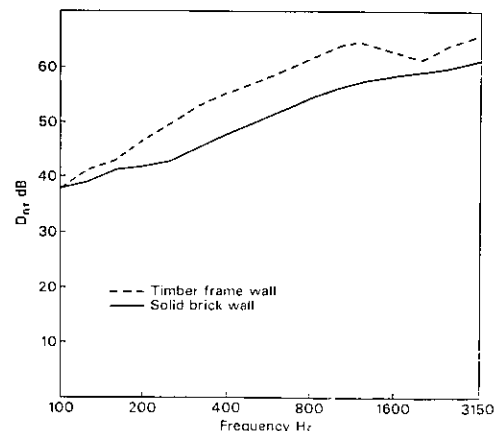


Figure 1 Comparison of insulation provided by timber frame and solid brick walls

two leaves of plasterboard supported by the timber frames and separated by a cavity at least 200 mm wide containing a sound absorbing curtain have been shown both theoretically and experimentally to provide insulation at least as good as masonry types having over five times the mass/m<sup>2</sup>. A comparison of the insulation provided by a 225 mm brick wall and a timber framed type is shown in Figure 1. Party floors have to provide insulation against airborne sounds but they are also required to provide insulation against impact sounds. This is normally achieved by adding a soft covering to a massive base or by using a floating floor comprising an upper layer and a base separated by a resilient layer compliant enough to keep the mass-spring-mass resonance frequency well below 100 Hz.

It has not been found possible to predict accurately the performance of constructions by modelling techniques and so physical measurement surveys have been used to determine the typical performance of many types of common construction with a view to identifying factors affecting performance. Measurements of both airborne and impact insulation are normally made in the 16 1/3 octave bands between 100 Hz and 3150 Hz and rating methods are used to reduce the 16 measured values to a single figure index. The criterion for a good rating method is how well the single figure index correlates with user satisfaction. Methods for rating airborne insulation have been validated by social surveys but the development of a good measurement and rating method for impact insulation remains a problem.

The conversion of houses into flats gives rise to many sound insulation problems, in particular, upgrading house floors to become party floors. The best solution found so far is the construction of an additional ceiling, supported by

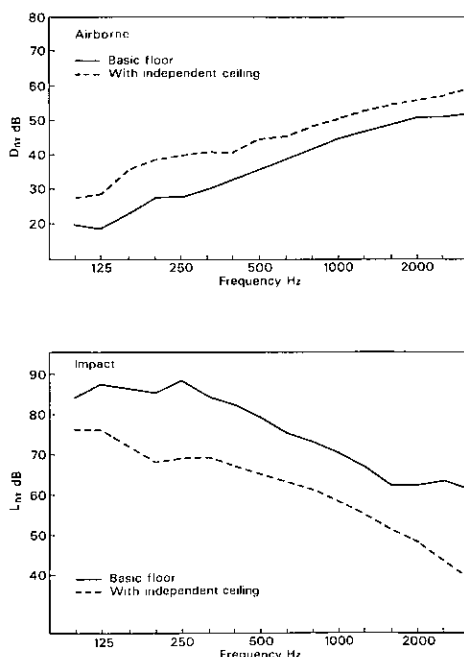


Figure 2 Effect of independent ceiling

its own joists running below the existing ceiling. This provides a useful increase in insulation to both airborne and impact sounds as shown in Figure 2.

The interdisciplinary nature of acoustics is well illustrated in Building Acoustics where the skills of the physicist, social scientist and builder are all involved.

#### Further Reading

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#### Building Research Establishment Digests

- 128 Insulation against external noise -1.
- 129 Insulation against external noise -2.
- 252 Sound insulation of party walls.
- 266 Sound insulation of party floors.

## Noise Sources in Domestic Buildings

G M JACKSON

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THE NUMBER of people complaining to their local authorities about the noise from neighbours increased by over 700 per cent between 1973 and 1981. A possible reason for this increasing demand for acoustic privacy may stem from a more general awareness of noise legislation and the channels for complaint. It was for a good reason that Julius Caesar banned

evening chariot drives in the streets of Rome! In more recent times domestic appliances such as TV, radio, Hi-Fi and, especially in multi-occupancy dwellings, washing machines, spin driers and vacuum cleaners have become sources of potential noise complaint. The women's organisations giving evidence to the Wilson Committee, prior to 1963, emphasised the need

for quieter domestic appliances. This increasing awareness of noise in the home led to an exhibition at the Design Centre in 1972 concerned largely with the noise of domestic appliances.

#### Room Effects

When such a noise source is placed in a room the noise level heard depends upon its acoustic power output and directivity, the absorption characteristics of the surfaces in close proximity to it, the total sound absorption and volume of the room, and the distance between the noise source and the listener. The acoustic 'liveness' of the room may be described by its Reverberation Time which is proportional to the volume and inversely proportional to the total absorption in the room. Reverberation times in modern living rooms are typically 0.3 to 0.4 second, while in older Victorian houses, having large high rooms and hence lower total absorption, they are typically 0.5 second or more. The noise level heard in a room is made up of two sound fields. The distance from the appliance at which these direct and reverberant fields are equal (the Reverberation Radius) is typically 0.4 to 1.5 metres, depending upon the directivity factor of the noise source.

A living room may also modify the frequency characteristics of the appliance. This is most noticeable when a dominant frequency from the appliance coincides with a resonant frequency of the air in the room. A typical living room may, depending upon where the noise source is placed, resonate at frequencies of less than about 125 Hz, especially if the room dimensions are in simple proportions to each other. In this respect the aesthetically pleasing double cube shape so favoured by Palladio and used by Inigo Jones in the Banqueting House in Whitehall, is one of the worst acoustically. Each living room will impose its own individual frequency response on the free-field spectrum of the noise source. With modern, relatively small rooms this raises the question as to why so many people, when buying Hi-Fi equipment, spend large amounts of money on systems having 'flat' frequency responses down to lower and lower frequencies?

In-house entertainment, be it Hi-Fi equipment or all night parties, is probably the most disturbing source of noise to non-participating people in the vicinity. Might there be a case for mandatorily fitting pre-set volume control limits to all new entertainment equipment sold for use in the home?

## Noise Control at Source

Although, in reality, probably little can be done to reduce entertainment noise at source, there is potentially greater scope for reducing the noise of other household equipment such as washing machines and vacuum cleaners. Informal discussions with some manufacturers has indicated that there is a current awareness of the need to reduce noise levels, but without losing their competitive price edge. The present trend appears to be to incorporate noise control into the design of new models, so that these more powerful machines produce no more noise than their predecessors.

The main techniques used in appliance noise control can be grouped under the following main headings:

- (a) Vibration isolation between the primary power source and the rest of the machine.
- (b) Vibration damping and, if necessary, stiffening of light weight casings.
- (c) Enclosure of the main power source to reduce noise radiation.
- (d) Absorption of airborne noise.

Electric motors are usually isolated from the rest of the machine by mounting them on resilient bearings. The choice of isolator is important to ensure efficient operation in the frequency range of the machine, while at the same time ensuring that transient responses (such as on run-up and run-down) do not cause excessive motion and the transmission of energy to the machine casing. Out-of-balance forces, in for example spin driers, may cause the machine to jump up and down on the floor. In one such case a lady complained of her upstairs neighbour's washing machine and the cracks appearing in her lath and plaster ceiling. As no money was available for a quantitative investigation, the simple expedient of mounting the washing machine on a piece of blockboard and foam rubber pads kept everyone happy.

The use of strategically placed strips of damping material on the inside casings of washing machines is well known. However, the obvious development of this principle, namely a dual purpose solution incorporating airborne sound absorption and structural damping, seems to be more common in the car industry.

## Examples of Appliance Noise Levels

Airborne noise levels in the home, from sources other than entertainment, range from typically 40 to 90 dB(A). In noise terms (even if in no other), the most

## Typical appliance noise levels

|                          | dB(A) |
|--------------------------|-------|
| Food Mixer (1 m)         | 72    |
| Liquidiser (1 m)         | 89    |
| Whistling Kettle (1.5 m) | 81    |
| Washing Machine (1.5 m)  | 72    |
| Vacuum Cleaner (1.5 m)   | 77    |
| Fan Heater (1.5 m)       | 47    |
| Gas Fire (1.5 m)         | 34    |
| Electric Razor (75 mm)   | 80    |
| Bath Filling (1.5 m)     | 73    |
| Flush Toilet (1.5 m)     |       |
| High Cistern             | 82    |
| Low Cistern              | 76    |

typically 'industrial' room in the house is the kitchen, with Liquidisers and Whistling Kettles reaching 90 dB(A). The table shows that several other traditionally kitchen appliances are not far behind. Living rooms are usually more civilised with the noise from heating appliances being usually less than 50 dB(A). Bathrooms can also be noisy with electric razors up to about 80 dB(A) and running water typically 70 dB(A). The smallest room in the house

is also one of the noisiest, with high level cisterns producing over 80 dB(A). In fact flush toilets represent one of the acoustic design success stories, with low level cisterns being typically 6 dB(A) quieter than their high level counterparts. Perhaps the designers, 'flushed' with their success, should now turn their attention to the kitchen.

## Future Developments

Approximately ten years ago the United States Environmental Protection Agency proposed noise labelling requirements for domestic appliances. Even further back the Wilson Report called for the objective measurement of appliance noise, using a standard procedure, to enable customers to compare the noise of different makes of appliance. The closest we have come to this recommendation is the occasional use of phrases such as 'quiet' and 'fairly noisy' in the Consumers' Association magazine 'Which' — perhaps it is time to follow the American example and consider the introduction of noise labelling.

# Research into Noise Transmission

## R CRAIK

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**A**S WITH many areas of acoustics there is a wide gap between the research work carried out into acoustic problems and the acoustic expertise that is actually used in the design of buildings. Builders and architects are traditionally reluctant to take new ideas on board and since it may take many years to construct a building there can be a very long delay before there is evidence that the new solutions actually work. The problem is further complicated since research is often carried out on problems where realistic answers can be obtained; these are often simplified problems so that the answers obtained cannot always be applied directly to real life problems.

In addition the builders and architects are expected to be able to take into account many factors affecting their building of which acoustic problems form only one small part. Since many of the solutions to very complex problems are perhaps only known to a few individuals there is a very real communications gap between the person who knows the answer and the person who needs to know that answer.

Over the past few years there has been a continuing increase in the research

carried out into sound transmission through domestic dwellings. This includes sound transmission between rooms, sound transmission from outside, factors affecting privacy and the noise from common noise sources. Unfortunately much of this information has not resulted in new designs for buildings and many of the old traditional forms of construction are still being used even when they are known to be inadequate.

Studies in sound transmission may be broken down into two main types. Firstly there are studies into mechanisms of sound transmission between individual parts of the building. Thus there have been studies to look at how much sound is radiated by a wall, how much sound passes from a wall to a floor, the effect of a resilient layer between the floor and a floating subfloor. Studies of this type have been useful not only in enabling the performance of individual components to be evaluated but also in giving great insight into the way in which improvements can be brought about.

The second area where research has been carried out is in combining the

results of simple studies to enable the acoustic performance of larger complicated structures to be determined. Thus studies of sound radiation from walls, transmission from one wall to another and the excitation of a wall by airborne sound can be brought together for a particular situation to give both the performance of the entire building (or part of it) and the importance of particular sound paths such as direct sound paths or flanking paths.

Unfortunately it is often found in practice that although the performance of some part of the building can be accurately predicted in a laboratory situation

it is not always realised in practice. Laboratory 'buildings' are built more carefully and with better supervision than real buildings are on a building site. There is therefore a greater variation in real life buildings and although the laboratory experiment may be a good measure of the average performance of a component in the field it is often found that nominally identical structures vary enormously from one building to another even on the same site. This can be attributed to workmanship and the inherent variabilities of materials.

However, the fact that laboratory based studies do not always reproduce actual

construction does not mean that studies on real buildings should be discontinued. It is important to study real situations but since the results may be affected by workmanship it is necessary to study several similar situations to remove these effects and it is dangerous to draw conclusions from the study of only one sample.

Although progress sometimes seems slow many of the problems of sound in buildings are being overcome either by the 'appliance of science' or by trial and error. Long term improvements can only be brought about by education as well as research into fundamental aspects of sound transmission.

## Building Services

### N SPRING

Sandy Brown Associates, London

*Building services noise, that is the noise introduced by mechanical and electrical installations in buildings, has always been a problem and is increasingly so as architects design buildings which employ novel techniques and generally less massive structures than hitherto. Designing out the noise is largely a matter of applying past experience; where this is inadequate, tests are carried out to provide better data. When applying acoustical theory to a design problem it is difficult to choose between a simple analysis which may be a serious oversimplification and a more comprehensive analysis for which the input data may have to be guessed.*

**B**UILDING services engineering consists of all the engineering associated with a building other than civil or structural engineering. Building services noise arises from the mechanical and electrical equipment that is part of the permanent installation of a building. The kinds of equipment which can be a noise nuisance include:

- Fans
- Pumps
- Electric motors
- Compressors
- Cooling towers
- Boilers
- Diffusers and grilles
- Transformers

This list is by no means exhaustive, and it is unlikely that a complete list can ever be provided as a foolproof check list for the building designer. The noise-generating mechanisms in the list are extremely diverse, including airflow, liquid flow, mechanical vibration of rotating and reciprocating parts, combustion and magnetostriction. Almost the only characteristic unifying the items on the list is that they are all often associated with noise in buildings.

The scale of noises from building services is also very wide-ranging. Noise from a large cooling tower may be of no importance whatsoever on an industrial estate; on the other hand, the noise from a standard fluorescent lamp in a recording studio may be intolerable.

#### Acoustic Design

Probably most acoustic design of building services, if it is done at all, is based on experience, intuition and a few simple calculations. The calculations are often based on empirical data. Sometimes, the calculations are based on acoustical theory, but the value of these is limited because the simplifying assumptions underlying the theory are often violated to an extent which makes the results very uncertain. To experienced practitioners, the calculations can be unsettling if they produce answers which appear suspect. Possible ways out of this dilemma are to try alternative calculations with alternative assumptions, or to discuss it with one's colleagues until one feels comfortable again. This may appear shocking to some, but the constraints on building design, in the UK at least, are often such that no other approach is practicable.

The main constraints are:

- (a) a tight building budget, usually arrived at before any consideration has been given to possible noise problems,
- (b) a short design programme,
- (c) inadequate data on noisy plant,
- (d) data arriving too late to influence the design.

As an example of what happens in a typical building design, consider a simplified ventilation system, part of which is shown diagrammatically in Figure 1. The fan will have been selected by the building services engineer. The acoustic engineer will estimate the sound power level of the fan using empirical formulae or from data provided by the manufacturer. He (or she) will then subtract the insertion loss of the attenuator (provided by the manufacturer) and the attenuation associated with the length of duct between the fan and room A. He will apportion the sound power between the main duct and branch duct A on the basis of their cross-sectional areas. At low frequencies, he will allow for the end-reflection loss associated with the duct termination. Long-established charts or forms are used to provide standard corrections

and organise the arithmetic. The sound power transmitted into room A from the fan is thus calculated. If it is excessive then a lossier attenuator may be considered, but the ventilation engineer may insist on a more powerful and noisier fan to overcome the increased resistance presented by the longer attenuator.

The designer also must consider the noise generated by the flow of air past the attenuator and past the grille, as well as that generated by obstructions to smooth airflow such as dampers.

Sometimes the *ad hoc* corrections do not work. The investigative work to find out the cause of excessive noise can be very satisfying, especially when a successful solution is found. It is often necessary to decide initially whether the noise is produced by direct excitation of the building structure or by airborne sound. Simulating the sound of the fan by the use of tape recordings and a loudspeaker will usually give a good indication of the transmission path. For those who can afford them, modern sound intensity measurement probes

noise tests were carried out at the University of Delft on jet-ball diffusers at various air-flow rates. By removing the interior fittings of the jet-ball it was possible to achieve a satisfactory noise level even for discharge velocities as high as 6 m/s. With 1500 jet-balls in the main hall, a mistake in calculation could have been costly to correct.

Multi-storey office blocks have potential noise sources repeated many times throughout the building. Where a novel design is proposed, testing a mock-up is essential. Figure 2 shows the underfloor system for supplying air in the new building for Lloyd's of London. This system was tested not only for noise generation, but also for the effect it had on reducing the sound insulation of the office partition above.

Acoustic designers should not be surprised if their recommendations have repercussions on other aspects of the design, eg the mechanical stability of machinery. The textbook illustration of a pump sitting on anti-vibration mounts, with inlet and outlet pipes isolated with flexible connectors, the pipes being supported from the ceiling via resilient hangers, may provide an inexperienced installation contractor with unexpected problems. On filling the system with water, the geometry of the pipework is disturbed by the increased weight. Switching on the pump may make it tilt at an angle which, at the very least, offends one's aesthetic sense.

### Electroacoustic Sound Systems

Building services engineering traditionally includes public address systems, multi-lingual conference facilities, and similar sound distribution systems. However, these systems are extremely difficult to specify in the traditional way and special expertise is necessary to

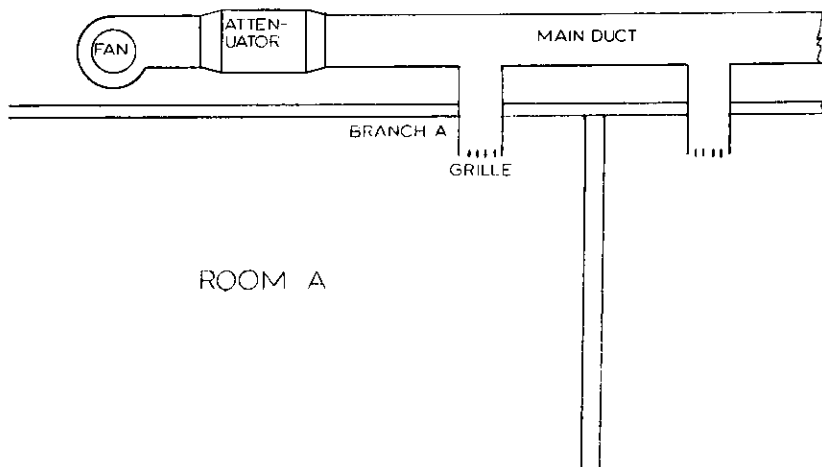


Figure 1 Part of ventilation system

Anyone with a good training in theoretical acoustics will probably be at a great disadvantage if called upon to carry out such calculations for the first time; he will probably be very uneasy about such a simplistic procedure. Are all the effects simply additive? Does not the loss of the attenuator depend on its distance from the fan? Does not the sound power of the fan depend on the acoustic load presented to it? If there are several outlet grilles to a room, how does their mutual impedance affect the end-correction? The more practical engineer will say that the procedures are justified by the results, but he will usually admit to having added a safety factor of a few decibels at the end of his design.

Some buildings turn out to be noisier than intended by the designer. Sometimes the noise is cured, or at least made bearable by *ad hoc* corrective measures. This may include the simple replacement of a pulley on a fan, so that it runs more slowly. If the ventilation was designed with a big enough safety factor, no-one is unhappy. These *ad hoc* corrections are not widely publicised, for obvious reasons, but it does raise the question as to how effective in practice the usual simplistic acoustic design procedures really are.

should be a valuable diagnostic tool in identifying noise paths.

Where very special requirements exist on a large project, special sound measurements are required. One requirement which often occurs in auditoria is the need to direct air from high outlets with sufficient velocity to reach the audience. With standard outlets, the noise associated with the high air velocity is likely to be excessive. When the concert halls of De Doelen in Rotterdam were designed, laboratory

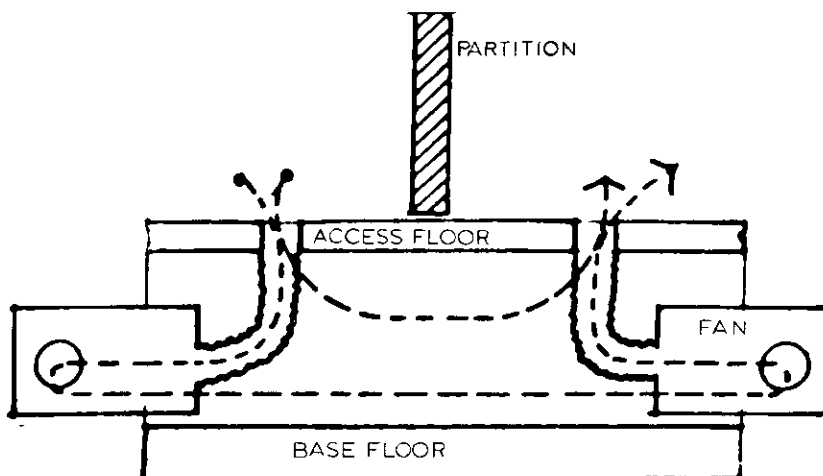


Figure 2 Underfloor air supply system

obtain satisfactory results. Such expertise is more likely to be found in an acoustic consultancy practice than in a building services consultancy.

### Use of Computers

Almost everyone has access these days to inexpensive computing hardware and software. Modern microcomputers are so much more fun to use than an electronic calculator (or tables and charts) that one would expect a lot of the drudgery involved in the noise control design of a ventilation system to be taken over by computers. This does not seem to have happened. This is despite the fact that computer programs to carry out the necessary calculations have been available for at least seven years. The reason is probably that the calculations are too trivial and the drudgery is mainly a matter of taking off duct dimensions and inputting the necessary data. This is done more quickly and easily by filling in a standard form using a readily-available and user-friendly pencil (truly portable, disposable and no power supply required). The position might change if:

(a) more complex design methods involving lengthy calculations were developed

(b) computer-aided draughting methods in building design were developed to the stage where basic data such as the lengths and cross-sections of the network of ducting could be retrieved automatically.

### Future Developments

In spite of undoubted improvements in the general quality of acoustic design over the last decade, no-one can be satisfied with the present state of acoustic design of building services. To be satisfied with the present empirical methods, simply because they appear to work most of the time, is to prevent progress on the production of more economical systems and more efficient components and machinery. The big problem is in funding the necessary research. Government is unlikely to provide assistance at the present time; one would expect the response that it is up to market forces to provide the impetus. However, one cannot expect fan manufacturers, etc, to provide the funds until they are convinced either that users are prepared to pay more for quieter devices or that they will lose business to competitors who are developing improved devices. The universities are obvious candidates for

research in this field but it may be difficult to obtain researchers of the necessary calibre, in view of the low esteem students have for building services engineering.

There is at least one bright spot on the horizon, namely the field of active noise control (anti-noise). This is the control of noise by electroacoustic means and the control of vibration by electro mechanical means. The real pioneers are working intensively in this country and it is heartening to see how many British firms are developing active control devices. No doubt much of the interest is sustained by possible military and industrial applications, but there must surely be some spin-off for building services design.

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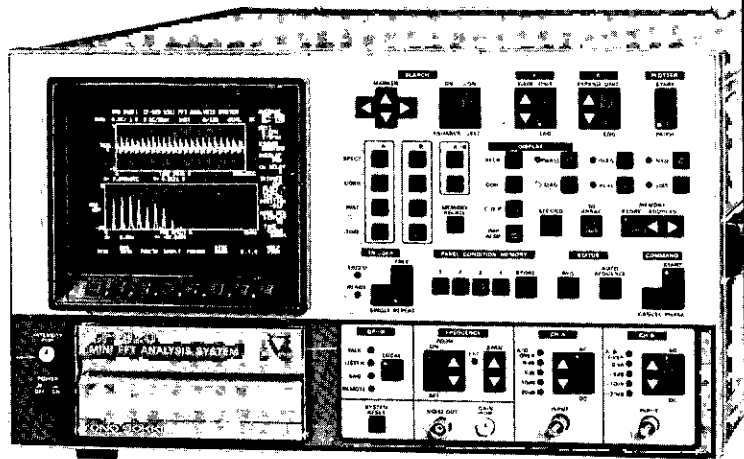
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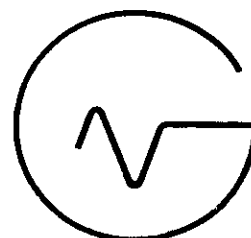
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## BRANCH AND GROUP NEWS

### NOW HEAR THIS!

A joint meeting, hosted by the North West Branch and sponsored by the Building Acoustics Group and the Industrial Noise Group, was held at the University of Salford on 20 September 1984. The hard work of organising the meeting was done by Geof Kerry of the University; Stewart Bennett (National Coal Board) and Peter Allaway (Grootenhuis Allaway Associates) arranged the speakers on behalf of ING and BAG respectively.

The subject was **Noise from Building Services**. Richard Cowell (Arup Acoustics) batted first with a perceptive review of the importance of early planning for good acoustics and noise control. Phil Nelson, ISVR, spoke of flow noise in ducts and silencers and gave useful prediction techniques for use by practitioners. Last before lunch came John Bridges (Acoustic Design) on a systematic approach to acoustic commissioning of air systems in building services; he discussed the sometimes conflicting requirements of air balancing and noise control.

Following an excellent buffet lunch in the University we listened to Chris Corcoran (University of Aston) on the variation of sound pressure level in rooms due to modal patterns. Roger Thomsett (Atkins R & D) then gave some interesting case histories of velocity generated noise.

Due to an unavoidable business commitment the last speaker had to withdraw at short notice but we were ably assisted by Phil Nelson who spoke on the prediction of noise and breakout from ducts.

A discussion period rounded off a very useful and interesting day. The attendance was 49 which, with the slide projector, filled all the available seats! A small display of instruments and equipment was mounted by Gracey & Associates, Brüel & Kjær and Atmospheric Control Engineers. Peter Allaway chaired the meeting.

Peter Allaway

### Musical Acoustics Group.

#### Visit to Henry Willis and Sons Organ Builders.

Members had the pleasure of a visit to the Rotunda Organ Works of Henry Willis and Sons at Petersfield, Hampshire on the 9th of July. The group was met at the factory gate by the Company Chairman, Henry Willis 4, who outlined the history and great tradition of the company over four generations.

The factory, we were informed, had been purpose built to ensure that its necessary acoustic output did not interfere with houses close by. It appears that later another company's sawmill was established next to the works with no such attention to details of noise suppression.

In the yard the timber stocks were viewed and it was noted that these were air dried and well stabilised before entering the works. Our first introduction to organ making was in the metal shop, where Mr Willis, suitably attired, demonstrated the casting of pipe metal on the slate casting bench which was covered with fine cotton. This was a rare treat for which we are most indebted; this ancient process is

only occasionally used, as a quantity of metal sheets are cast at a time and some modern pipes are made from rolled sheet and not from cast metal.

The tour continued, and included a sequence of organ making techniques demonstrated and described by Mr Willis, and one or two fine instruments for us to see, including the organ from Alexandra Palace which is under reconstruction. After lunch the party travelled to Haslemere, passing close by the former home of John Tyndall at Hindhead, to St Bartholemews Church. This, the Parish Church of Haslemere, has a fine organ recently rebuilt by Henry Willis and Sons. The organ was described by Henry Willis and a short recital was given by a young organ builder from the company who also opened the console for inspection. The meeting concluded with thanks to Henry Willis 4 who had personally devoted the day to our visit and with a series of demonstrations by volunteer organists from the Musical Acoustics Group.

T M Pamplin

#### East Midlands Branch

A most interesting and enjoyable visit was made by sixteen branch members to the Pedigree Petfoods plant at Melton Mowbray, on 1 November 1984. The plant is one of the largest high speed food canneries in Europe.

The party was welcomed to the plant by Barry Pratt, Health and Safety Officer, and Mike Laws, Section Manager, Red Shift. A brief history of the company and its development at Melton Mowbray since 1951 was given, and the company's noise control policy was described in detail. Plant noise reduction at source has always been the preferred course of action, but stringent hygiene requirements often prevent the use of conventional noise control materials and techniques. Personnel ear protection has had to be employed in some process areas. Two years ago a new noise control strategy was adopted with the aim of achieving 85 dB(A)(Leq) maximum noise exposure within five years. Similarly high standards of control are applied to environmental noise emissions, with a level of 60 dB(A) set by the company at the site boundary.

The party was divided into two groups for a ninety-minute tour of the production facilities, from the empty can reception through the product blending, can filling, seaming and sterilising operations to the final labelling and casing operations. Most visitors were

impressed by the very high speed of operation of the canning lines, at up to 1000 cans per minute.

Following the tour, the party was entertained by Mike Laws to a brief analysis of the range of petfoods produced at the plant. Although not invited to taste the products, we were assured of their wholesome quality. The Branch is indebted to Pedigree Petfoods for the excellent arrangements and most welcome hospitality which concluded the evening's visit.

John Athey

#### North East Branch

The first meeting of 1984 was the Annual General Meeting of the Branch which took place in February at Newcastle Polytechnic. The chairman, Chris Norris, and fourteen members heard reports from the Secretary and Treasurer concerning activities over the previous year. The small loss which was made over the year was attributed to a lack of support at some functions despite a varied and attractive programme.

In March a meeting was organised in conjunction with the Institute of Physics specifically for Teachers as it was thought that the syllabus for Acoustics in schools could be improved. Much work was expended in preparation of demonstrations and work sheets but attendance was disappointingly small being only 20 out of 40 who had booked.

April's meeting was organised by Bill Walton in Carlisle to cater for members in the West and also interested people from the west of Scotland. The programme was a re-run of the Noise Workshop previously held at Grey College, Durham and this attracted an audience of 25.

Darlington Town Hall was the venue for the May Technical Meeting, the subject for which was **Noise at Work**. A speaker from Her Majesty's Factory Inspectorate outlined the proposed regulations and demonstrated methods of noise control while Dr Bob Kell discussed noise induced hearing loss and the role of Audiometry. Also in May was a social evening which consisted of a visit to the new Tyne Theatre in Newcastle upon Tyne to see productions of HMS Pinafore and Trial by Jury followed by a conducted tour backstage. The building, which has recently been restored, is a rare example of Edwardian theatrical architecture as it retains all of the original manually operated stage machinery in perfect order.

Most recently the Branch has held the first meeting of the 1984/85 programme which as usual took the form of two presentations of Institute of Acoustics Diploma projects by this year's students. The subjects were *Helicopter Noise at Carlisle Airport* by P Daly and *A Portable Mechanical Noise Generator* by G Turnbull.

#### North West Branch

On 8 November sixteen members of the Branch met at the Acoustics Department of the Nuclear Development Laboratories at UKAEA, Risley, near Warrington. On this occasion the Branch was honoured by the presence of the IOA President, Dr H G Leventhall.

The visit opened with a welcome and introduction by Iain McLeod who explained that there were several difficulties associated with the use of liquid sodium as a heat transfer medium and that close co-operation between scientist and engineer was needed to determine, evaluate, remedy and monitor. The slide/tape presentation which followed presented in a clear way the structure of the UKAEA and RNL's place within it, and referred to the different reactor types currently under evaluation.

Visitors were then shown around the various laboratories and facilities to see in greater detail the results of current and past projects, and their applicability in the design and operation of sodium-cooled reactors. These included the use of ultrasonics to detect and measure distortion of fuel rods *in situ*, the measurement of 'temperature noise' caused by the incomplete mixing of fluid flows, and the laser calibration of acoustic emission transducers used in the evaluation of weld quality.

After a short break for refreshment, the visit continued with an explanation of the special problems of erosion due to cavitation in pumps moving liquid sodium and a view of a very large rig which allows the test of equipment in that hostile environment. The boiling of sodium can result from hot-spots in the core of the reactor, and its location by use of transducers designed to operate reliably for hundreds of days at 600°C forms another aspect of the work.

The Chairman thanked Mr McLeod and the staff of RNL for an instructive and entertaining visit. Special thanks also go to Chris Waite for the local co-ordination and detailed arrangements.

Alan Baines

## Southern Branch

The Annual General Meeting of the Southern Branch was held on 15 November. The committee remained unchanged, with Ian Sharland as Chairman, Geoff Charnley as Honorary Treasurer and Frank Fahy as Honorary Secretary, except for the replacement of Phil Nelson by Martin George, a welcome newcomer to the branch. Sadly, the visit to the laboratories of the ISVR which preceded the AGM was very poorly attended, but the pub meal immediately prior to the meeting found greater favour. The AGM was followed by a two-hour film show featuring such diverse subjects as a surrealistic anti-podean promotion of ear defenders and industrial ultrasonics in the 1940s.

In September a group of about 25 members visited the premises of Vosper Thorneycroft at Cosham and were treated to lunch, a trip round the works to see ferries under construction, followed by talks by a member of Vosper Thorneycroft's staff and a consultant on on-board noise and vibration problems; the event was greatly enjoyed by the visitors.

F J Fahy

*N B Dates, venues and topics of future meetings, as received from Branches and Groups, are included in the list of Institute meetings inside the back cover of the Bulletin. Further details may be obtained by contacting the Secretary of the appropriate Branch or Group (see Acoustics Bulletin, July 1984, p2). □*

# IOA Diploma Examination 1984

**Congratulations to the following candidates who have qualified for the award of the IOA Diploma in Acoustics and Noise Control.**

## North East Surrey College of Technology

K Bock  
P H Brown  
G A Casey  
D J Durrant  
J C Eccles  
R K Frost  
S G Gardner

M S George  
P G Gough  
A J C Martin  
J F Messer  
Mrs I K Moss  
F O'Grady  
J D Ostler

L C Paton  
Miss R M Starling  
P H Vierk  
M A Webb  
J T Whittingham  
N R Wood

## Liverpool Polytechnic

T J Bassett  
M E Brownjohn  
J E Gledhill  
R P Hallows  
S R Handley  
D Hind

C A Lewis  
I G Mercer  
D J Parker  
H C A Phillips  
M I Redman  
J L Rose

D F Rothwell  
G Seiffert  
A Short  
A Watson  
G J Williams  
W A Zawistowicz

## Newcastle Polytechnic

P A Daley  
D Foster  
I Hepplewhite

W T Lowry  
S J Millman

S J Taggart  
G D Turnbull

## Cornwall Technical College

T A Bennett  
R J Bowles  
P M R Davies  
R D Evans

T G Jones  
A H Kershaw  
P Long

A C McWillie  
B A Taylor  
D C Silvester

## Leeds Polytechnic

M R Harrison  
J A Parish

T Parkin

C J Wood

## Derbyshire College of Higher Education

P J Hubbard

R D Logie

C A Shaw

## NON-INSTITUTE MEETINGS

### 1985

21 March. *Refinements in the Impulse Testing of Loudspeakers*. Lecture at NPL, Teddington. Contact: B F Berry, Division of Radiation Science and Acoustics, NPL, Teddington, Middlesex TW11 0LW.

17–19 April. *Radiology 85*. Contact: Mr A F Yates, UMIST, PO Box 88, Manchester M60 1QD.

6–8 May. *4th International Symposium on Hand-Arm Vibration*. Finland. Contact: Dr Ilmari Pyykko, Institute of Occupational Health, Laajaniityntie 1, SF-01620 Vantaa 62, Finland.

2–4 July. *Fifth British Conference on the Teaching of Vibration and Noise*. Sheffield. Contact: Mr P B Round, Short Course Support Unit, Sheffield City Polytechnic, 33 Collegiate Crescent, Sheffield S10 2BP.

2–4 July. *Ultrasonics International*. London. Contact: Dr Z Novak, Conference Organiser, Butterworth Scientific Ltd, PO Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH.

3–5 July. *IUTAM Symposium on Aero- and Hydro-Acoustics*. Lyon, France. Contact: M Sunyach, Centre Acoustique, Ecole Centrale de Lyon, B P 163, 69131 Ecully Cedex, France.

*Notice of future non-Institute Meetings should reach the Editor at least four months before the date of the meeting. □*

## NATO Advanced Study Institute

A NATO Advanced Study Institute on **Ultrasonic Methods in Evaluation of Inhomogeneous Materials** will be held at the Ettore Majorana Centre for Scientific Culture in Erice, Italy, 15–25 October 1985. Approximately 15 experts from Europe and North America will present invited state of the art papers; in addition, a small number of advanced research papers by participants will be considered. Limited financial support for qualified post-doctoral fellows, post-graduates, and research workers is available. As participation is by invitation only by the ASI directors, inquiries should be sent to: A Alippi, Istituto di Acustica — CNR, 1216 Via Cassia, 00189 Roma, Italy, or to W G Mayer, Physics Department, Georgetown University, Washington, DC 20057, USA. □

**Tottenham Technical College**

R D Broomfield  
R W E Farr  
S R Glass

J W Lee  
C Lofts

S R Perfect  
P K Thompson

**Colchester Institute of Higher Education**

P Chisnall  
Miss C M Concannon  
M J Halliday

Mrs D J Hawes  
J Nockels  
I M Read

P A Rolando  
M A Stigwood  
P S Williams

**Heriot-Watt University**

M A Din  
W C Frame

J Nicol  
J G Sanderson

S T Walker

**North Staffordshire Polytechnic**

G Beeston  
P W Birch  
H Boswell

A G Fuller  
Mrs G E Hassall  
R Jones

G A Murray  
C J Pritchard

**Coventry (Lanchester) Polytechnic**

D W Barsby  
J Magrath  
G J Mandora

J A Pickard  
D R Robinson

Mrs K J Stone  
W H Tromans

**Ulster Polytechnic**

P P Cosgrove

D G Smiley

# Institute of Acoustics Diploma 1984

In another active year, there were over 500 separate module entries and despite absences, over 500 module examinations were sat. About 100 Diplomas were awarded. The totals for the separate Colleges and modules are shown in the Table, which also gives the numbers of Merits (M), Passes (P) and Failures (F). The percentage success rates are generally good, across both Colleges and Modules. However, the Examining Board continues to be concerned about the low completion rate of Projects. The Project is an essential part of the Diploma examination, but appears sometimes to be left till too late in the course, and then tackled at too ambitious a level.

The following candidates are to be congratulated on obtaining passes in additional Specialist Modules.

R D Armitage  
R Bainbridge  
D E Barke  
P W Birch  
C C Buxton  
P H Brown  
B Caygill  
P Chisnall

S P Dart  
J Davison  
J A Duffield  
D J Durrant  
D F Edge  
C D Harland  
P Hepworth  
S J Millman

D R Morris  
P J Nutt  
J Pearson  
J F Perkins  
J M Southwell  
S F Unwin  
D C Walton

The large number of Diploma entries places a heavy load upon Headquarters, particularly during July and August. Staff are to be congratulated for the smooth way in which the marks were checked and processed in a year when the Institute's computer was first used for the Diploma records, and the potential for confusion was at its greatest! ☐

H G Leventhall

**IOA Diploma Summary 1984**

|               | General Module |     |    | Architectural Acoustics |    |   | Noise Control Engineering |    |    | Transportation Noise |    |   | Vibration Control |   |   | Law and Administration |    |    | Totals |     |    |   | M + P + F | Pass % | Projects complete |
|---------------|----------------|-----|----|-------------------------|----|---|---------------------------|----|----|----------------------|----|---|-------------------|---|---|------------------------|----|----|--------|-----|----|---|-----------|--------|-------------------|
|               | M              | P   | F  | M                       | P  | F | M                         | P  | F  | M                    | P  | F | M                 | P | F | M                      | P  | F  | M      | P   | F  | → |           |        |                   |
| A             | 10             | 25  | 3  | 3                       | 10 | 1 | 4                         | 14 | 5  | 5                    | 13 | 2 | —                 | — | — | —                      | 21 | 5  | 22     | 83  | 16 | → | 121       | 86.8   | 21/44             |
| B             | 5              | 17  | —  | 2                       | 5  | — | —                         | —  | —  | 1                    | 15 | — | —                 | — | — | —                      | 16 | 1  | 8      | 53  | 1  | → | 62        | 98.4   | 16/20             |
| C             | 1              | 5   | 4  | —                       | —  | — | 6                         | 14 | 2  | —                    | 15 | 3 | —                 | — | — | —                      | —  | —  | 7      | 34  | 9  | → | 50        | 82     | 8/11              |
| D             | 2              | 11  | —  | 3                       | 8  | — | 2                         | 3  | —  | —                    | 4  | — | 1                 | — | — | 1                      | 12 | 3  | 9      | 38  | 3  | → | 50        | 94     | 8/18              |
| E             | —              | 10  | 4  | —                       | —  | — | 1                         | 7  | 6  | —                    | —  | — | —                 | — | — | —                      | 10 | 4  | 1      | 27  | 14 | → | 42        | 66.7   | 5/13              |
| G             | 4              | 10  | —  | 1                       | 2  | — | 1                         | 4  | 1  | —                    | 10 | — | —                 | — | — | —                      | 9  | 2  | 6      | 35  | 3  | → | 44        | 93.2   | 7/20              |
| H             | 1              | 7   | 2  | —                       | —  | — | —                         | 1  | —  | —                    | 6  | 3 | —                 | — | — | —                      | 6  | 2  | 1      | 20  | 7  | → | 28        | 77.8   | 4/12              |
| J             | 6              | 3   | 1  | 6                       | 3  | 1 | 3                         | 6  | 2  | —                    | —  | — | —                 | 1 | — | 2                      | 3  | 0  | 17     | 16  | 4  | → | 37        | 89.2   | 7/11              |
| K             | —              | 5   | —  | —                       | 2  | — | —                         | 4  | 1  | —                    | 2  | — | —                 | — | — | —                      | 2  | —  | —      | 15  | 1  | → | 16        | 93.8   | 5/5               |
| L             | —              | 7   | 1  | 1                       | 4  | — | 1                         | 8  | —  | —                    | —  | — | —                 | — | — | —                      | 2  | —  | 2      | 21  | 1  | → | 24        | 95.8   | 6/7               |
| M             | —              | 8   | 2  | —                       | —  | — | —                         | 9  | 1  | —                    | —  | — | —                 | — | — | —                      | 6  | 1  | —      | 23  | 4  | → | 27        | 85.2   | 7/11              |
| N             | —              | —   | —  | —                       | —  | — | —                         | —  | —  | —                    | —  | — | —                 | — | — | —                      | 2  | —  | —      | 2   | —  | → | 2         | 100    | —                 |
| Totals        | 29             | 108 | 17 | 16                      | 34 | 2 | 18                        | 70 | 18 | 6                    | 65 | 8 | 1                 | 1 | — | 3                      | 89 | 18 | 73     | 367 | 63 | → | 503       |        | 94/172            |
| Module Pass % | 89.0           |     |    | 96.2                    |    |   | 83.0                      |    |    | 89.9                 |    |   | 100               |   |   | 83.6                   |    |    | 87.5   |     |    |   |           |        | 54.7              |

**Key to Diploma Centres:**

A: North East Surrey College of Technology  
B: Liverpool Polytechnic  
C: Newcastle Polytechnic  
D: Cornwall Technical College

E: Leeds Polytechnic  
G: Tottenham Technical College  
H: Derby Lonsdale College of Higher Education  
J: Colchester Institute of Higher Education

K: Heriot-Watt University  
L: North Staffordshire Polytechnic  
M: Lanchester (Coventry) Polytechnic  
N: Ulster Polytechnic

# New Techniques in Sonar Transducers

This conference was the fourth to be held at the University of Birmingham under the auspices of the Underwater Acoustics Group on the subject of electroacoustic transducers for sonar systems, the previous ones having been held in 1976, 1978 and 1980. This number of meetings dedicated to a single specialist subject area is an indication of the importance of transducers, since every sonar system must incorporate at least one such device. The conference was truly international, the 95 delegates including 33 from abroad representing countries from the USA to mainland China.

Although in many applications traditional types of transducers are used, there is still plenty of scope for novel designs, some of which were described in the contributions to this conference; one noteworthy paper was on magnetostrictive metallic glass for hydrophones, by Walmsley (UK). A relatively new area of development is in the use of piezoelectric polymer films; it had been hoped that several papers on this topic would be included, but restrictions were imposed because the applications were for essentially military projects. However, an invited survey paper on developments in the USA by Ricketts was included and another paper by Van Buren *et al* (USA) was concerned with the application of plastic film transducers to special calibration arrays. Even traditional designs still pose problems, and the technique of

finite element analysis is a powerful tool in the theoretical analysis of apparently simple structures. A group of papers described some of this work, starting with an introduction to the subject by Dunn (UK) and continuing with two mainly theoretical papers from France and Denmark; the first, by Vanderborck *et al*, was concerned with the radiation impedance of transducers in an array covered by an elastic skin, and the second, by Jensen and Krenk, with the resonances of piezoelectric discs. An example of a transducer for which finite

element analysis was used in the design was the flextensional structure described by Oswin and Thomas (UK).

Two A B Wood Memorial Lectures were presented during the conference. It so happened that this was the most convenient meeting for the presentation of the medal for 1983 to Peter Mikhalevsky (USA); the subject of his address was *Envelope statistics of multi-path propagation in the ocean*. Martin Earwicker (UK), the medallist for 1984, gave a very appropriate address on *Passive sonar arrays: some aspects of their design and construction*. □

J R Dunn



The A B Wood Medal for 1984 was presented to Martin Earwicker of the UK by the President of the Institute

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## London Evening Meetings

The first in a new series of London Evening Meetings began on a very musical note. In **Design of Brass Musical Instruments**, Dr Richard Smith of Boosey and Hawkes gave a most interesting talk about the differences between a whole variety of brass instruments. He was accompanied by Gordon Higginbottom who gave practical demonstrations on cornet, trumpet, flugal horn, tenor horn, euphonium and trombone.

An 'Electronic' trumpet was used to show how the basic notes are generated and a rendition of *Amazing Grace* on a rubber tube showed how the pitch can be altered by skilful manipulation.

Some pictures of ancient instruments, now kept in the B & H Edgware Museum, led to a discussion of the greater versatility of the compensating four valve euphonium over the non-compensating variety. The method of using the fourth valve along with the other three to add in extra lengths of tube (a principle patented in 1878) was described in some detail and we learned how you need one of these instruments to play all the notes written by Prokofiev in his *Romeo and Juliet*.

The different vibration patterns set up in the bell of trombones were then described, and it was shown how they vary depending on the material type and

thickness. Curiously the frequency spectrum when measured at the end of the bell seems to be independent of these differences, although a measurable difference in one of the harmonics when measured at the player's ear was found. However, blindfold tests by top professional musicians showed that subjectively they could not significantly detect any difference. These blindfold tests are also being used B & H to dispel the myth that has apparently arisen that they cannot make trombones!

Finally we were taken on a pictorial tour of the factory showing how these instruments are made. The discussion was lively, considering amongst other things the relative styles of jazz and classical musicians, how Japanese brass bands sound different from British, and how

## Are we getting WISE in Acoustics?

1984 was WISE year. WISE stands for Women Into Science and Engineering, and is a campaign organised by the Engineering Council and the Equal Opportunities Commission to encourage more girls and women to take up careers in science and engineering.

As WISE year comes to an end, I feel it appropriate to spend a short time considering the situation of women in Science and Engineering, and more especially in acoustics. Many of you may feel that the WISE initiative is not of particular interest to you, as a cursory glance at the IOA membership shows that most of you are men. Women do not form a very large proportion of this Institute, and indeed the women members probably do not consider that being a part of the female minority is very important one way or another, but because of this low percentage, it can be seen that the WISE initiative is highly relevant to the Institute.

In his letter in the last issue of the Bulletin, the President outlined the structure of the membership, and expressed a hope that in the future we can attract more members. I would suggest that attracting more women firstly into science and engineering and secondly into acoustics is one way of going about this. One fact left out of the President's letter is that out of the total membership of the Institute, 4% are women. This is a pretty abysmal figure, but not unusual in scientific or engineering professions, which are still having trouble recruiting women in this

country despite equal pay and anti-discrimination legislation. Obviously training for science and engineering starts very early on at secondary school and, by the time subject choices are made in the third year, most girls have already decided that science and mathematics are not for them. The Women's Engineering Society gives many careers talks at schools, and finds in many cases that fifth year girls begin to show an interest, but have already dropped maths and physics. It is very difficult to get them back into science at this stage. However, it is likely that problems start much earlier in life, and the attitude of parents is of paramount importance.

So what of the Institute? Are we too far along the system to have any influence? I suppose the immediate answer is yes, but unless we are aware of the situation, and monitor it, we may be unaware of the needs of women in the Institute. It must be borne in mind that by only having a 4% female membership, we are ignoring a large pool of possible talent, which the acoustic profession cannot afford to pass over. This is one area where we should look for our new members.

One bright spot — 1% of Fellows are women (if you see what I mean — and as for sexist nomenclature, well that's another matter!), 3% of Members, and 9% of Associates. This does look as if numbers are increasing as time goes on, as by and large the Associates are younger than the Members, who are younger than the Fellows. On the other hand, there is the possibility that

numbers decrease after women leave work temporarily to have children, and cannot get back into the industry, hence the shortage of Members and Fellows. This is something the Institute and membership can do something about, by encouraging colleges and polytechnics to run refresher courses should the need arise, and by realising that working hours and the length of the working week are not eternal verities laid down by God (or science) and can be flexible enough to meet all needs. Some consultancy work can easily be done at home, and much of the practical side of it does not take place during normal working hours anyway. The industry may have to change to attract more women, and the methods may be different but no less valid than in the past. (Just think, the men may have been wrong for all this time!)

In the last Bulletin, the editor wrote that one reason why acousticians may be unavailable to write articles is because they are otherwise engaged having babies. It's encouraging to see that women are sometimes remembered. However, this must be balanced against the President saying that retirement 'may be at age 60, if present trends continue'. 4% of us have to retire at 60 now (although few if any would consider these double standards desirable) and we do, sometimes, get a bit tired of being overlooked.

I hope that all the membership will think positively about this subject, because it can only benefit all of us in the end. □

Sue Bird

really only Northerners can get a good tone from a brass instrument because the rest of us don't speak proper!

Stephen Turner

### Guidelines and Criteria

The second meeting in the current series was entitled **Guidelines and Criteria**. The first part of the meeting took the form of a look into the past. John Hyde of the GLC Scientific Services Branch reviewed some of the guidelines and criteria that have been developed and used in the past, in particular the GLC Guidelines for Environmental Noise and Vibration, as agreed by the Council in 1976. He also described the guidance given in the DoE circular 10/73, the GLC codes of practice for pop concerts and discotheques and the GLC noise

standard for helicopters. The second part of the meeting looked to the future. Having pointed out some of the strengths and weaknesses of the existing criteria John indicated that the GLC Guidelines were soon to be revised and asked for comments and discussion on future developments or revisions. A well informed discussion took place covering the problems of guidelines for public buildings such as libraries, the use or misuse of  $L_{10}$  for low road traffic flow rates, the use of  $L_{eq}$  as a unified noise unit and guidelines for vibration damage to buildings.

The meeting was very well supported with nearly 50 people attending and although officially closed at 8.00 pm the discussion continued much later in alternative surroundings. □

Paul Freeborn

## FASE 1985

The fifth FASE Symposium is to be held in Thessalonika, Greece, from 27 to 29 August 1985. The main topic will be the creation of spaces with minimum noise and good acoustical quality, in outdoors and indoors acoustical design. All presented papers will be included in the Proceedings of the Symposium and a technical exhibition of acoustical equipment, instruments and products will be held. The official languages of the Symposium will be English, French and German.

Intending contributors should send abstracts no later than March 1985 to the Organising Secretary:

E Tzekakis (5 FASE 85)  
5 Agiou Seraphim Str  
54643, Thessaloniki, Greece.

# New Products

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

## Salex Acoustic Quilting and Mufti-Lag

New from the Materials Division of Sound Attenuators Ltd are two noise control materials, Salex acoustic quilting and Mufti-Lag.

Salex acoustic quilting is manufactured using a new production technique and is totally impervious to oils and fluids. The fire resistance of the material is to BS 476 Part 7 Class 1 and it therefore has the advantage of being a good fire barrier as well as an acoustic barrier and absorber. This material is usually supplied in pre-fabricated shapes with sealed edges but can also be supplied in the form of purpose made jacketing as well as sheets or rolls.

Salex Mufti-Lag is acoustic duct and pipe insulation consisting of a four-part laminate incorporating a spacer layer, heavy mass core and outer protective vapour barrier. Being of laminate construction it overcomes the need for a separate isolation layer normally required beneath most forms of acoustic lagging. Mufti-Lag is applied as a dry one-layer treatment, is suitable for both internal and external application and has a high level of fire resistance meeting the flammability

requirements of BS 476 Part 7 Class 1.

Brochures on these materials are available from the Materials Division, Sound Attenuators Ltd, Eastgates, Colchester, Essex CO1 2TW. Tel: 0206 866911.

## Portable Level Recorder B&K 2317

This new Level Recorder is a compact and robust instrument designed for field and laboratory use which will record AC and DC signals, vibration and noise levels, reverberation decay curves and frequency analyses. Recordings are made as a function of frequency or time on 50 mm wide pre-printed frequency calibrated or lined paper and eight paper speeds are available.

The 2317 has six calibrated full scale ranges, AC detection from 100 microvolts, four well defined AC averaging modes and AC and DC handling up to 40 volts. It has two basic recording modes: a linear DC mode with variable zero calibration and a logarithmic AC mode with selectable 10, 25 and 50 dB dynamic ranges. In the AC mode four different time weightings can be selected: 'fast' and 'slow' in accordance with IEC 651 type 1 for sound measurements; 'Vibr' providing a 2 second time constant for human vibration measurement; and 'reverb' for recording reverberation times down to 0.2 seconds. Further details from

Brüel & Kjær, Cross Lances Road, Hounslow, TW3 2AE. Tel: 01-570 7774.

## VMC Vibration Isolators

Following their appointment as exclusive UK agent for the VMC range of vibration isolators, Industrial and Marine Acoustics Ltd announce the general availability from stock of the main line of neoprene rubber isolators. Covering an extremely wide range of load capabilities, from 5 to 2000 kg, the R and RD series are available as both compression mounts and hangers.

Further details from Industrial and Marine Acoustics, PO Box 8, Cheadle, Stoke-on-Trent ST10 4LH, or telephone Barry Watkins on 0538 723537. □

# Book Review

## Mikrofon — Aufnahmetechnik

M Dickreiter

S Hirzel Verlag

139 pp DM 48.00 1984

This book describes different techniques for recording music and speech. However, the discussion is limited to the part of the recording technique which is called the 'microphone-recording technique'.

The book is divided into three chapters. Chapter one gives a brief account of the acoustics involved. It starts with the usual description of sound waves and then continues with room acoustics. Chapter two discusses different sound sources. It describes the composition of different orchestras and the acoustical characteristics of the musical instruments and voices involved. Finally, chapter three describes the different microphone techniques required to record different compositions of musical instruments and voices. This chapter also discusses the different types of microphones which may be used for recording purposes.

Having in mind a book which should instruct people how to record music and speech, the author has tried to give a very full but factual account of the different aspects involved; thus the book reads rather slowly. However, a great number of facts are listed and are fairly well explained with the help of many well illustrated diagrams. Although the book did not read easily, I believe the author has achieved his aim and created a text which can be of great help to those who are concerned with the recording of music and speech. □

U Guggenbühl



*Peter Mikhalevsky of the USA received the A B Wood Medal for 1983 from the President of the Institute, Dr Geoff Leventhall, at the Conference in Birmingham on New Techniques in Sonar Transducers*

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Due to continued expansion, vacancies exist for enthusiastic engineers or acousticians with a major independent acoustic consultancy Practice.

Applicants for the post of Assistant Consultant should have a good command of the basics of noise and vibration control techniques, and be willing to adapt quickly to a demanding and rewarding career with excellent promotion prospects.

Applicants for the post of Consultant should be experienced in building and building services acoustics and be capable of running a variety of projects with minimum supervision.

Salaries are negotiable and company cars will normally be made available for Consultants.

Application Forms may be obtained from:

**Hann Tucker Associates,  
18, The Broadway,  
Woking,  
Surrey GU21 5AP.  
Tel: Woking 70595**

## Senior Acoustic Engineer

Due to an increasing work load and client base, a further engineer is required by an acoustic consultancy practice in a location convenient to NW London. Requirements are: a degree in a relevant science or engineering subject and several years practical experience in the control of noise and in the solution of problems due to structural vibration. The successful candidate will need to demonstrate an ability to handle acoustic projects on his or her own initiative. A salary of about £12,000 is envisaged, although a higher salary will be considered for a very experienced engineer. There are long-term prospects of associateship or partnership to exceptional candidates.

Write with CV to:

**James Moir and Associates,  
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Amersham,  
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# PHYSICIST/APPLIED PHYSICIST

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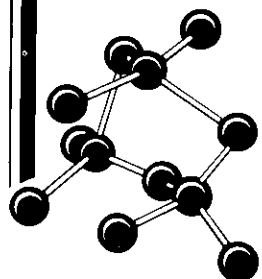
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**GEC Research Laboratories**  
**Hirst Research Centre, Wembley**

# Institute of Acoustics

## Meetings

### 1985

|                |           |                                                                                                                                                                                                                                                                                      |                         |
|----------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| 4 February     | SB        | Use of Lasers in Noise and Vibration Measurement                                                                                                                                                                                                                                     | Univ of Southampton     |
| 6 February     | SG        | Problems in Reception and Communication of Speech                                                                                                                                                                                                                                    | Univ College London     |
| 14 February    | LEM       | A talk about the mental health effects of noise                                                                                                                                                                                                                                      | The County Hall, London |
| 20 February    | BAG       | Auditorium Acoustics                                                                                                                                                                                                                                                                 | Cambridge               |
| 27 February    | NEB       | AGM                                                                                                                                                                                                                                                                                  | Newcastle Poly          |
| March          | MAG       | Visit to Boosey & Hawkes, Edgware, and MAG AGM                                                                                                                                                                                                                                       | London                  |
| 11 March       | M         | Local Government Noise Problems                                                                                                                                                                                                                                                      | Birmingham              |
| 14 March       | SB        | Assessment and Control of Noise of Onshore Drilling Rigs                                                                                                                                                                                                                             |                         |
| 20 March       | NEB & YHB | Joint Meeting                                                                                                                                                                                                                                                                        | Darlington              |
| 21 March       | LEM       | Lorry Bans                                                                                                                                                                                                                                                                           | The County Hall, London |
| 25 — 29 March  | M         | Colour in Information Technology. Joint with the Institution of Electronic and Radio Engineers                                                                                                                                                                                       | Univ of Surrey          |
| 2 — 3 April    | UAG       | Scattering Phenomena in Underwater Acoustics                                                                                                                                                                                                                                         | ARE, Portland           |
| 15 — 17 April  | M         | <b>Acoustics 85.</b> Sessions on: National and International Aspects of Noise Legislation; Hearing and Noise Damage to Hearing; Transportation Noise; Acoustics of Buildings and Building Services; The Application of Intensity Measurements; Spectral Analysis and Instrumentation | Univ of York            |
| 16 April       | SB        | Noise from Leisure Activities (Joint with EHA)                                                                                                                                                                                                                                       | Lyndhurst               |
| 24 April       | MAG       | Visit to BBC Research Department, Kingswood Warren, Tadworth                                                                                                                                                                                                                         | Surrey                  |
| 24 April       | NEB & ScB | Joint Meeting                                                                                                                                                                                                                                                                        | Carlisle                |
| 25 April       | LEM       | Audiometry                                                                                                                                                                                                                                                                           | The County Hall, London |
| 10 May         | NEB       | Oriental Music Society                                                                                                                                                                                                                                                               | Newcastle Univ          |
| 23 May         | SB        | Industrial Deafness from the Witness Box                                                                                                                                                                                                                                             | Univ of Southampton     |
| June           | M         | Structural Dynamics and Modal Analysis (Organised by ING)                                                                                                                                                                                                                            |                         |
| 1 — 3 November | M         | <b>Autumn Conference</b>                                                                                                                                                                                                                                                             | Windermere              |

### 1986

|              |   |                     |                 |
|--------------|---|---------------------|-----------------|
| 7 — 10 April | M | <b>Acoustics 86</b> | Univ of Salford |
|--------------|---|---------------------|-----------------|

#### Key:

M = Meetings Committee Programme  
 BAG = Building Acoustics Group  
 ING = Industrial Noise Group  
 MAG = Musical Acoustics Group  
 SG = Speech Group  
 UAG = Underwater Acoustics Group  
 LEM = London Evening Meeting

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:**  
 Institute of Acoustics  
 25 Chambers Street  
 Edinburgh EH1 1HU  
 Tel: 031-225 2143



# **ACOUSTICS 85**

at

**UNIVERSITY OF YORK**

**15 - 17 APRIL**

**INSTITUTE OF ACOUSTICS SPRING CONFERENCE**

The technical programme will place particular emphasis on national and international aspects of noise legislation; hearing and noise damage to hearing; transportation noise; acoustics of buildings and building services; the application of intensity measurements; spectral analysis and instrumentation. In addition, a compendium session or sessions will be arranged to allow for the inclusion of papers which fall outside the main topics of the programme.

The conference will include a major exhibition of instrumentation and technical products by manufacturers and suppliers and several technical visits will be arranged.

The University is situated on an attractively landscaped campus two miles from the centre of York. There are excellent rail links with all parts of the country and the campus is easily reached by road. The nearest airport is the Regional Airport at Leeds.

The University is collegiate and the conference residential accommodation will be in Wentworth College in single study bedrooms; a limited number of twin rooms will be available. There is ample car parking available adjacent to the college.

York provides many attractions for the visitor; the Minster, the Castle Museum, the National Railway Museum, the Viking Centre, as well as an attractive shopping centre, a theatre, cinemas and a racecourse. York also provides easy access to the North Yorkshire Moors and the Dales National Park in addition to several fine country houses and historic sites of which Castle Howard (Brideshead) and Beningbrough are probably the most well-known.

A social programme for delegates' guests will be arranged to take advantage of the many attractions in the area.

## **CALL FOR PAPERS**

Offers of contributions of 20 minutes' duration for presentation at the conference are invited. All contributions presented at the Conference will be published in Volume 7 of the Proceedings of the Institute. Intending contributors should send titles and abstracts of 100—200 words to:

Conference Secretary: Mrs C M Mackenzie  
Institute of Acoustics  
25 Chambers Street  
Edinburgh EH1 1HU  
Tel: 031-225 2143

Members of the Institute will receive further details in due course. Non-members can obtain this information, which will be available in early 1985, from the Conference Secretary at the above address.