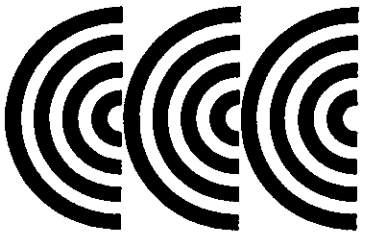

Acoustics Bulletin

April 1985 Volume 10 Number 2

INSTITUTE OF ACOUSTICS

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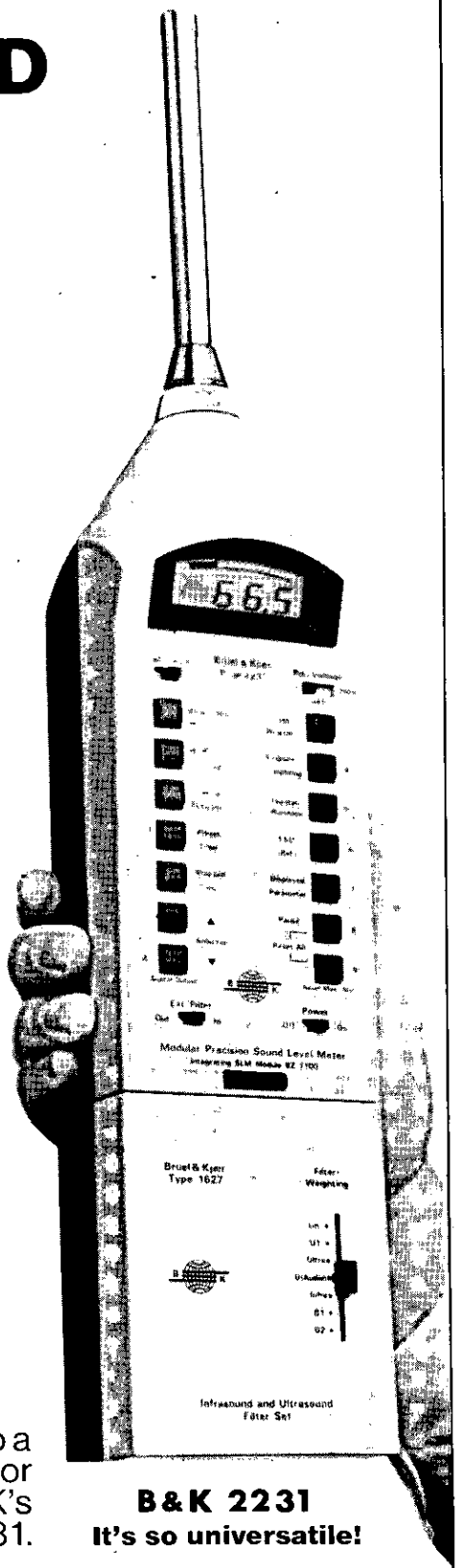

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Acoustics Bulletin

Editor:
F A Hill

Associate Editors:
S J Flockton
A J Pretlove
J W Sargent
R W B Stephens

Advertising enquiries to:
Sydney Jary Ltd
28 Southway
Carshalton Beeches
Surrey SM5 4HW
Telephone: 01-642 5775

Contributions and letters to:
Editor, IOA Bulletin
25 Elm Drive
St Albans
Herts AL4 0EJ

Books for review to:
S J Flockton
Physics Department
Chelsea College
Pulton Place
London SW6

Published by:
The Institute of Acoustics
25 Chambers Street
Edinburgh EH1 1HU
Telephone: 031 225 2143

The views expressed in Acoustics Bulletin are not necessarily the official view of the Institute, nor do individual contributions reflect the opinions of the Editor.

Single copy £4.50

Annual subscription (4 issues) £14.00

ISSN: 0308-437X

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April 1985 **Volume 10** **Number 2**

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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.

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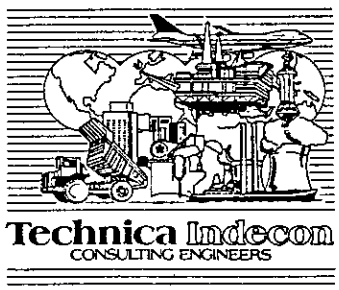

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Dear Member,

Our position with respect to the Engineering Council should be known soon, since the Second List of Nominated Bodies is to be published in May. The Engineering Council has defined three main groups of engineers, which are given below with their normal minimum qualifications and minimum age of entry to the Register:

Chartered Engineer (CEng) — Honours Degree; Age 27
Technician Engineer (TEng) — Higher National Certificate; Age 23
Engineering Technician (Eng Tech) — National Certificate; Age 21

It is possible to progress through the groups in the Register by obtaining further qualifications, but all three sections require training and experience in addition to qualifications.

The response to the enquiry sent out with this year's subscription renewal form has shown considerable interest in the Engineering Council. An analysis of the first 347 replies received is as follows:

Grade	Number Of Returns	Presently Chartered	Interested
Fellow	*65*	*23*	*31*
Member	*232*	*35*	*145*
Associate	*50*	*4*	*22*
Totals	*347*	*62*	*198*

Assuming that these are representative of the Institute as a whole, we probably already have about 200 Chartered Engineers amongst our members and another 600-700 who are interested. The rules of the Engineering Council are such that the title of Chartered Engineer can be awarded only by a Chartered Institution and this has led us to negotiate an affiliation with the Institution of Mechanical Engineers, solely for the purpose of awarding the CEng to IOA members. However, all bodies on the Second List will be able to recommend registration of Technician Engineers and Engineering Technicians directly to the Engineering Council. The responsibility for ensuring that applicants for registration comply with the requirements will fall upon the Membership Committee — which may have a busy time ahead.

Yours sincerely

Acoustics at Bickerdike Allen Partners

J G Charles FIOA

In the early 'sixties, at the beginning of his term as Director of the Architectural Association School, Bill Allen started the present practice with his architect friend, the late John Bickerdike. Over the last two decades BAP has developed steadily into a multi-disciplined firm whose fields of activity include a conventional service of building design and supervision, acoustics, the investigation of building failures, study of fire prevention and protection, historic buildings conservation, lighting and energy conservation. There are now four Partners and a staff of about sixty. The Acoustics section is one of the firm's specialist groups and its staff work exclusively in the field of acoustics and noise control.

IN THE FIRST decade of BAP's existence, the major area of acoustic work concerned architectural projects among which important examples were the design of the Royal Northern College of Music and the Calouste Gulbenkian Foundation concert and opera halls in Lisbon. This type of work continued in the second decade, but there was expansion into the control and prediction of industrial and transportation noise. Work within buildings included control of services noise and, in recent years, its converse — the production of sound in open-plan spaces to mitigate the effect of too quiet a background, or in performance areas as part of live music systems. Major projects were the rehabilitation and development of the Royal Academy of Music in London, the new County Headquarters establishment in Reading, the Arts Centre Hall at Warwick University, and a national computer complex for a leading insurance company. In the area of environmental assessment, BAP evaluated traffic noise impact resulting from various motorway and highway layouts, assessed the eligibility of insulation work in terms of the Regulations, and studied the noise impact of the third London Airport proposed for Stansted or Heathrow, and the development proposals for the UK's first STOLport in London's Docklands.

Four areas of BAP's acoustic consultancy work are now reviewed in more detail.

Auditorium Acoustics

Players' acoustics has been a long-standing and special preoccupation of BAP Acoustics, and the team has been given a number of opportunities to design new halls and received many specific requests to improve playing conditions in existing halls. Sixty auditoria have been studied to date. New designs include the Gulbenkian Foundation Concert Hall's uniquely variable stage geometry and the array of special reflectors designed for Warwick University Hall (Figure 1). The latter includes pyramids, for each of which sound incident over a wide angle is reflected back to the source, thus providing reflections of his own sound back to each player. So far, both players and audiences seem delighted with the result. Recent remedial studies for Birmingham University Great Hall, where the reverberation time is 2.1 seconds, and York University Central Hall (0.8 seconds) confirm our experience and that of Cathedral and other musicians that long RTs are not the answer to players' acoustic problems.

York Central Hall, which is now required to accommodate music performance, was originally designed with a short RT for speech, something we now recognise as unnecessarily restrictive. Experience with various multi-purpose halls and acoustic models shows that sufficient clarity for speech can be obtained with an RT of 1.5 seconds, which will often be satisfactory for music. In any case, providing sufficient volume for a long RT usually has undesirable design and cost implications, and there is little point in obtaining a long RT if other features of the design such as deep balcony overhangs defeat achievement of the desired sense of reverberance. This problem did not arise at Warwick where there are no balcony overhangs, but was very evident in 1:50 scale model tests of a new opera house in Argentina carried out for us by Mike Barron in Cambridge.

More recently, model tests of a 1200-seat multi-purpose theatre in Hong Kong were used to show the effect of radically changing the ceiling from a diffusing and scattering surface to one which was largely plane. The desired increase in early energy at the rear of the theatre was obtained, together with an increase in total energy (loudness), though some undesirable echoes were also created and had to be removed. These tests also showed explicitly the merits of an orchestra shell on stage and threw new light on its design.

Sound Insulation

Sound insulation commissions are mainly concerned with domestic buildings and offices, but also include such applications as music practice rooms and rehearsal studios where

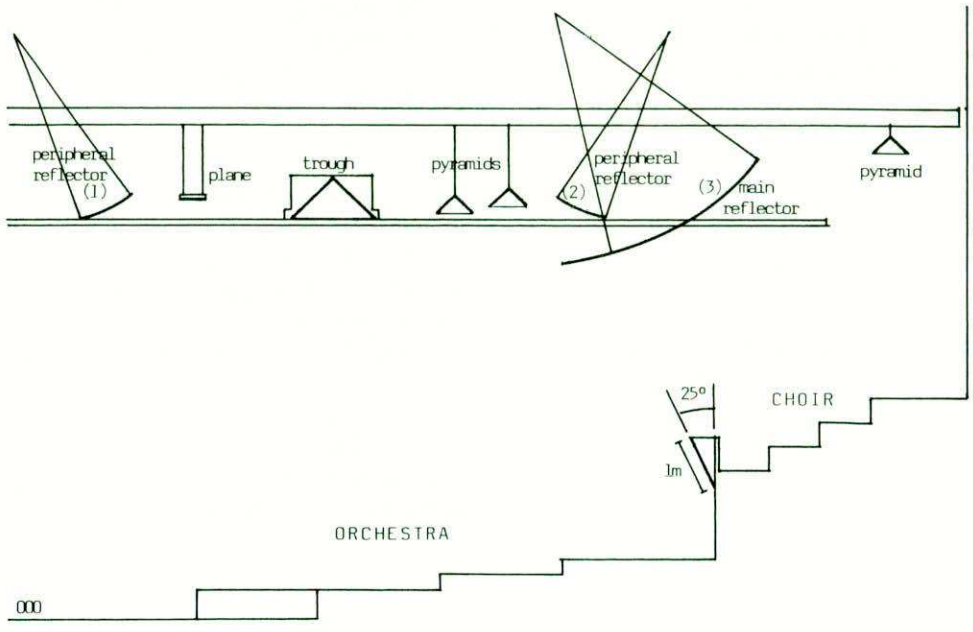

Figure 1 Array of overstage reflectors

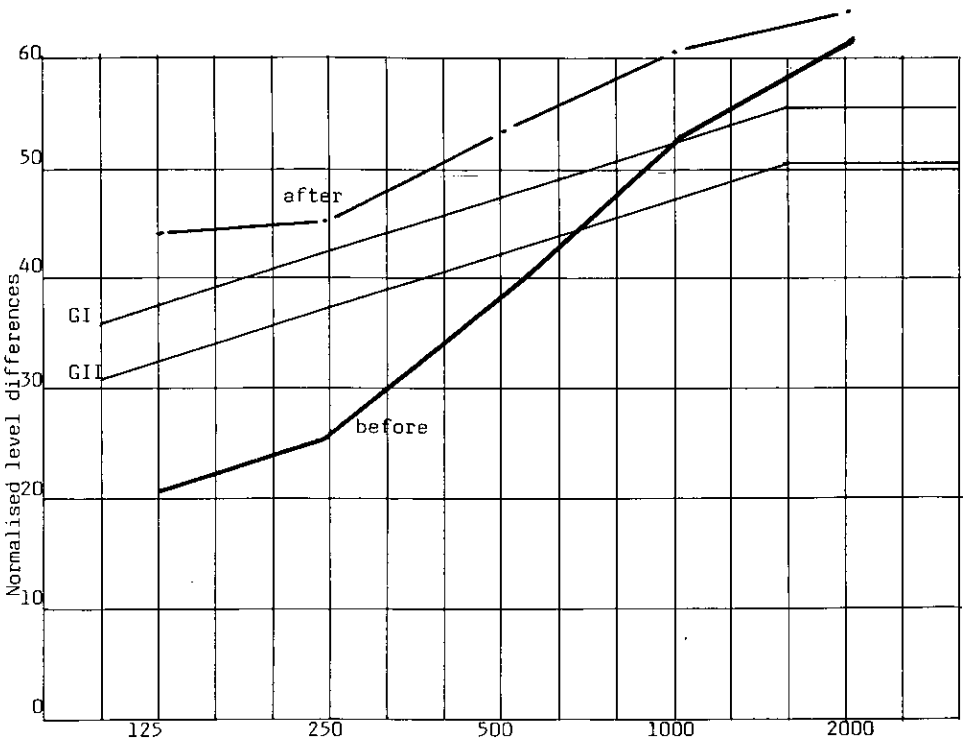

Figure 2 Party floor airborne sound insulation before and after installation of independent ceilings in a converted property

special isolation techniques have to be used. Unfortunately, BAP are more often asked to investigate the causes of poor sound insulation and advise on remedial measures than to contribute at the design stage.

The acoustic team's standard approach to these day-to-day sound insulation investigations is as follows:

- Measure airborne and, where necessary, impact sound insulation
- Compare the results with published criteria and the client's description of the problem
- Compare the field test results with published results for similar types of construction

A poorer than expected performance at mid and high frequencies suggests an error in detailing or construction, such as an interconnecting ceiling void or a 'hole' in the construction. If the test result is as expected for the construction type, an inadequate criterion has probably been adopted, and an improved construction will be necessary to meet an improved criterion. The correct solution for a specific building needs particular consideration of the amount of mass and isolation practicable for building loading, space and, of course, cost. The client may also impose special requirements such as building flexibility in the form of demountable or moveable partitioning.

There may sometimes be concern that sound transmitted via the common flanking construction may jeopardise achieving the chosen criterion if only the partition is treated. This can often be quantified by the accelerometer measurement method from which the sound power radiated from individual room surfaces can be calculated and the practicable improvement stated with more confidence.

Much of BAP's work has concerned sound insulation improvements in converted properties where residents complain about noise from stairs, slamming doors and communal areas. However, the airborne and impact sound insulation of timber joist party floors is usually the main cause for complaint. Figure 2 shows the measured airborne sound insulation for a typical case before and after installation of a new ceiling on independent joists. In contrast, the sound insulation achieved between music practice rooms at the Royal Academy of Music was an average sound insulation of 70 dB, derived from two isolated 4½ inch rendered brick walls separated by a 6 inch cavity containing absorbent, see Figure 3. It would be interesting to see if the housing market would like such a standard of insulation — at least for the play room.

A variety of techniques often has to be used when designing for these high levels of sound insulation, in the light of the experience of the acoustic engineer. For example, the principles used at the RAM are being adopted in other situations needing a high degree of sound insulation, and the results show that it is quite unnecessary to adopt such 'solutions' as the triple wall.

Environmental Noise

BAP frequently investigates noise and vibration problems resulting from airports, highways, and railways, often

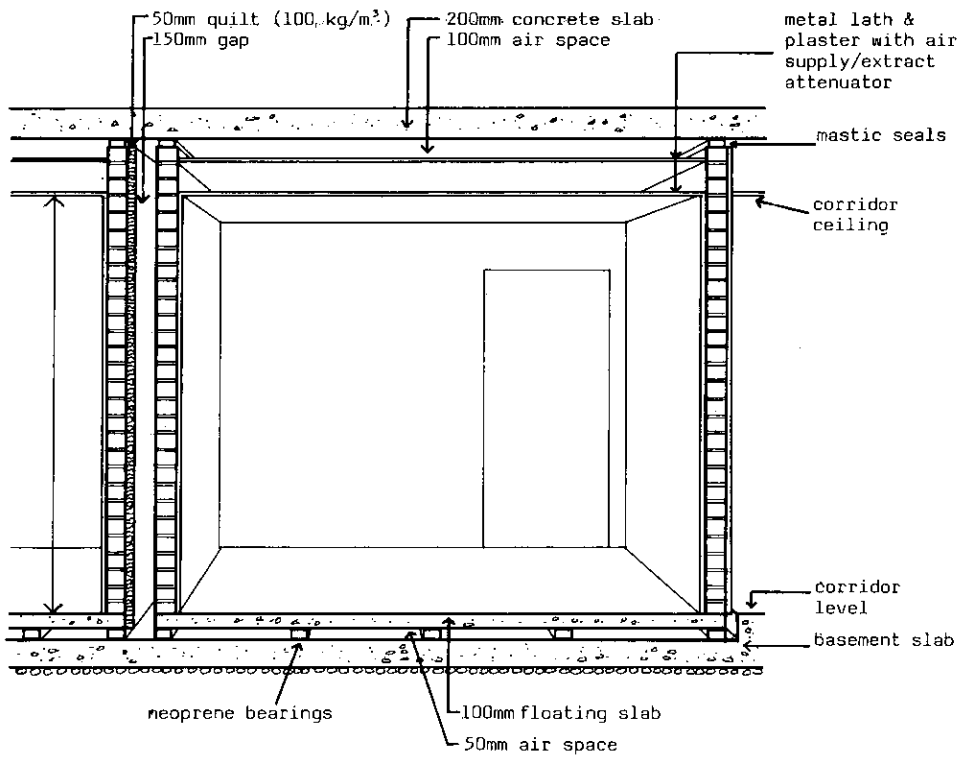

Figure 3 Typical section through well-isolated rooms

providing technical evidence at Planning Inquiries and courts of law. An acceptable level of noise has to be established, and is usually determined from relevant Standards or any research available. Satisfactory ambient noise conditions have become an important factor in people's expectations about the quality of their life-style, but the subjective effect of noise is difficult to quantify, as different people can show such differing reactions to the same noise. For example, in a study of aircraft noise a majority reported serious disturbance, while a third of those surveyed reported no disturbance at all.

Although much research has been done, there is still disagreement about the basis for assessing people's reactions to noise. At the long-running Public Inquiry into the proposal for the third London Airport at Stansted (or a fifth terminal at Heathrow), BAP advised the local authorities that the low level of background noise in their quiet rural area was very important in assessing the impact of the vast new airport. (The standard NNI assessment procedure has long been criticised for not including background noise in its rating method.) As the British Standard for industrial noise uses background noise as a basic feature of assessment, it seemed reasonable that at least ground noise sources should be considered in this way. The developer's noise consultant disagreed, and proposed an assessment system based on the contribution of an individual noise source to the overall Leq (24 hour). The BAP system gave preference to Heathrow as an airport development site, of course; but even around Heathrow it can be surprisingly quiet in between aircraft movements.

More recently, BAP acted for the developer at the Public Inquiry into siting a STOLport in the London Docklands. The background noise factor favoured the establishment of a small airport in an area which was previously very noisy, although it had recently become relatively quiet through disuse. Another advantage was that such an airport would use only STOL aircraft with a short take-off and landing capability and steep ascent/descent angles to carry aircraft higher over populated areas. Also the chosen aircraft, the turbo-prop De Havilland Dash 7, was much quieter than a conventional jet.

New motorways can drastically change the noise environment of a wide swathe of countryside, and BAP has appeared at several Public Inquiries into their impact. The traffic noise prediction technique has now been refined to a considerable accuracy, except at distances over 300 m where wind effects can produce variations of 10 dB(A). Once again, levels of acceptability are debatable; too much numerical significance tends to be given to the compensatable level in the Noise Insulation Regulations, without taking into account other factors which strongly influence people's ability to tolerate noise intrusion.

Work on environmental noise includes detailed measurement, numerous predictions, impact assessment, and design of remedial measures.

Control of Noise and Vibration

A major area of acoustic work is control of noise inside buildings and exclusion from them of external noise, often from traffic or machinery. BAP's usual approach is to:

- Measure the noise or vibration of the source (or similar) and the background noise
- Make predictions to see whether the noise can be controlled at source (the best solution) or during transmission
- Compare these predictions with published data and the field test results
- Predict the effect of various noise/vibration control features such as barriers, enclosures, vibration isolators etc, and alternative types of plant

Unfortunately there is little reliable information provided by manufacturers about the noise of products, and even less about vibration. It is much more difficult to predict vibration propagation through structures than airborne sound transmission, because the passage of the latter is often confined to a specific building element such as a plant room wall, whereas vibration can cause disturbing noise due to re-radiation as it passes through a complex array of structural elements. Because many control measures achieve a reduction of about 10 dB, prediction methods with combined margins for error of ± 10 dB make it difficult to prove conclusively the need to pay for the measure.

The result of adopting an unusual vibration control measure was seen recently in the case of a large arts complex. To reduce vibration transmission from transportation sources, foundation blocks were used which were bigger than structurally necessary. In Figure 4 the prediction of the effectiveness of this blocking mass is compared with what was achieved in practice. As it happened, this relatively simple measure proved successful, but the whole question of vibration transmission around and into buildings is basically empirical, and prediction may therefore be inaccurate.

Barriers are often used to mitigate external noise sources such as heat pumps, cooling towers, taxiing aircraft, and road traffic, but in built-up areas

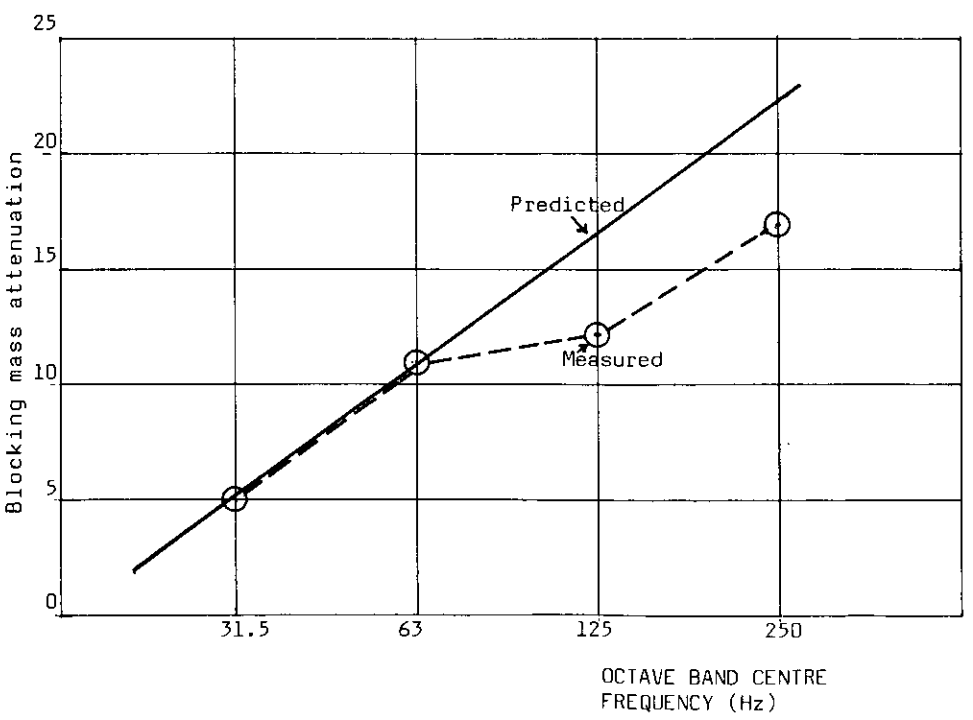

Figure 4 Comparison of measured and predicted blocking mass attenuation for vibration on pile cap

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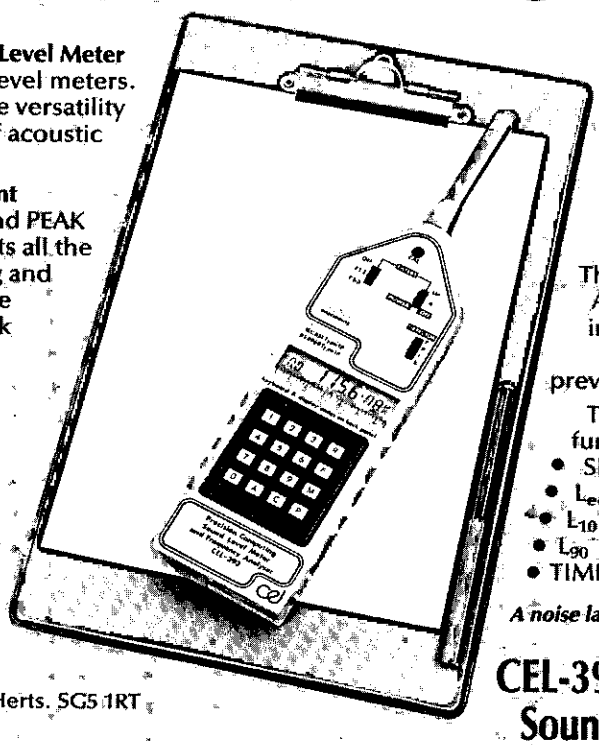

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calculation accuracy is low, as is prediction of external noise over long distances. In a debate about ground noise attenuation at a recent Public Inquiry, technical opinions varied from 8 to 12 dB(A) per doubling of distance — a 10 dB prediction variation over 600 metres. Barriers (eg partitions) can also be used within buildings, but it is more usual to control noise sources by using silencers, enclosures, duct linings /lagging, and vibration sources by heavyweight structures and isolators.

Air-handling systems are a common problem. The supplier will usually provide the sound power level of the fan (the major noise element), although this is often simply an empirical prediction not checked out by a full noise test. Furthermore, the results apply to *ideal* inlet and discharge conditions — a rare event in real life. Allowance has to be made for the insertion loss of various duct layouts and silencing options, and then for the radiation from the supply diffuser or return air grille in the room to the noise-sensitive location. Finally, contributions from noise generated by air flow over ductwork elements and the diffusers/grilles are added in.

Although prediction in this area is remarkably inaccurate, BAP have found it possible to control noise and vibration adequately in a variety of situations even when stringent criteria are adopted. Problems are rarely due to the weakness of the design; more often they are the result of equipment being inappropriately installed, or obvious errors such as bad aerodynamics, isolators or isolated equipment short-circuited by rigid connectors nearby, unsealed gaps in partitions, doors etc.

BAP is now into its third decade. Some of the challenges remain the same — noise control of boilers, heat pumps, chillers and plant rooms. However, a clutch of food establishments has recently sought acoustic help, and bread, hamburgers and haute cuisine have all been voraciously studied. Auditorium work has embraced, with equal enthusiasm, small practice rooms, a CCTV studio, an orchestral recording studio, a fringe theatre, a children's theatre, and several medium-size auditoria seating about 1500. Environmental assessment has extended to a detailed analysis of subway vibration, specialist facilities near a heliport, and noise control measures for London's STOLport. Sound insulation projects reflect, as always, the individual's struggle to live relatively undisturbed by his neighbours in new, old or rehabilitated dwellings in the domestic scenario, and his hopes of a working life unafflicted by the intrusive results of an insensitive office layout. □

Letter to the Editor

Dear Alison

I read your Editorial in the October Bulletin with interest. Could one of the reasons for the lack of copy be that if authors follow your margin instructions they end up with a blank sheet of A4?

Yours sincerely

Rob Harris

I should of course have asked for a margin of 25 mm (not 250) and 35 mm (not 350) at the top. Thank you Mr Harris and congratulations — no-one else has drawn this to my attention! (And I can't even claim it was a misprint....) — Editor. □

London Evening Meetings

The London Evening Meetings continued the present series with a talk given by Bill Stevens of AIRO Ltd, on **Assisted Resonance at the Royal Festival Hall.** He explained that when the hall was completed in 1951 it was judged to lack a certain 'fullness' or 'warmth of tone'. This was attributed to the reverberation times being too short. Bill went on to describe how the hall was originally designed with holes in the ceiling so that Helmholtz resonators could be used as absorbers if the hall was too 'lively'. In fact the opposite was true, so the late Peter Parkin, the acoustic designer of the hall, decided to use the holes for an electronic method of increasing the reverberation time. This system was capable of increasing the reverberation time from 1.5 to 2.5 seconds at 63 Hz. The speaker informed the meeting that there are in fact two settings, one for rehearsals, when the hall is empty, and one for concerts. The concert setting takes account of the extra absorption by the audience, although if the box office report a particularly small audience the rehearsal setting can be used. He told us how in the early days a permanent land line was installed to Peter Parkin's home so that he could keep an eye, or an ear, on the system. Moving on to the present day, Bill told us how the system has been updated and how it is regularly maintained and adjusted. He finished his talk by relating a few humorous stories about the system, one of which involved the control technician unintentionally adding some 'special effects' to the last movement of the Planet Suite that Holst had not included in his original composition.

Paul Freeborn

Over 20 people managed to defy the snow and a British Rail strike to hear John Miller of Bickerdike Allen Partners talk on **Sound Insulation in Dwellings** at the January meeting. BAP are currently involved in a project for CIRIA to produce a manual on all aspects of sound insulation.

The talk began by reviewing the subject, covering the method of measurement and assessment, and the meaning of the curves in the current Building Regulations. Various designs were looked at for both party walls and floors with the important points of detail being highlighted. Some limitations of the BRE social survey were mentioned together with the age-old problem that once people start complaining, you tend to need total elimination of the noise to satisfy them.

A case history of a conversion was discussed where independent ceilings were the answer despite the detailing problems around the windows, doors and cupboards. The criterion for the partition between the common areas and the dwelling was set at less than the Building Regulation standard because of the restricted use of the common areas. Carpet was used on the stairs to reduce the impact transmission (which was tested by the mobile free-thinking reasonably precision-grade variety of tapping machine); and door closers were used to control the velocity of the slamming door.

BS 5821 was discussed with the equivalent to an AAD of 23 dB being given as 54 dB (wall); 51 dB (air-floor); 58 dB (impact). The thorny subject of the new Building Regulations concluded the talk with the meeting pondering the difference between 'adequate' and 'reasonable' and whether the new regulations really were trying to do away with the fun of field measurements.

The discussion covered the relevant forthcoming articles in the London Environmental Bulletin; the limitation of the impact test procedure (using the standard non free-thinking machine); the cost of remedial measures; and the validity of correcting to half-second RTs. Fortification then took place as usual before everyone made their valiant way home.

Dr Stephen Stansfeld of the Institute of Psychiatry gave the talk at the meeting held on St Valentine's Day on the subject of **Noise Annoyance and Mental Health.** He started by considering the various definitions of noise and went on to outline the physiological effects of noise that had been discovered mainly in laboratory tests.

He then discussed the findings of the survey carried out around Heathrow in 1977 looking at the effects of aircraft noise on people. The sample was divided into four groups according to NNI exposure and it showed first that annoyance generally increased with noise. He defined annoyance as arising from feeling bothered/disturbed; the interference caused; and the symptomatic effects of headaches/tension/irritability, and he looked in more detail at the noise/symptom relationship. Here, the number of people experiencing symptoms did not significantly increase with noise. This led to a closer look at the vulnerability or sensitivity to noise and a follow-up survey that was carried out in 1980. Unfortunately no clear pattern seems yet to have emerged.

There was a wide-ranging discussion from an audience that included both acousticians and residents who lived near Heathrow. This covered the validity of simple 'are you sensitive to noise?' questions; the fact that people are not good judges of their own physiology — ie when people say they have got used to the noise, it may in fact not be true physiologically; the effect of noise on mothers with young children, and the disabled; and complaint behaviour. The meeting was concluded in the usual manner.

Stephen Turner

Meeting Alteration

The last meeting in the present series was to have been given on 25 April by Ivan King from the Polytechnic of the South Bank on the subject of Audiometry. Sadly, due to his premature death, the meeting has been cancelled. An alternative meeting has been arranged as follows.

2 May 1985: Acoustics and Audiology. Dr J J Knight of the Institute of Laryngology and Otology, University of London, will talk about the contributions of acousticians to the field of audiology. Topics to be covered include the design of suitable test rooms for audiometry, the possibilities of various modern hearing tests in diagnosis, assessment of noise induced hearing loss and non-organic hearing loss. The talk will take place as usual at the County Hall, London, commencing at 6.00 for 6.15 pm. □

In case you didn't hear...

A number of members have notified us of changes in their employment in the last six months. **Dr John Holmes** FIOA is now working as an independent Speech Technology Consultant from his home in Uxbridge. **David Richardson** FIOA has joined Arup Acoustics as an acoustic consultant. **Daryl Coffey** has formed his own consultancy in Bedfordshire offering advice on noise, asbestos and purchase. We wish them all well in their new enterprises. □

Proceedings of The Institute of Acoustics — Abstracts

Scattering Phenomena in Underwater Acoustics

International Conference organised by the Underwater Acoustics Group, 2-3 April 1985 at Admiralty Research Establishment, Portland

Invited Paper: An Overview of Outstanding Problems in Boundary Scattering

C Sienkiwicz
University of Washington, Seattle, USA

Sea Bed Scattering Strength with Angle and the Accuracy of Doppler Speed Sensor Measurements

A T Smith, J G Boulton, M D Macleod and R J Granger
Cambridge Consultants Ltd, UK

Changes in the scattering strength with angle characteristic between land and sea surfaces cause errors in airborne Doppler radar speed sensors. The technique of lobe switching is in common use to compensate for this effect. The analoguous effect in Doppler sonar speed sensors is considered from a theoretical aspect which is supported by extensive measurements of the scattering strength with angle characteristic from real sea beds using narrow beam high frequency single element transducers. The implications of the effect in the design of an accurate Doppler speed sensor for use in UK coastal waters are discussed.

Bottom Acoustic Backscattering at Low Grazing Angles in Shallow Water. I: Bottom Backscattering Strength

H Boehme, N P Chotiros and D J Churay
Applied Research Laboratories,
The University of Texas at Austin, USA

Acoustic backscattering measurements of the ocean bottom were made at grazing angles in the range of about 2-10° in water depths of approximately 15 m. Data from these measurements have been analysed to determine the mean value and standard deviation of the bottom backscattering strength per m^2 as a function of grazing angle, insonified area, transmit signal type, and frequency. A curved ray path propagation model and measured sound speed profiles were used to determine grazing angle versus time. The mean values were observed to follow Lambert's law for the range of grazing angles measured and for all frequencies used. No significant differences in mean value were observed when the insonified area and transmit signal type were varied. The observed frequency dependence of the bottom backscattering strength per m^2 falls in the range from $f^{1.0}$ to $f^{1.5}$ for the relatively flat, sandy ocean bottom regions where measurements were made.

Bottom Acoustic Backscattering at Low Grazing Angles in Shallow Water. II: Statistical Characteristics of Bottom Backscatter

N P Chotiros, H Boehme and D J Churay
Applied Research Laboratories,
The University of Texas at Austin, USA

Analyses of the statistical characteristics of ocean bottom acoustic backscatter, measured in relatively shallow water regions, are presented. An experimental sonar, operating at 30 kHz, mounted on a fixed platform near the bottom was used to gather data over wide azimuthal sectors of the bottom within its operating range. The ocean bottoms were comprised of areas of coarse and fine sand. The distribution function and probability of false alarm function of the detected envelope of a 'widebeam' and a 'narrowbeam' signal were measured. Some spatial and temporal correlation functions of the signal amplitudes were also measured. A limited attempt was made to compare the results with existing theoretical models.

Anomalies in the Reflection Behaviour of Marine Sediments

M von Haumeder
SACLANT, La Spezia, Italy

Acoustic mapping of the sea-bed requires a precise knowledge of the bottom reflectivity. In some marine sediments we have to consider strong anomalies in their reflectivity. These marine sediments consist of two components: a sand which forms a stiff frame and a liquid which fills the interstices. Such sediments can be considered porous materials. A theory which analyses the response of a porous material to an elastic wave is the Biot-theory. It treats the two components as two interpenetrating elastic continua and predicts some remarkable anomalies in the acoustic behaviour of porous materials. One important prediction of the Biot-theory is that acoustic energy of a certain frequency band can penetrate the sediment even in the range of total reflection. The porous material behaves here like a frequency filter with respect to acoustic energy. This is due to the excitation of an internal flow of the pore fluid relative to the frame which results in relaxation. The internal flow is critically dependent on geometric factors describing the flow resistance of the frame-ducts and on the exciting frequency. In an attempt to model a real marine sediment as realistically as possible we use measurements of the reflectivity anomaly in order to determine the interdependence of the Biot input parameters. These parameters are descriptive of the internal structure of the sand. A parameter interconnection is presented which fits best the measured behaviour of a real marine sediment.

A B Wood Medal Lecture: Sonar Estimates of Sea-floor Microroughness

T K Stanton
University of Wisconsin, USA

Modelling of Sea Surface Scattering

P A Crowther
Marconi Underwater Systems Ltd, UK

Modifications and extensions are given to a physical model proposed by the author in 1979 for sea surface scattering strength over a wide range of windspeed, incidence angle and frequency, in view of recent reported research into near surface bubble distributions, turbulence properties and rough surface interfacial scattering theory. The basic property of the 1979 model, that scattering is a combination of that due to bubbles and to interfacial roughness, remains. Details have been re-examined, firstly by considering bubble creation and migration more closely, with use of recent data, modified turbulence diffusion dependencies, and inclusion of solution effects. Resulting solutions of the transport equations are given. Secondly, composite interface scattering theory is re-examined from the critical standpoint of the short/long scale spectrum bifurcation wave number. It is concluded that previous workers have tended to set this too high, and thereby probably overestimated interfacial scattering. Evidence for the significance of bubbles at windspeeds 6 m/s at frequencies as low as 3 kHz is presented. Resonant and non-resonant bubble scattering are considered, the latter being significant only at $\gtrsim$ 60 kHz. The general windspeed dependence remains as given in 1979. Turbulent diffusion related terms have been modified to be more consistent with present knowledge.

The Near Field and Far Field Regimes of Rough Surface Scattering

N G Pace and Z K Shafik
University of Bath, UK

P D Thorne
Institute of Oceanographic Sciences, Taunton, UK

A theoretical expression for the normal incidence, high frequency backscattering coefficient as a function of range from a rough surface which has Gaussian statistics is presented and its correctness substantiated with a series of experimental measurements. Ideally the backscattering coefficient of a rough surface should be dependent only on properties of the surface. For the usual definition of backscattering coefficient this is shown to be true only in the far field of the surface scattering patch. In the near field of the surface, the backscattering coefficient is shown to be independent of all properties of the surface except its reflection coefficient. In a range interval between the near field and far field the backscattering coefficient is shown to depend on both the surface statistics and the measurement geometry.

Numerical Simulations of the Degradation of Array Directivity due to Scattering

P F Dobbins and C Schofield
BAe Underwater Research and Engineering Unit, Weymouth, UK

A practical consequence of scattering in underwater acoustics is the distortion of the propagating wavefront and resulting degradation of the directivity of sonar receiving transducers and arrays. Various theoretical expressions have been published which give both the expected beampattern and the variation in the level at any bearing when the statistics of the arriving wavefront are known; in principle any distribution of phase and amplitude fluctuations with any spatial correlation function can be dealt with. To date these theories have no experimental confirmation and a programme of experiments is being conducted to provide such confirmation, but as a preliminary check a series of beampattern simulations have been carried out using computer generated phase and amplitude fluctuations with statistics typical of scattering due to a temperature microstructure. It has been found that the average directivity pattern obtained is in good agreement with the theoretical prediction, even for a small number of realisations, but that under certain conditions the variance in the simulated pattern is much greater than expected. In this paper the simulation technique is described, typical results presented and the reasons for the discrepancies between simulation and theory discussed.

Computer Simulation of Reverberation from a One-Dimensional Seabed

M R Gething
ARE, Portland, UK

A simple computer model has been created to calculate the reverberation of a pulsed signal off a one-dimensional hard seabed. A variety of transmitted pulse types can be used, and the angles of incidence and back scatter can be varied independently.

Seabed cross-sections have been generated randomly but with constraints on the statistical properties of inclination, facet length and height. The variation of reverberation with angle of incidence conforms with published seabed measurements.

The model has been used to evaluate the correlation between pings at different frequencies, for various angles of incidence and pulse lengths. No random noise has been added to the signals.

Preliminary results indicate that for grazing angles less than 60° the correlation between pings is very high even with a ratio of 8 between frequencies. This appears to be due to the reverberation being dominated by specular reflections from facets perpendicular to the line of sight. The sum of these contributions varies very little with frequency.

At all angles of incidence, correlation between pings at different frequencies decreases as the pulse length increases. The correlation is reduced if the pulse has a $\sin^2$ envelope rather than a square envelope.

A Numerical, Narrow-Band Reverberation Model of the Sea

B Aulton
Marconi Underwater Systems Ltd, UK

A numerical simulation model of reverberation is described which produces non-stationary narrow-band spectra, as these would appear at the output of a receiver. A simpler Doppler domain model based on the more straightforward radar situation is also outlined. The basic FOM (Faure, Ol'shevskii, Middleton) reverberation model of randomly distributed, point scatterers is used but modified to deal with long pulses, large isolated scatterers and the effect of wind direction on scattering spectra. A further extension to the model allows for a receiver with automatic gain control, hard limiting and restricted dynamic range to be modelled as a matched filter. Acoustic returns from each scatterer are taken to be delayed and distorted versions of the transmit signal.

The Chamberlain-Galli technique of using linear prediction to synthesise a beam-to-beam correlated time series has been extended and four modifications are considered in detail. These are:

a) the use of a pre-whitening filter

b) the choice of the normal equations to suit requirements

c) the use of selective linear prediction

d) the application of prior knowledge of the spectra.

It is the intention that the eventual outcome of this work will be a reverberation model, running in real time, as part of an environmental model.

A Numerical Acoustic Reverberation Simulator

C Davies and C H Harrison
CAP Scientific Ltd, London, UK

This paper describes a numerical acoustic reverberation simulator which is one of several modules in a sonar simulator. A monostatic pulsed sonar with a steerable beam is assumed, and the object is to produce a life-like waveform for the reverberation without entailing large amounts of computation time or storage. The model includes sea bed and surface scattering, volume scattering, specular reflections from sea bed and surface, and Doppler effects. It copes with a generalised pulse shape and generates the characteristic amplitude fluctuation in time associated with the acoustic pulse length and pulse to pulse fluctuations.

Rather than attempt to calculate the true reverberation using detailed scattering theory a simplified approach is taken whereby a random number sequence with appropriate distribution is first multiplied by a 'tail-off' function giving the correct coarse delay time or range dependence and then convolved with the pulse function (including carrier). The advantage is that uncertainties in scattering theories for rough surfaces and bubbles are avoided, and a sea surface need not be constructed. Variations of roughness parameters are inserted via tunable coefficients.

Measurements of Backscattering from Large-scale Physiographic Features of the Sea Floor

J M Berkson, T Akal and H J Kloosterman
SACLANT, La Spezia, Italy

Low-frequency acoustic backscattering from the sea floor has often been studied using omnidirectional measurement techniques. An advantage of directional measurements is that it is possible to process the data to obtain images of the scattered features and to estimate the scattering strength of specific physiographic features. Such information is applicable to long-range acoustic mapping of the sea floor and to the study of sound scattering phenomena of the sea floor at low frequencies. In this paper, we describe scattering measurements made in the southern Tyrrhenian Sea with an explosive source and a towed-array receiver. The acoustic signals received by the array are processed by a frequency-domain beam-forming procedure to estimate the directional distribution of energy for a given time increment. An assembly of these distributions as a function of time displays the geographic location of large-scale features of the sea floor that scatter sound back to the array. The scattering strengths of the coast over the frequency range of 150 Hz to 700 Hz are typically between − 25 dB and − 35 dB and are generally independent of frequency and azimuth of insonification to the coast.

Application of Back Scattering Acoustic Waves in Submarine Cartography

J P Longuemard and A Goutierre
University of Perpignan, France

Ultrasonic waves echoed by the sea-bed can be classed in two categories: reflected waves and back scattering waves. The amplitude of each depends on the conditions of measurement and the geoacoustic characteristics of the sediment.

The authors describe a method of measuring the characteristics of the water-sediment interface. They use the coefficient of reflection r of the sea-bed to determine the wet density of the clay and silt, and the amplitude of the scattering waves to determine the dimension of the particles (mean grain size Q_2).

The experimental formulae used to measure these characteristics are as follows:

— for the wet density ϱ :

$$\varrho = a + br + cr^2$$

where a, b and c depend on the mineralogy.

— for the grain size:

the level of the scattering waves I_D depends on the ultrasonic frequency and the size of the grains. For the prototype used, I_D is at its peak when F is defined as a function of Q_2 by

$$F = a + b \ln Q_2$$

The equipment used to obtain these results, functions at frequencies of between 15 and 100 kHz. Results obtained in the Mediterranean are also presented.

Statistical Properties of Side-scan Sonar Signals and the Computer Classification of Sea Beds

Z Reut, N G Pace and M J P Heaton
University of Bath, UK

Side-scan sonars are nowadays routinely and widely used in underwater surveying. They employ only the sound field backscattered from the superficial sea bed and at the usual frequencies there is hardly any penetration of the sea bed. However, the usual paper display contains less information than the signal creating it, and moreover the interpretation of any paper display is often difficult especially regarding sediment types. In order to overcome these two shortcomings, and since the signals are of a

stochastic nature, computer analysis drawing upon suitable statistical properties of the signals is indicated. The probability distribution function (PDF) of digitised signal envelope corresponding to an area of the sea bed relates to its roughness, while spectral analysis is more sensitive to its acoustic hardness. The spectral analysis method is dependent upon the system bandwidth to a much greater extent than the PDF, and empirical evidence for these assertions is provided. The normalised central moments of the PDF and certain integral features derived by spectral analysis are independent of the signal dc level and gain and thus suitable for sea bed computer classification procedures.

Automatic Gain Control for a Side-Scan Sonar Imaging System for investigation of sea bed and submerged objects

L Short and S Butters
Waverley Electronics Ltd, Weymouth, UK

Until recently manual adjustment of gain has been necessary to compress the wide dynamic range of the received signal levels to fit within the narrow dynamic range of the display medium to produce the optimum image for interpretation.

Microprocessor techniques now make possible realisation of an economical and reliable automatic gain control system which eliminates the need for constant attendance by an operator.

Consideration is given to dynamic range of the sonar echo signals and contrast requirements by gain variation, using the following techniques:

1) Predictive, fixed law, look-up tables

2) Combination of fixed law with manual adjustment

3) Adaptive, constrained AGC

The concept of a simple analogue AGC system is developed into a practical and low-cost multichannel digital control system.

Also discussed is the compromise made between a short time-constant highlighting small features and the requirement to distinguish large uniform areas necessitating long time-constants.

Contrast of particular features can be increased by suppressing unwanted detail using pattern recognition and image processing algorithms to improve the rules of supervision governing the basic gain control loop.

Acoustic Mapping of the Sea Bed: The University of Bath Depth Swathe Sounding System

R L Cloet
University of Bath, UK

An interferometric depth swathe sounding system has been developed, in the course of the last few years, funded by the Science and Engineering Research Council. It is based on the production of two interferometers, generated by means of three 300 kHz sidescan transducers. These are each spaced several wavelengths apart, one pair having a slightly different spacing from the other. The resulting 'vernier', produced by the phase differences between the two pairs, provides the means of resolving the phase ambiguities, while the spacing of several wavelengths yields a higher resolution than would otherwise be the case.

The transducers are mounted on a pressure vessel which contains a full set of attitude sensors.

Sea trials have been carried out from a 37 ft catamaran vessel of the Plymouth Polytechnic. These have culminated in the execution of a hydrographic survey of an area in Plymouth Harbour which has both reasonably level, and steep terrain, as well as a range of seabed textures. The area had previously been bench-marked in detail by means of duplicate echo sounding surveys.

The results show that depth accuracies of 25 cm should normally be obtained where errors induced by the positioning system are not a factor.

A matrix, consisting of depths spaced every 5 m on a rectangular grid, has been adopted as being adequate to record the dimensions of most features which exceed in height the resolution of which the swathe sounder is capable at present. Access to such data matrices permits sensitive monitoring of seabed areas which are liable to movement.

A significant contribution swathe sounding can make is that it helps materially in overcoming the sometimes misleading information yielded by aspect dependent sidescan sonars.

The Accuracy of an Interferometric Side-scan Sonar

G R Gapper and T Hollis
University of Bath, UK

Interferometric side-scan sonars have been developed in the recent past for seabed surveying purposes (Cloet et al, 1982; Denbigh, 1983). These sonars provide not only range and amplitude information as a function of time but continuous estimates of the angle of arrival of the wavefronts in the vertical plane. The angle of incidence is usually estimated by measuring the phase difference between the signals from a pair of transducers mounted above one another. The resolution of such a system is set primarily by the frequency bandwidth and acoustic beam widths; the accuracy by factors such as the signal-to-additive-noise ratio and the degree of temporal, and spatial, coherence.

An expression will be given for the effective correlation coefficient between the signals from two transducers when additive noise, temporal incoherence and spatial incoherence contribute. The probability distribution of the instantaneous signal amplitudes and phase-difference will be related to this effective correlation coefficient.

A novel form of signal pre-processing which dramatically reduces the tails of the phase-difference probability distribution will be briefly discussed. Plots of the distributions resulting from a Monte-Carle simulation will be presented and the benefits of this form of pre-processing for interferometric side-scan sonar made clear.

Temporal and Spatial Variabilities in Shallow Water Acoustics: Measurements and Predictions.

H B Ali, T Akal and M Ferla
SACLANT, La Spezia, Italy

In attempting to use acoustics in the ocean, one is inevitably confronted by the basic problem of the inherent complexity of the medium. The parameters controlling the propagation vary, usually unpredictably, both spatially, and, more significantly, temporally. An acoustic signal propagating in such a medium is consequently scattered not only by interactions with the bottom and surface boundaries, but also by volume inhomogeneities caused by non-uniformities in temperature, density, and salinity distributions. The degradations in the acoustical signal are manifested as fluctuations in its amplitude and phase and by an accompanying loss in its coherence properties. The results of measurements in selected areas of the Mediterranean have been used to establish correlations between fluctuations in acoustic transmission loss and variability in environmental parameters. The preceding has included the effects of volume scattering caused by well-known (though less well understood) oceanographic features such as gyres and fronts. By conducting the experiments at various distances and over a frequency range covering at least two decades, valuable data has been obtained on both high and low frequency fluctuations. The use of a modified version of SNAP (SACLANTCEN Normal Mode Acoustic Propagation Model) developed especially for the analysis of the time variability of acoustic transmission loss, has provided insight into the mechanisms involved.

A Study into the Effects of Bubbles on Submerged Reflectors

C H Harrison
C A P Scientific Ltd, London, UK

Abstract not available.

Diffraction of a Plane Acoustic Wave by a Layered Elastic Sphere

D Husson
GERDSM, Toulon, France

The theoretical analysis of the diffraction of a plane acoustic wave by a solid or hollow sphere immersed in a liquid has been solved by several authors: the incident wave is expanded in spherical harmonics, and the boundary conditions on the different interfaces lead to a system of linear equations for each harmonic. The acoustic field diffracted by a sphere formed of several elastic layers is calculated by the same technique.

A FORTRAN routine has been developed to solve this problem. It will accept spheres formed of up to eight layers, and frequencies up to ka = 100. Complex velocities are used to model the effects of attenuation in the elastic layers.

For each configuration studied, several types of numerical results are presented: plots of the acoustic pressure back-scattered by the sphere and of the total pressure in the near field of the sphere as functions of ka, colour-coded maps of the modulus of the acoustic pressure in the surrounding fluid at a given frequency; plots of the displacements induced in the sphere by the propagation of the acoustic wave.

These theoretical results are compared with experimental measurements performed at frequencies between 10 and 100 kHz of the near field pressure around a hollow 20 cm diameter aluminium sphere immersed in water.

Reflectivity produced by a Target (Hollow Sphere) Buried in a Sand Bottom

R Carbó-Fité and C Ranz-Guerra
Institute of Acoustics, Madrid, Spain

Experimental results are shown on the Sonar signal deformation after being reflected in a sand bottom when an air filled sphere was buried in it. The dimensions of the target were of the order of Ka $\cong$ 5. The acoustic exploration of the bottom was carried out at normal incidence. The generated echo brought back information on the whole bottom column, target included. The results presented here refer not only to the buried sphere but also to the sphere submerged in water without any influence of the bottom. The reflection coefficient of the bottom column, R, varies from 90% when the air filled sphere is present, to 40-50% when that target is away from the isonified region.

The reflected signal analysis was carried out by two different methods. Method M_1 refers to the recording in real time of the DC value that corresponds to the RMS amplitude of the signal; the signal was time filtered through consecutive windows of 0.2 ms. The other method, M_2, was focused on getting the value of R in a given frequency band; to get this information the signal was recorded and postprocessed. In this analysis the echo signal was divided into its most significant parts; those parts were processed independently. Each one of these signals was cross-correlated with the emitted signal; so the S/N ratio was increased, and afterwards, by FFT techniques, the R = R(f) function was obtained in the frequency band of interest.

The results obtained by both methods present a good agreement.

A Hybrid Computational Method for Underwater Acoustic Scattering

E A Orme
Smith's Industries Ltd, Cheltenham, UK

P B Johns and J M Arnold
University of Nottingham, UK

The modelling of acoustic scattering by objects can be regarded as two separate problems: the disturbance produced locally by the object, and the propagation of this disturbance back to the observer. In many cases of interest the local disturbance near the object can be effectively modelled by surrounding the object by a co-ordinate mesh and using discrete numerical methods (such as finite elements or TLM) to solve the local boundary value problem. This technique is very inefficient, however, for modelling the long range phenomenon of propagation to the receiver. In the usual case, where the medium supporting this propagation has acoustic parameters varying slowly on the scale of the wavelength, geometrical ray tracing techniques are much more efficient for modelling the latter phenomenon.

This natural separation of the scattering problem suggests the possibility of combining the two techniques into a hybrid method. The central problem is then that of connecting the geometrical ray and discrete mesh representations for the acoustic field across the outer boundary of the mesh, which is assumed to lie quite close to the scattering object.

The paper presents a number of methods for achieving this connection, generally based on local Fourier transforms, and also discusses the experience we have gained by studying various cononical test problems by means of this hybrid method. The essential idea of the method is that the local Fourier transform probes the mesh surface to detect the directions of local plane waves, where the spectra exhibit peaks, these directions are also initial directions for geometrical rays leaving the mesh boundary, along which the disturbance may be transported to the observer.

Acoustics '85

1985 Spring Conference, 15-17 April at the University of York

Plenary Sessions

1985 R W B Stephens Lecture: Trends and Perspectives in Non-linear Acoustics

Professor L Bjorno
Technical University of Denmark, Lyngby, Denmark

1985 Rayleigh Medal Presentation and Lecture: Some Practical Applications of Non-linear Acoustics

Professor P J Westervelt
Brown University, Providence, USA

Acoustic Instrumentation and Measurement

Application of Digital Techniques to Noise Recording and Analysis

J R F Jackson
Rolls Royce Ltd

Abstract not available.

The Use of a Digital Audio Processor and VRC for Low Frequency Noise Measurements

G Kerry and D J Parker
University of Salford

Abstract not available.

A Battery-powered Portable FFT Analyser

A J Myles
CEL Instruments Ltd, Hitchin

Abstract not available.

An Application to BCS for Acoustical Approval

J H Hamilton
The Services Electrical Standards Centre

Abstract not available.

Recent Changes to the NPL Hearing Protector Test Rig

M S Shipton
National Physical Laboratory, Teddington, Middlesex

Abstract not available.

Location of a Sound Source Using 2 or 3 Vertically Separated Microphones, Near to Porous Ground

K Attenborough, N W Heap and A P Watson
The Open University, Milton Keynes

Well-established theory of atmospheric propagation over a ground surface may be used in the absence of meteorological effects, to deduce a procedure for locating a point source of sound from the difference in spectra received by microphones placed at the ground surface and up to 3 m above that surface. The procedure utilises an iterative search for ground properties, source elevation and horizontal range. Two parameters have proved sufficient to represent the acoustical properties of the ground. These are effective flow resistivity and effective rate of change of porosity with depth. In a two-microphone procedure, values of these parameters and source elevation are found, after an initial calculation of path length difference from the second and third peaks in the level-difference spectrum, by fitting the first peak in the spectrum. Iteration over the whole spectrum then produces an estimate or range. A three-microphone array offers three pairs of level difference spectra and enables use of a smaller processing bandwidth than the two microphone system. The algorithms are completed by deduction of source spectrum from the signal received at any one of the microphones.

So far the systems have been validated over ranges up to 150 m using fixed loudspeaker sources of white noise in both calm and windy conditions.

Low Power Digital Interfaces in Hand-held Sound Level Meters

A J Myles
CEL Instruments Ltd, Hitchin

Abstract not available.

Aircraft Noise Monitoring in London

J Hyde
Greater London Council

Abstract not available.

Measurement of Acoustic Transmission Properties of a U-Tube Heat-Exchanger

D McLaughlin
Yard Ltd, Glasgow

A new development in measuring the acoustical transmission properties of elements in ducts is described. The method is based on the resolution of a standing pressure wave into its two travelling components, using an array of transducers, as has been done with some success in established test facilities. Where the present approach differs is in the use of phase measurements between pairs of

transducers, together with the application of a least-squares technique to provide a stochastic estimate of the required parameters. A computer program is used to determine reflection coefficients and transmission losses from measured transfer functions. The technique has been used on an air-filled styrene model test rig using 12 microphone locations. For both simple area-change silencers and more complex designs, such as a model heat exchanger consisting of 81 tubes of different lengths, reflection coefficients and transmission losses were measured and found to compare very well with theoretical predictions. The method can also be used to measure the normal reflection coefficients of absorbent materials much more quickly than the traditional 'travelling microphone' method.

Noise Control including Active Control

Quadratic Optimisation Problems in the Active Control of Free and Enclosed Sound Fields

P A Nelson, A R D Curtis and S J Elliott
ISVR, University of Southampton

Given a point 'primary' source of known strength and a single point secondary source, it is possible to determine the strength of the secondary source which will minimise the net far field power radiated by the source combination. This analysis yields the 'best possible' reduction in net power output that could be achieved by active means. A similar approach can be applied to the active control of harmonic enclosed sound fields. In this instance, the total time averaged acoustical potential energy is the relevant quadratic function which has to be minimised. A theory will be presented which enables the determination of the optimal strengths of a given number of secondary sources placed at given locations in the enclosure. It will be demonstrated that for the particular case of a point primary source and a single point secondary source, in the high frequency limit, the optimal secondary source strength which minimises acoustical potential energy is identical to the optimal secondary source strength which minimises power radiated in the free field case.

Active Control of Harmonic, Enclosed Sound Fields of Low Modal Density: A Computer Simulation

A J Bullmore, P A Nelson and S J Elliott
ISVR, University of Southampton

A computer model is used to determine the effectiveness of an active noise control system applied to the harmonically excited low modal density sound field in a lightly damped two dimensional enclosure. The optimal reduction in total acoustical potential energy is calculated for a number of different secondary source distributions by optimising the gain and phase of each of the secondary source strengths relative to the primary source strength. It is shown that, for driving frequencies corresponding to acoustical resonances of the system, appreciable reductions in the overall acoustical potential energy can be achieved. The level of reduction obtained is shown to depend critically on source location, and a physical explanation for this is given.

A more practical means of reducing the overall acoustical potential energy is also presented. This involves sampling the sound pressure field at a number of discrete locations, and minimising the sum of the squares of these samples. It is found that, for any given secondary source distribution this method can provide reductions close to those of the optimal method whilst using surprisingly few sensors. However, the reductions are shown to be heavily dependent on sensor locations. The reasons for this are discussed and some 'good' sensor locations are suggested.

Error Surfaces in Active Noise Control

S J Elliott and P A Nelson
ISVR, University of Southampton

The aim of most active noise control systems is to minimise some error function. This may be the mean-square pressure at a single point, or the sum of the mean-square pressures at a number of points. The variation of this error function with each of the adjustable parameters of the active noise control system forms the error surface, which will generally be multidimensional. Examples will be presented of error surfaces from various active control applications.

The shape of the error surface will determine the success of adaptive systems. If the surface has a unique global minimum, a number of methods guarantee success, although they may be distinguished by the speed of adaption. The conditions under which the surface takes this shape will be discussed with special reference to active noise control systems in ducts.

The Application of Simple Source Theory to Active Noise Control

I Brown
University of Essex

Active noise control is the reduction of unwanted noise by radiating a sound wave of equal amplitude and opposite phase. This technology has been successfully applied to the noise emanating from the exhaust or air intake of reciprocating engines.

To get cancellation of a monopolar noise source in this manner, the antiphase sound must be radiated omnidirectionally from a point as close as possible to the noise outlet. However, perfect cancellation is only possible in one plane.

The desired aim of global cancellation would require the superposition of the noise and cancelling sources, which is obviously not possible for sources of finite size. As the noise and cancelling source are separated, a polar plot of the sound pressure reveals a dipole, whose maximum amplitude is a simple function of the separation and the wavelength.

A theoretical investigation of the degree of global cancellation for a single noise source and cancelling loudspeaker show the limitations of this configuration.

This paper considers the effect of altering the source configuration. Computer modelling has enabled a number of source configurations to be evaluated for their levels of global cancellation. This has demonstrated that much improved cancellation can be achieved by reconfiguring the exhaust/speaker system to radiate as a quadrupole, and has also indicated the importance of correct residual microphone positioning.

Infill Damping Treatments as a Method of Noise Reduction on Power Presses and other Structures

G Stimpson
ISVR, University of Southampton

Many machinery and other structures are often constructed as a welded fabrication of steel plates. Such constructions, unless treated, possess little inherent structural damping which can lead to high levels of noise radiation if excited into vibration by the working or other forces. Conventional damping materials, ie, stick-on layers, etc, tend to be ineffective on the thick sections of typical machinery structures without resorting to impractically thick damping layers. Many such structures, however, possess numerous internal cavities which, when filled with granular materials such as sand, gravel, lead shot, metal chips, etc, can instil substantial increases in structural damping.

Much current research is being performed at ISVR on this and other types of 'industrial' structural damping treatments, especially in relation to sand as an infill material. Experimental work will be described with regard to measurements taken on a one-third scale model of a 200 tonne straight-sided power press on which noise reductions of up to 10 dB have been achieved by the use of sand as a damping material in the internal cavities.

Adaptive Control of Periodic Disturbances in Resonant Systems

P Darlington
ISVR, University of Southampton

When a linear time invariant system is subjected to unwanted additive noise, a gradient searching adaptive noise cancelling scheme may be applied, given a reference signal correlated with the noise. For the case of a periodic disturbance, this reference need only take the form of knowledge of the noise's fundamental period. If the system is mixed AR/MA, then its 'memory' (considered in terms of the length of its impulse response) can impose a severe limitation upon the convergence rate and stability of the controlling algorithm, inhibiting the application of simple adaptive controllers to the highly resonant or reverberant systems typical of acoustic noise control problems.

The behaviour of the widely used 'Widrow Hoff LMS' algorithm is analysed in the context of control of periodic noise in a generalised system. An explicit description of the controller's behaviour is presented for any linear network, which takes the form of a simple time invariant frequency response function for certain noise signals.

The analysis is introduced by consideration of the control of a simple AR system characterised by a second order ordinary differential equation, subject to a sinusoidal disturbance. The effects of the resonance upon the adaptive controller's convergence rate are discussed by identifying the pole locations of the composite controlled system's frequency response, for various noise normalised frequencies. The generalisation to a periodic disturbing signal is then approached as an extension of the simple harmonic results.

The analysis is extended to the case of control of periodic disturbances in generalised systems, again with explicit discussion of the controlled system's

frequency response singularities for any linear network.

The results of the analysis are illustrated by a discussion of the application of a Widrow-Hoff noise cancelling system to:

i) linear communication channels with multiple reverberant delays due to incorrect line terminating impedances,

ii) electroacoustic elements of practical communication systems (headsets, mask/microphones etc),

iii) the control of periodic signals in bounded acoustic and other distributed parameter systems.

Some Transducer Design Considerations for Earphone Active Noise Reduction Systems

R C Twiney
Plessey Research (Caswell) Limited, Towcester

The use of the techniques of Active Noise Reduction (ANR) in an earphone can provide a considerable improvement in the comfort of the wearer and the intelligibility of a communications link through the earphone. This paper outlines some of the general design criteria for circum-aural earphone ANR transducers, particularly low distortion, small physical size and weight, good amplitude and phase responses and a wide dynamic range.

Movement of the earphone relative to the head can generate very large sound levels (140 dB spl) with most of the energy of the pulse being contained at frequencies below ~20 Hz. Although these pulses are inaudible they can force the system into non-linearity if it does not have sufficient dynamic range. By careful design a working ANR system has been developed which can generate 'anti-noise' levels of up to ~130 dB spl. The system generates a peak noise reduction within a 1/3 octave band of ~28 dB with noise reduction occurring across a bandwidth of ~2.5 kHz.

Economics of Active Attenuation of Noise

W Hong, K H Eghtesadi and H G Leventhall
Atkins Research and Development, Epsom

Abstract not available.

Active Attenuation in Small Enclosures

P A Brewer and H G Leventhall
Atkins Research and Development, Epsom

Abstract not available.

The Possibilities for Active Sound Reduction in Limited Spaces

E Lindqvist
Chalmers University of Technology, Sweden

Abstract not available.

Open Session

Finite Element Analysis of the Effect of Damping in the Piston and Surround of a Loudspeaker Diaphragm

C J C Jones
B & W Loudspeakers Limited, Worthing

A finite element model for the steady state vibration of a loudspeaker diaphragm is described. The widely differing loss factors present in the piston and outer suspension are incorporated in the computer program by assembling the global damping matrix from the element matrices. However this necessitates the direct solution of the equations rather than a modal analysis approach.

The technique of measuring Young's modulus and the loss factor for use in the model is described and a sample set of experimental results illustrating scatter and modal dependence is discussed.

Computed solutions are presented for a typical diaphragm over its operational range of frequency alongside corresponding measurements made using a laser vibration interferometer. The role of the surround is studied by comparing the analyses before and after it has been added to the structure.

The Acoustic Field of a Solid Dielectric Transducer with a Metallic Diaphragm

N Apostolopulos
Liverpool Polytechnic

Abstract not available.

Laboratory Investigation of Fundamental Noise Producing Mechanisms in Gaseous Combustion

B Dalamagas, J Roberts and M Vuillermoz
Polytechnic of the South Bank, London

Combustion generated noise has often been categorised in terms of a random distribution of monopole sources. This paper describes an experimental arrangement which has enabled the acoustic pressure from such small pockets of combusting fuel mixtures to be measured. Also described is the stroboscopic Schlieren technique which has enabled the size of the burning elements to be estimated. Data is presented on the relationship between the element size and the peak acoustic pressure measured, reasonable agreement is found between the measured and predicted results.

Noise Legislation and Standards

R Collman
Acoustical Control Engineers Ltd

Abstract not available.

Gas Film Damping of Mining Conveyors

S C Bennett
National Coal Board

In all automated mining processes, and particularly in modern long-wall coal mining processes, the initial transportation of the extracted mineral is via robust all-metallic conveyors (termed Armoured Face Conveyors, AFCs). These exist along the mineral face itself and for short sections along access roadways from where the mineral is then passed to belt conveyors which take it to the surface. In addition, shorter sections of these conveyors often form integral parts of the larger machines which are used to drive underground roadways. All of this equipment is located in areas where relatively large numbers of men may be permanently employed.

The paper describes a specific application of the damping of structural vibration by a thin gas film, as applied to the large metallic base section of these Armoured Face Conveyors. It will be appreciated that other damping treatments are inapplicable for this type of environment.

It will be shown how the theoretical calculations and experimentally derived values of Loss factor compare, using Impact excitation tests. Subsequently the predicted noise emission from the damped structure on an actual installed conveyor is shown to agree well with measured results.

Transportation Noise

The United Kingdom Aircraft Noise Index Study: Part I — Main Results

P Brooker and Catriona Richmond
UK Civil Aviation Authority

The Noise and Number Index (NNI) has been used over the past two decades in the UK for the assessment of noise nuisance resulting from aircraft flights at major civil airports. A number of criticisms have been made of the NNI: the relative weight attached to the number of aircraft movements in producing disturbance and the NNI being 'out of line' with other countries' noise indices are perhaps the two most important issues. The UK Department of Transport commissioned this study to either substantiate the NNI or, if necessary, devise a new index of aircraft noise disturbance. Noise measurements and social surveys were carried out in 1980 and 1982 at areas mainly around Heathrow, but also at Gatwick, Luton, Manchester and Aberdeen. Major elements in the study design and analysis were the determination of response measures to underpin an index and the statistical modelling of response relationships (see companion paper II). This paper presents a synopsis of the methodology and main results of the study, which, in particular, indicate that 24 hour L_{eq} — *without* a time of day weighting — is preferred to NNI as a measure of disturbance.

The United Kingdom Aircraft Noise Index Study: Part II — Statistical Analysis of Disturbance and Noise Exposure

P Brooker and Catriona Richmond
UK Civil Aviation Authority

The companion paper (I) presents the main results of the UK Aircraft Noise Index Study. A major element in the study design and analysis is the statistical modelling of response relationships. An aircraft noise index is formed from a combination of those physical variables representing noise exposure giving the most close match with people's disturbance reactions. The analysis of noise measurement and social survey data on response to aircraft noise must therefore contain two stages: the *measurement* of disturbance, and the *statistical matching* of this disturbance to combinations of physical variables. The former has involved a non-parametric statistical examination of both overt and covert responses to aircraft noise: the latter mainly uses step-wise multiple regression analysis. A careful sampling design has made it possible to determine the relative importance of the noise level and number of aircraft in generating annoyance. It has also been possible to assess the relative impact of noise exposure at different times of the day.

Taxiing Noise from Aircraft

J B Large and J Walker
ISVR, University of Southampton

Abstract not available.

Traffic Vibrations in Historic Buildings

P Ellis
Greater London Council

Abstract not available.

Drive-wheel Vibrations and Driver Discomfort in Earth Moving Vehicles

G J McNulty and D Douglas
Sheffield City Polytechnic

Previous work by the authors demonstrated that the ISO 2631: 1978 maximum acceleration levels, before driver discomfort, were exceeded at certain low frequencies. The principal area of concern was in the 'Z' axis direction where the problem frequencies appeared in the spectral analysis from each measurement site from axle to seat.

A test programme is being carried out to determine the static and dynamic characteristics of the wheel-tyre system for comparison with the frequency responses from the previous work on the travelling vehicle.

The tests involve a typical, large diameter drive wheel for an excavator, which is mounted in a test frame and subjected to forces via a hydraulic ram. The responses at tyre and axle have been recorded and found to correlate well with the data from the 'on-machine' analysis. This suggests that the tyre construction produces dynamic characteristics which are responsible for some aspects of driver discomfort on these vehicles.

ROPLAN — Software for Modelling Noise from Road Schemes

K R Tompsett
Atkins Research and Development, Epsom

ROPLAN has a wide range of applications in the analysis of road traffic noise. It enables a 3-dimensional model of a road and its surroundings to be built by digitising commonsense items directly from scheme plans, Ordnance Survey Maps, etc. Using computer graphics, the model can be viewed in plan, profile or perspective, or drawn to scale on tracing paper. These can be overlaid on the originals to give an easy but foolproof verification of the model. Results may be stored on a database, avoiding the problems of storing printouts but giving rapid recall of selected information. Comparison of results against measurements shows good accuracy and suggests that some accusations laid at the door of *Calculation of Road Traffic Noise* may be blamed more properly on the shortcomings of manual calculations.

Modelling Traffic Noise in High Density Development

L Brown
ISVR, University of Southampton

Abstract not available.

Propagation of Road Traffic Noise Over Ground of Mixed Type

S N Chandler-Wilde and D C Hothersall
University of Bradford

An approximate method, based on the boundary integral equation method, for the calculation of the propagation of sound from a point or line source over flat ground consisting of two half-planes of different impedance is presented. Some results are given comparing this method with the boundary integral equation method. The application of this method to the propagation of road traffic noise over level two-impedance terrain is described, and some L_{eq} contour charts are presented for the prediction of road traffic noise when the propagation path is partly hard ground and partly grassland. Comparison is given with experimental or field results.

The Acoustical Performance of a Right Angled Barrier

M M Radwan and D J Oldham
University of Sheffield

It is well known that the performance of a finite barrier differs greatly from that of an infinitely long barrier of the same height, especially when used to combat highway noise. One method of improving the performance of a finite barrier is to return it at one or both of its ends, ie the resultant barrier consists of a wall parallel to the highway with 'wings' at right angles to the highway at the ends.

This paper describes a scale model investigation of such a barrier configuration and an attempt to relate its performance to conventional finite barrier performance predictive techniques.

Human Response to Noise from Interrupted Traffic Flow

K S Jraiw and D Croome
University of Bath

The survey of road traffic noise associated with non-free flowing vehicular traffic in the city of Bath has provided an opportunity to investigate human responses to traffic noise and other parameters which characterise the urban environment. A social survey was carried out at 48 sites where there are already complaints about the effects of road traffic on the community. Sites were alongside the accelerating and decelerating streams of traffic from where they joined the traffic lights, roundabouts, and priority junctions, to an appropriate distance. Sites were selected to represent four types of land use and three types of traffic conditions in the city. The population had to be living or working along the roads and experience the effect of the traffic. Traffic noise was measured for 18 and 12 hours. The questionnaire consists of items concerning subjects' attitudes and different urban parameters. A 5 point scale was used. The correlation coefficients were obtained between noise indices and the individual dissatisfaction scores. Correlation between noise indices was gained. Also there was correlation between interview response items. High correlations were found between noise levels L_{10}dB(A) and annoyance scores, ie sleep disturbance = 0.60, intersections = 0.62. The correlation between individual annoyance from traffic lights and distance was 0.80.

Local Authorities' Traffic Noise Criteria

R A Hood
Travers Morgan Planning

Abstract not available.

Traffic Induced Vibration Disturbance — Results of a Jury Experiment

G R Watts
TRRL, Crowthorne, Berks

Traffic induced vibrations in residential properties are a widespread problem. Studies have shown that where the road surface is not uneven the vibration effects such as doors and windows rattling or buzzing and floors shaking or trembling are caused by low frequency airborne sound pressure waves generated by passing vehicles. The aim of the present study was to gain a better understanding of the relationships between noise levels and building vibration levels and disturbance. One objective was to determine scales of noise which were highly correlated with vibration disturbance and could be used as a basis for noise emission standards and environmental appraisal. A further objective was to determine vehicle types and their modes of operation which would produce the greatest degree of building vibration and disturbance. The paper describes a jury experiment where a number of residents made ratings of vibration disturbance inside the front room of a dwelling situated close to a heavily trafficked urban road. Individual vehicle events were selected for vibration assessment and noise and vibration levels were monitored. The analysis involved the correlation of these subjective and objective measures.

Application of Intensity Measurements

Sound Intensity Terminology

K B Ginn
Brüel & Kjær, Denmark

During the last four years interest in sound intensity, and intensity measurements in general, has increased dramatically. Many organisations and committees are at work on the preparation of standards for the determination of sound power using sound intensity. In the effort to qualify the measurement environment and the intensity measurement system several new concepts have arisen and have been defined. For the common good, divergence in the terminology of the various standardising bodies must be avoided as far as possible. This paper suggests a number of definitions and methods of employment of the following terms:

1. Active sound field
2. Reactive sound field
3. Reactivity index
4. Residual intensity
5. Residual intensity index
6. Dynamic capability of an intensity measurement system
7. Intensity nomogram
8. Calibration of intensity measurement systems

Sound Power Distributions in Branched Piping Systems

F J Fahy
ISVR, University of Southampton

The distribution of sound power in branched piping systems such as ventilation ducts and industrial networks is of interest to system designers and noise control engineers. At

present, estimates of the division of sound power at branches in such systems are based upon relatively little systematically derived experimental data.

The advent of sound intensity measurements greatly facilitates systematic studies of power flow in piping systems, at least in the plane wave frequency range below the first cut-off frequency. The results of such measurements in simple branched systems, at mean air flow speeds of up to 25 ms^{-1} will be reported. The performance of a form of dissipative attenuator which introduces negligible flow resistance into a pipe will also be described.

Sound Intensity Distribution in Ducts

F J Fahy
ISVR, University of Southampton

The distribution of axial sound intensity over the cross section of ducts at frequencies above the lowest cut-off frequency is of interest for a number of practical reasons. In the past, approximate estimates of sound power flowing in such ducts have been based upon spatially sampled distribution of mean square pressure over a cross section. In estimating the transmission of internal noise through pipe walls, assumptions have to be made about the relationship between the fluctuating wall pressures which excite the pipe, and the sound power carried by the pipe. The development of sound intensity measurement techniques now allows direct investigation of these relationships.

A brief theoretical discussion of sound intensity distributions in ducts, supported by numerically generated distributions in idealised cases, will be followed by a presentation of the results of experimental investigations made in ducts without flow, in which mean square pressure and intensity distributions are compared. The problem of extending the measurements to ducts carrying flow will be briefly reviewed.

Offshore Intensity Measurements

M J Newman and O K Ø Pettersen
SINTEF, Trondheim, Norway

The tight packing of powerful equipment in reverberant steel modules on offshore platforms makes the assessment of their sound power levels difficult using normal pressure measurements. Sound intensity measurements, with their inherent ability to describe direction as well as level, have made the assessment of equipment power levels (in-situ and at normal operating conditions) much easier.

Two intensity measuring systems have been used in the field, one based on an FFT analyser and microcomputer and the other using a two channel real time 1/3 octave analyser. The FFT based system using the two microphone method and the 1/3 octave analyser using both this method and a special pressure and velocity transducer. Point by point and scanning techniques have been used to sample the measuring surface. These field measurements have been backed up by laboratory work, to test the effectiveness of intensity measurements in ignoring background sources of noise.

The work has been sponsored by Norwegian oil companies, to produce a survey method for the use of intensity measurements, for the determination of machinery sound power levels under difficult conditions, on offshore platforms.

Measurement Techniques for Assessing the Contribution of Individual Sources to the Noise Level in a Multiple Source Environment

P R Wagstaff and J C Henrio
Université de Technologie de Compiègne, France

Many industrial environments suffer from high noise levels at certain points which cannot be easily attributed to a particular noise source, but which are the result of the combination of the acoustics of the site and the effects of several noise sources. The origins of the noise are more difficult to detect in highly reverberant situations where the directive effects of noise radiation are masked by the multiple reflections which take place.

If measurements can be made of the characteristic vibrations of each source the energy contributed by each to the overall noise level at any point can be found by calculating the transfer functions between the source reference signals and the measured noise level. In order to obtain acceptable results the transfer function should include all the possible reverberations of the source radiated noise. In the case of sources which are linked together in some way the noise spectra of the sources are generally partially coherent and it is necessary to use partial coherence and multiple input techniques to calculate the transfer functions involved.

These techniques have been applied to measure the contributions of the inlet valves and the high pressure turbine to the noise level in the turbine hall of a Nuclear Power Plant.

Selective Acoustic Intensity Measurements of the Radiation of Surfaces Subject to Single or Multiple Excitations

P R Wagstaff and J C Henrio
Université de Technologie de Compiègne, France

Acoustic intensity measurements are becoming normal practice for many types of diagnostic work using the standard two microphone method. Where the noise is transmitted by a vibrating surface the selective intensity technique using a source reference signal can improve the quality of the measurements in certain cases and also permits additional information to be obtained about the contribution of each source to the radiated noise. Where the sources exciting the vibration are totally independent the intensity vector can be decomposed into the components due to each source by using the reference signal for each source to condition the signals of the intensity probe.

Results are presented for a system possessing two sources exciting the same structure with uncorrelated and partially correlated source inputs. In the latter case the results require correction because of the measurement contamination of the source reference signals.

Acoustics of Buildings and Building Services

Transmission Loss Measurements in a Full Size Model of a Timber Frame Building

X Bohineust and P R Wagstaff
Université de Technologie de Compiègne, France

As part of an investigation into sound transmission in timber frame buildings a full size model has been built using standard construction techniques. The transmission loss of the dividing wall has been obtained by assuming a diffuse field in each room and using averaged sound pressure levels each side of the wall to calculate the incident and transmitted intensity.

This result is compared with that obtained by making acoustic intensity measurements over the surfaces of the different walls in the receiving room to calculate the transmitted intensities.

The difficulties encountered in this type of measurement are discussed and the advantages and disadvantages of each method for on-site measurements are presented. Ways of overcoming some of the problems are described.

Transmission Loss of Double Partitions Containing Resonant Absorbers

J Enger and T E Vigran
University of Trondheim, Norway

An increasing demand for better sound insulating properties of building facades, especially at low frequencies, has triggered an experimental study on using resonant sound absorbers in double glazing units. Due to the small amount of damping, the transmission loss of such windows is normally very low both at the double wall resonance frequency and at the lowest lateral modal frequencies.

Using resonators at one of the edges, an improvement of 8-10 dB was obtained measured in 1/3 octave bands. The improvement in insulation afforded against typical road traffic noise is calculated to be of the order of 4-5 dB(A).

Services Noise Control and Crosstalk in Curtain Walled Buildings

P H Allaway
Grootenhuis Allaway Associates

Abstract not available.

The Effects of Duct System Design and Final Balancing on Airflow Generated Noise in Air Conditioning Systems

R F Willmott

In the past the major emphasis in the design of ducted systems serving noise critical areas has been the incorporation of sufficient primary attenuation to reduce the fan noise to acceptable levels. An analysis of noise problems encountered on site, however, indicates that at least 60% of complaints of noise from ducted systems are due to airflow generated noise caused either by unsatisfactory system design or by inadequate final commissioning.

Many engineers, when designing a duct system, use the principle of 'guideline air velocities' for serving areas with a particular NC level and this is sometimes quite satisfactory. However, all systems are different and this can lead to both underdesign or gross overdesign depending on the complexity of the duct system.

Another design aspect which is nearly always overlooked is the layout of the various components in the system, particularly fans and terminal units. The inlet and discharge conditions of the fans will dramatically affect the 'in duct' sound power levels and it has been found that in certain circumstances, where centrifugal fans are selected to work above their optimum duty range and this is combined with a plenum discharge, fan instability can result, with an excessive increase in very low frequency noise, sometimes in the infrasound (0-30 Hz) region. This type of noise problem is almost impossible to cure using remedial treatment, since conventional attenuators are almost transparent at this frequency.

Finally, the commissioning of the duct system itself is of paramount importance, particularly in the low velocity systems. It is possible to balance a duct system in many different ways but only with the proportional balancing system will the final noise level in the conditioned zone be the minimum.

Noise and Vibration Control in Microelectronics Clean Rooms

D Malam and W Hong
Atkins Research and Development, Epsom

Clean rooms used for microelectronics production require large air handling units and utility plant to be close to clean areas, where sensitive wafer fabrication equipment is located. This close proximity makes the economic design of a facility more exacting than many conventional buildings.

An approach to quantifying the significant sources of vibration affecting a building structure, together with the dynamic response, will be discussed.

Identification of appropriate noise and vibration criteria, site qualification by measurement and continuing liaison with structural designers, architects, process engineers, vendors and the end user are critical to the design process.

Site as a Laboratory

A Fry
Sound Research Laboratories Ltd

Abstract not available.

The Sound Absorption of Upholstered Church Pews

L W Bean
Humberside College of Higher Education

Adding cushions has improved the acoustics of a church. From reverberation time measurements the extra absorption has been calculated. This has been done on the basis of Eyring's formula, and allowance made for different air absorption at the times of the measurements. The absorption is high at all frequencies from 125 Hz to 8000 Hz. There is some evidence of increased absorption at certain frequencies.

Digital Modelling of Room Acoustic Frequency Response Functions

S P Hough, P Davies and P A Nelson
ISVR, University of Southampton

The analysis of room acoustic frequency response functions is particularly difficult in the mid-frequency range. Statistical methods are applicable at high frequencies and at very low frequencies a relatively small number of room modes may dominate the response. Between these regions, room modes are too numerous to be easily accounted for individually yet the response function may still vary considerably with frequency. For the purposes of modelling the frequency response function, it is hypothesised that each 'group' of adjacent room modes can be modelled as a single second order system. The frequency response function is then treated as though it has only a fraction of the actual number of degrees of freedom. This is tested by using sampled time histories of loudspeaker volume velocity and room sound pressure in order to determine the coefficients of an autoregressive moving average (ARMA) model. These coefficients are found using a recursive least squares (RLS) algorithm. This paper describes the RLS-ARMA method and its application in modelling room acoustic frequency response functions. The influence is considered of sample rate, number of data points and choice of model order. The problem of modelling filtered data is also addressed.

Sound Insulation in Rehabilitated Tenements, Glasgow

W N Hamilton and R K McLaughlin
Glasgow College of Building and Printing

During the past eighteen months the Building Acoustics Group of the Glasgow College of Building and Printing has been working with several local housing associations on the problems related to sound insulation for timber joisted floors in rehabilitated tenement properties in the city.

A range of options has been explored in an attempt to determine appropriate specifications for floors which have been treated, partly or completely, during rehabilitation and for floors which are found to be sub-standard after re-occupation.

The options have included top surface, between joist and under ceiling treatments, and have involved both traditional and special methods.

This paper reviews and appraises the work carried out over this period.

An Investigation into the Noise Generated by Volume Control Dampers in Air Distribution Systems

Diane M Fairhall
Polytechnic of the South Bank, London

An investigation is made into the noise generation properties of volume control dampers in ventilation air conditioning systems. The report presents experimental measurements of noise generated by air flow over both parallel blade and opposed blade dampers at several air velocities and a range of blade angles of attack to the air stream.

The measurements are analysed in order to develop prediction techniques for noise generated by dampers in ducts. Overall sound power level is related to the blade angle and to the pressure loss coefficients of the dampers at different velocities and blade angles.

In the case of the parallel blade damper, the overall sound power level is found to be proportional to the pressure loss coefficient. However, the relationship linking the sound power emitted by the opposed blade damper is not yet clear, since present results show marked differences between the two types of damper.

Hearing and Noise Damage to Hearing

Noise Induced Hearing Loss in Singapore

R B W Heng
National University of Singapore

In Singapore there is now an emphasis on the industrial health and well being of workers. A recent Government requirement is that factory doctors have to undergo a course on industrial hazards faced by the workers. This move is timely with a constant emphasis on higher productivity and the tendency is towards increased mechanisation. In the past there has been either an insufficient education of the industrialist or else little effort on his part so that workers are often exposed to dangerously high noise levels. Amongst the most serious offenders in the local industry are the textile and the heavy metal working industries. In many cases the situation is worsened by the high number of overtime hours taken on by the worker. In this paper some aspects of noise induced hearing loss are reviewed and elaborated upon in the local context.

In association with proposed construction noise regulations, a study is made of the subjects on whom records were maintained in the various industries and audiology clinics of the air conduction thresholds of patients investigated for acoustic trauma. The study investigated patients who had had a diagnosis of noise induced hearing loss with a minimum of 5 years of noise exposure and looks into their background and working environment.

At the same time, a study is made of a systematic audiometric screening of young undergraduates in the first year of the National University of Singapore Engineering Course which has been in progress over the same period. Preliminary results show that a small number of these have minor hearing problems. Although the situation is far from serious at the present the trend cannot be ignored as these young adults are only just beginning their careers and their exposure to industrial noise may not even have begun.

In all cases, the subjects were audiometrically evaluated in sound proof booths specially made for the purpose in the various plants or in the Ministry of Labour, the Singapore General Hospital and the National University of Singapore.

Differential Susceptibility to Noise Induced Hearing Loss

B W Lawton and D W Robinson
ISVR, University of Southampton

The distribution of hearing loss resulting from damaging noise exposure is known to be skewed toward higher losses. Susceptibility to Noise-Induced Hearing Loss must therefore be differentially distributed throughout the population. This paper will show how NIHL develops by imposing a skewed damage susceptibility distribution upon a population exhibiting a Gaussian distribution of Hearing Threshold Levels. As damaging exposure accumulates, a clearly identifiable noise-resistant fraction emerges among those individuals who retain acute HTLs in spite of noise exposure (and increasing age). This observation suggests the possibility of turning the NIHL susceptibility problem on its head: Is there some property present in the ears of older 'hearing survivors' which can be used to predict which young, non-exposed ears will be resistant to NIHL?

Dynamic Binaural Processing: Masked Threshold Level Adaptation with a Non-stationary Masker

T M Shackleton
University of Surrey, Guildford

The experiments to be reported study the dynamic properties of the binaural hearing system. The state of adaptation of the binaural system to a temporal change in the interaural noise correlation is mapped using the masked threshold level of a pure tone pulse as a probe.

Preliminary work using No to N_π to No ($No_\pi 0$) or $N_\pi o_\pi$ correlation changes shows that i) the binaural system adapts slowly to such changes; ii) there may be a significant non-linear effect due to the length of correlation change; and iii) there may be a difference in the rate of adaptation for the $No_\pi o$ and $N_\pi o_\pi$ conditions.

Experiments to validate and extend these findings are currently running and will be reported, together with an analysis of theoretical consequences.

This work has far reaching consequences, since the current models of binaural processing either ignore, or have not been developed to predict the consequences of non-stationary input signals.

Measurement of Impulsive Noise Exposure

I R Price and E J Walles
Health and Safety Executive

The indications of a sound level meter set to PEAK response and IMPULSE response are compared for a range of electrical test signals. These consist of tone-bursts of varying duration, amplitude or frequency and recordings of two impulsive industrial machines (drop forge and power press). The calculated Leq of the tone-bursts is presented for comparison.

The Comparison of the Calculated Assumed Attenuation of Hearing Protectors using Two Methods — Department of Employment Code of Practice Method and Proposed ISO Single Number Ratings Standard

I R Price
Health and Safety Executive

The assumed protection of a hearing protector can be calculated from octave-band attenuation data for the protector using the procedure described in the Department of Employment Code of Practice for Reducing the Exposure of Employed Persons to Noise. The octave-band data being obtained according to BS 5108. An ISO Draft Proposal DP 8353 sets out a single number rating method for hearing protectors which potentially offers a simpler method for selecting hearing protectors for a particular application. This Paper compares the degree of protection calculated for a large number of hearing protectors for a range of industrial noise spectra using both methods of assessment.

Microprocessor and Computer Applications in Acoustics

27 November 1984, at the Society of Chemical Industry, Belgrave Square, London

THE first conference bearing this title took place in 1980 and demonstrated the diversity of interest in the field. This led to the idea for a further conference, four years on, to assess the developments in the fast changing world of microprocessors and computers. The wide range of papers submitted gives an idea of the jumps that have been made and the novel and imaginative uses that have been employed.

Demonstrations were a key part of the conference, as being an efficient means of communicating in an area with a language of its own and contributors are to be thanked for their efforts in providing such interesting exhibits.

Since Abstracts were not published for this Conference, brief details of each paper are given below.

Integrated Acoustic Navigation Systems, by P Dore of Bell Electronics

The Intelligent Transponder System has been developed by Bell Electronics to fulfil the industry's demands for a truly remote ranging and telemetry system encompassing roles of navigational transponder, remote unit for auto-calibration of a subsea grid and flexible node linking activities on the seabed to those on the surface using an inherently error free bidirectional data/command link. This flexibility is afforded by the use of microprocessor technology with modular control software, logical definition of software and unambiguous storage of all data. Modularisation is a key feature of the software design as states and modes of operation can easily be separated and their interfaces redesigned facilitating simple expansion to meet future requirements. The acoustics interface, packaging techniques and software and hardware reliability are addressed as crucial stages in the system design.

High Resolution Mechanically Scanned Sonar, by A Fenwick of dB Instrumentation Ltd

A high resolution sonar to give increased definition in turbid water has been developed by dB Instrumentation Ltd. It is capable of movement about two axes and has two range scales. Intended for mounting in an ROV, it is small in size and controlled via a serial line. All major functions are performed by a microprocessor, including the closing of a servo loop, and generation of one of two TV/GF characteristics. The state variable philosophy has been used to control real time operations. A complete and economical solution to the design of CPU and interfacing functions was found by the use of VECTOR MMD16 Eurocard boards. Because of the serial interface the unit can be readily integrated into an overall scheme for instrumentation of an ROV.

Applications of Commercial Microprocessor Technology to Acoustic Instrumentation, by A J W Myles CEL Instruments Ltd

The paper covers three instruments: the CEL 393B, 262 and 160/2B.

The CEL 393B possesses the ability to automatically sweep-scan third octave or octave band spectra by automatically calculating optimum filter dwell time before placing spectra in memory for subsequent recall or down-loading for further manipulation. Applications include building acoustics, sound power measurements and general frequency analysis. Down-loaded spectra may be subject to software subtraction and/or weighting and summation.

The CEL 262 possesses both RS 232 serial and IEEE 488 interfaces, both of

which copy the digital print format. The serial output is ideally suited to data-logging semi-permanent installations and the parallel interface is provided for modelling since raw statistical data can be passed over the interface.

The CEL 160/2B is a software development version of the CEL 160 Graphic Recorder. The software implementation enables automatic control of a noise generating system to provide RT60 measurements both digitally and with analogue trace.

Constraints on Acoustic Detection in Very Noisy Environments, by C F Ross and M Blakemore of Topexpress Ltd

This paper discusses the identification of low level signals in a noisy environment using an array of transducers. The way in which the optimum performance is limited by the properties of the signal and noise environment is analysed. The paper goes on to describe the practical constraints imposed by a realistic microprocessor implementation. A brief specification of a recently developed system is presented.

Desktop Computers for Acoustic Test Houses, Studio Tuner Selection, and Mechanical Services Attenuator Selection, by A T Fry of Sound Attenuators Ltd

This paper describes how Sound Research Laboratories Ltd and Sound Attenuators Ltd employ a microcomputer system to aid their laboratory work in the determination of sound power level, sound reduction index and studio tuner selection. In addition the system is used for both technical evaluation and business applications.

Some Applications in Acoustics of a Microprocessor System Especially Designed for Signal Processing, by S Flockton of Chelsea College, University of London

The paper discusses possible applications of the growing range of a new generation of microprocessors, programmable signal processors in acoustical measurement and signal processing. Their capabilities are summarised, some currently available devices are compared and finally there is a brief look ahead to the advances that are expected in this area in the next few years.

A Portable Field Noise Microcomputer, by B C Ross and L M Linnett of the Health & Safety Executive

A portable field noise microcomputer is described. The system incorporates an octave band filter set and allows data to be acquired, processed and printed on site. The data shows the time history of the noise, the Leq for the period and suitable hearing protectors.

Acoustic Reverberation Kit — A New Tool to Assist In Acoustic Measurements, by A Mornington-West and J A Bray

The franchise to operate an Independent Local Radio Station in the UK is awarded by the IBA. The acoustic and electronic performance of each station is required to meet the provisions of the Authority's technical Code of Practice. The paper discusses aspects of the Code relating to acoustics and describes a new microcomputer driven equipment which facilitates such measurements as reverberation time, background noise and isolation.

A Flexible Signal Processing System, by C Mercer, Prosig Computer Consultants

A package is described which provides a powerful flexible analysis tool, allowing rapid processing of data. A brief discussion of selection of analogue to digital conversion is given and an example of the use of such a system in the design and development of a high quality loudspeaker is shown. □

Acoustics Bulletin

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CITATIONS

RAYLEIGH MEDAL FOR 1985
Professor P J Westervelt

Peter Westervelt spent the years 1940 to 1950 at the Massachusetts Institute of Technology, first doing wartime work at the Radiation Laboratory and the Underwater Sound Laboratory and thus becoming heavily engaged with acoustics. He went on to take his degrees there, culminating in a PhD. In 1951 he moved to Brown University at Providence RI, where most of his research has been carried out, either alone or with his students and colleagues.

His acoustic work relates to both sound in air and sound in water, and also includes some on second sound in helium. The unifying point of the majority of his research is that it concerns high-amplitude or non-linear effects: there are a great many such different phenomena and Peter seems to have worked on them all, and sometimes to have started the subject. Acoustic waves produce a steady force or radiation pressure, and he has written on this. They can lead to a streaming or steady flow, and this is one of his study areas. Due to non-linearity in the medium sound can be scattered by sound, sound can effectively be absorbed by sound, and the circle is closed by his reporting on the non-scattering of sound by sound. He is responsible for the parametric acoustic array, of which more anon, as well as taking an interest in the active acoustic receiver which employs an auxiliary pump source. Second harmonic generation is well-known, and he has studied this for the plane piston. He has covered two different aspects of the interaction with heat: on the one hand heat transfer can be affected by sound, and on the other the sudden deposition of heat by a laser source can result in rapid expansion and sound radiation. A similar mechanism operates with high-energy particles such as neutrinos, which may therefore be detected acoustically.

Professor Westervelt is perhaps best known for the parametric acoustic array, in which two high frequency signals beat together in space. The medium non-linearity results in the generation of a low-frequency difference tone which constitutes an effective end-fire array. Thus a highly-directive low difference-frequency may be achieved using only a small transducer, since necessary size depends on the high and not the low frequency. This idea was first described in the early 1960s and has since grown into a large and flourishing subject.

Peter Westervelt's second research area is in general relativity, and, although this will not be covered here, it is worth mentioning some other work half-way between. His interest in gravitational waves is exemplified by his study of their effect on a mechanical oscillator, and he has also described a gravitational wave analogue to the parametric acoustic array!

If we broaden this account beyond research matters we may note Professor Westervelt's service on many important bodies as member or as chairman, for example the NAS Sonic Boom Committee and the NRO Committee on Hearing and Bio-acoustics. If we broaden it beyond the confines of NE America we note his long association with the University of Texas at Austin, and remember that he has lived and worked and become very well known outside

NEW ELECTIONS

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

Fellow

M J Earwicker	J A Gallego-Juarez	C H Harrison	D Stansfield
P B Fellgett	W S Gan	C J Manning	J W Tyler

Member

S Benton	S Ellis	P Hunnaball	S A T Stoneman
R C Brown	M R Forsdyke	K T Kan	W J Strang
A J Colthurst	G P Frost	S S-Y Lau	M R Taylor
D A Cordner	T E Gorman	E A MacGregor	D Trevor-Jones
R Crampton	S A Grundy	N Marshall	J T Wade
R G Daunton	L G Haslam	T J Murphy	N F Wan
N M J Dekker	R S Harrison	C M Reading	K A Worthington
P Ellis	G A Hearn	J H Richardson	

Associate

D Appleby	W C Frame	C A Lewis	K J Penny
C B Beggs	S J Garlick	C Lofts	J L Rose
M Bishop	S R Glass	J D Longman	M Sawyer
J G Boulton	G S Greenhill	K Malcolm	G A Shippey
M W Bullock	U Guggenbuhl	D Martin	L Smith
M Carnegie	I P Hale	G D Mather	A W M Somerville
G B Charles	S R Handley	D Maynard	J E Swistek
S M M Cheung	A D G Harvey	H K Milne	M Taylor
R I Clark	D J Hawes	F C M Moor	R Thorne
J J Conners	A R Hearl	C P Moore	C Tringham
T J Cromarty	D Hind	I Moore	J T Wade
L B Cronin	D Horrocks	R J Moores	R A Whitehouse
N Dadkhah	D M Howard	D A Muir	D P Williams
P A Daley	R H Jamieson	J H McColl	G J Williams
W A Deighton	A J D Jarvis	S Nejand	M K Winter
A Denholm	E Kruzins	D C Nevitt	A M Woodward
I P Fletcher	H Latham	J Nicol	

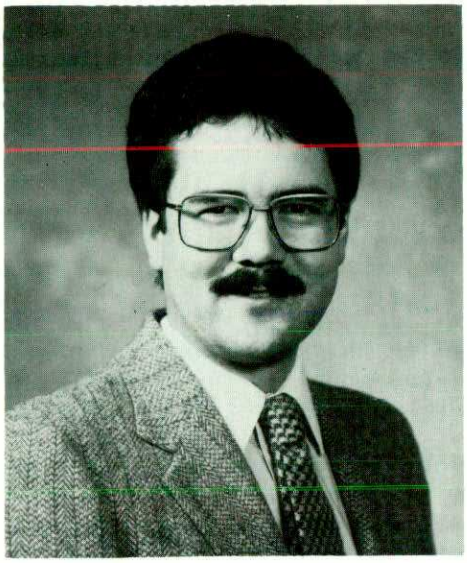
Student

C Bean	P L Hamblin	D N Howell	T M Shackleton
P Cosgrove	N J Haywood	T E M Noble	

the USA. In particular in 1951-1952 he was attached to ONR London, collaborating with British scientists.

From all this it may be judged that parametric arrays and non-linearity and Westervelt are practically inseparable. For his unique and far-reaching contributions to non-linear acoustics the Institute of Acoustics presents Peter Westervelt with the Rayleigh Medal.

A B WOOD MEDAL AND PRIZE FOR 1985
Dr T K Stanton



Since graduation Timothy Stanton has had no less than three careers in underwater acoustics, with three different organisations, and has succeeded in making significant contributions in three different areas of underwater acoustics.

During the years 1975 to 1978 he was a Physics Research Assistant at Brown University in Rhode Island, carrying out studies towards his PhD. These concerned the non-linear interaction of high-frequency sound with noise in water, which can result in a calculable absorption of the noise, and in fact his measured effects agreed well with expectation. In this period he was also responsible for the design and implementation of novel instrumentation for power measurement in a reactive acoustic field.

From 1978 to 1980 Dr Stanton had industrial experience in sonar, working for the Raytheon Company as a senior engineer. Among his many efforts at this time may be mentioned his published research on fibre-optic devices as hydrophones.

In 1980 he joined the University of Wisconsin, Madison, where his experimental and theoretical interests have been in scattering or remote sensing. He has worked on the acquisition and the understanding of echo returns from marine organisms such as fish and plankton, paying particular attention to the distribution in level of the returns from dense aggregations of animals. Timothy Stanton's modelling of this process, with overlapping echoes, fits the data well. Another acoustic scattering problem concerns the remote sensing of the roughness characteristics of the sea-floor, and here he has applied broadly similar techniques. He has helped to demonstrate just how much can be learnt both in bioacoustics and on the sea-bed by these important methods.

This record identifies Dr Stanton as an inventive worker, prolific in his publications, who is fast in finding his feet in each new field and who tackles each new job with enthusiasm. It is for this distinguished work in several different aspects of underwater acoustics that the Institute of Acoustics presents him with the A B Wood Medal and Prize. □

Appreciations

Robert Bruce Lindsay

The international world of acoustics will have heard with sadness of the passing of Robert Bruce Lindsay on March 2nd of this year. He was in hospital last year with congestive heart disease but appeared to have made a good recovery. However late in February his heart began to weaken and he returned to hospital where he passed away peacefully with his wife, Rachel, at his bed-side.

He was a philosopher, educationalist, research worker and writer who was originally interested in spectroscopy but at Brown University as Head of the Physics Department he created a very active acoustics research group. This had a close linkage with the Applied Mathematics Department, where Professor Ronald Truel and his colleagues were concerned with ultrasonic instrumentation. As indicative of the strong team of acoustic researchers Bruce gathered around him, may be mentioned the names of Professor Robert Beyer and Professor Art Williams. The Acoustics Laboratory achieved an international reputation under his guidance.

Bruce's work was appreciated worldwide and he is an Honorary Fellow of The Institute of Acoustics. Among his other honours was the Gold Medal of the Acoustical Society of America. Probably however, the most outstanding achievement of Bruce was his guidance and development of the Journal of the Acoustical Society of America since its inception to its present unrivalled position as the leading Journal in Acoustics. He was still Editor-in-Chief at the time of his death at the age of 85. He was a staunch friend and his penetrating voice was louder than his bark. He and his wife will be much missed from the acoustic scene and our sincere sympathy is with Rachel and their son and daughter at this sad time.

RWBS

Ivan King

We are sad to have to record the sudden death on 3 January of Ivan King FIOA at the age of only 42 years.

Ivan was well known and loved for his work at the Polytechnic of the South Bank in London where he was a Senior Lecturer. He joined the then National College of Heating, Ventilating, Refrigeration and Fan Engineering in 1968, specialising in applied acoustics. In 1982 he moved to the Extra Faculty Unit where he was course director for the Occupational Hygiene degree, dedicating himself to the creation of the Centre for Industrial Safety and Health. He was also a cornerstone of the MSc degree course in Environmental Acoustics, lecturing and tutoring in the area of subjective and building acoustics. His research interests included audiometry, particularly the hearing of the very young. He also served on a number of BSI committees and as secretary to the Education and Training Committee of the British Occupational Hygiene Society.

For the student he was the ideal teacher, encouraging the challenging of fundamental assumptions and preferring to give his explanations in terms of the real world rather than mathematical concepts.

Ivan will be remembered for the dedication to his personal ideals, for his active interest in music, and for his wit and dry sense of humour. We extend our sincere condolences to his family; he will be sorely missed. □

The 23rd International Acoustic Conference of the Czechoslovak Scientific and Technical Society

Physiological and Psychological Acoustics, Acoustics of Speech and Music.

Ceske Budejovice, 2 - 5 October 1984

The Acoustic Conferences of the Czechoslovak Scientific and Technical Society provide useful opportunities for acousticians from West and East to get together and discuss common research problems; the 23rd Conference was no exception. There were approximately 96 papers (some were not presented at the last minute), about 15% from the Western Countries. These were arranged in three parallel sessions, two of verbally presented reports plus one of poster papers. A useful idea, new to your reporter, was that there was a daily plenary meeting before sessions started wherein each of the authors of poster papers gave a five minute outline to the assembled delegates.

The Conference itself was held in the Hotel Gomel, a comparatively new building having all the features of smaller modern hotels. To the annoyance of most of the delegates, though, it was distinguished by service of an almost record slowness. It was quite easy to take one and a half hours over a two course lunch without coffee. Simultaneous translation between English, Czech and Russian was provided by the Czechoslovak Scientific and Technical Society; this was of a very high quality and extremely useful. The translators deserve a special mention for their contribution to the success of the Conference.

As usual there was a core of Invited Papers intended to describe recent progress in the subject matter, not necessarily by the author or his group. The remainder of the papers were shorter contributions describing more limited topics. The Invited Papers had the following titles and authors: *Coding of frequency at cochlear nerve level* by Evans of the UK; *Comparison of activity in the auditory nerve with acoustic and electric stimulation of the cochlea* by Klinke and Hartmann of the BRD; *Psychological aspects of playing musical instruments* by Bowsher of the UK; *Stimmungscharakteristik von Blockflöten und ihre spieltechnische Korrektur* by Wogram of the BRD; *Impedanzcharakteristik und akustiche Eigenschaften von Blasinstrumenten* by Krüger of the DDR; *Auditory image movement and binaural masking level difference* by Altman of the USSR; *Acoustics of music and speech-some common factors* by Rakowski of Poland; *Glottal voice source in singing* by Sundberg of Sweden; *Discrimination function and the perception of German vowels* by Tscheschner of the DDR; and *Discriminant analysis of inter-phoneme and inter-speaker differences affecting the formant frequencies of Polish vowels* by Jassem of Poland.

One special Invited Paper is not listed above and deserves mention: Professor Novotny, the leader of the Prague String Quartet, gave a short paper in the afternoon on intonation problems in music and also gave an informal talk on the first evening liberally laced with his views on ergonomics, psychology, physiology etc, on why he considered the violin to be the best musical instrument it is possible to invent. He was an enormously enthusiastic speaker and concluded with performances of several unaccompanied violin pieces. Many European acoustical conferences make a feature of the importance of musical acoustics as the cornerstone of our subject.

The contributed papers are too numerous to list in detail, but are available in the Conference Proceedings. They covered the whole range of material suggested by the title of the Conference. The Conference organisers arranged the papers into sessions of broadly similar subjects, but, as usual, their opinions were not universally acceptable. Going through the papers again afterwards using a not too rigid partitioning scheme revealed that 35 were on Musical Acoustics, 16 on Physiological Acoustics, 25 on Psychoacoustics and 20 on Speech. It is not possible to review the presentations of these papers adequately owing to the pressures on time imposed on invited visitors. As an aside it may be worthwhile mentioning that in a way it is a mixed blessing to receive an invitation to a conference. It is, of course, very flattering to be asked to give a paper, to be a Chairman, and to have special tours of places of local interest. Many people gave up much time to arrange that all had an enjoyable time. A consequence, however, was that there was no time available to attend papers from other sessions and even some in the session of main interest had also to be missed.

The overall standard of the Conference was very high and some papers were truly stimulating and thought provoking. It was interesting to observe how similar conclusions about problems can be reached from different starting points and by different routes. There was an emphasis on Musical Acoustics which reflects the close relationship between the Research Institutes and the manufacturers on the continent; but some of that work revealed that perhaps too much emphasis was being placed on immediate solutions and not enough on the underlying science. The sessions on Physiological Acoustics and Psychoacoustics had a most welcome breadth of papers from many countries and there was much discussion here. The Speech papers afforded a chance to hear of work on unfamiliar languages — dare one suggest that English, with its particular tonal structure, has been rather too dominant in the thinking of the speech research community? There is much interest in speech research in the Eastern countries and preliminary announcements of important meetings next year were made.

Overall, then, the Conference was well worth visiting, it was well organised and had a pleasant, informal atmosphere which added to the usefulness of the discussions on a wide range of acoustics. □

J M Bowsher

12th ICA

The 12th International Congress on Acoustics is to be held in Toronto, Canada, from 24 July to 1 August 1986, providing an open scientific forum in all fields of acoustics. In addition, Symposia are planned on specific topics before or after the Toronto meeting; Internoise 86 will take place in the eastern United States immediately before the Congress (July 21—23). Further information may be obtained from:

12th ICA
Secretariat
Box 123, Station 'Q'
Toronto, Canada
M4T 2L7

BRANCH AND GROUP NEWS

News from STAG

NPL Involvement in a National Speech Technology Assessment Programme

There is a need to promote standardised procedures in the areas of performance assessment of speech recognition and speech synthesis equipment. The Speech Technology Assessment Group (STAG) has decided, therefore, to make an approach to the National Physical Laboratory as an independent body whose main function lies in the Standards field. As a result, the NPL has agreed to collect together copies of the many different recorded English language speech data bases in order to form a national archive of materials which can be used for the assessment of speech technology devices. This material will form the basis of a study of the problems involved in establishing a national speech technology assessment programme.

Some of these activities have already been identified by STAG. In addition to establishing the archive, these include: exploratory tests of speech recognisers using existing test materials; the development and proving of new methods of assessment; the provision of adequate descriptions and measurements of data base materials; the provision of additional test materials needed for any new tests devised; the definition of recording standards and the provision of advice and guidelines for potential customers.

In support of NPL's programme of activities, a consortium of interested bodies has made a submission to the Alvey Directorate to carry out work in support of a national assessment programme which will cover many of the areas identified by STAG.

R K Moore

North West Branch

Testing Hearing Defenders

The Annual General Meeting of the North West Branch on Wednesday, January 30th was followed by a talk and demonstration by Ian Hempstock of the Department of Applied Acoustics of the University of Salford and Paul Clarke of Inspec. They brought an interested audience from industry, local government and acoustic consultancy up to date with that part of the hearing conservation world concerned with hearing defenders and their testing.

Firstly, Ian Hempstock identified the University of Salford as being one of the three establishments within the United Kingdom approved to conduct testing under British Standard 5108, and reviewed the current construction of 'Muffs' and 'Plugs' and the use of 'glass down', indicating their respective performances. Communication difficulties were highlighted as illustrated in drop forging processes in the heavy engineering industry, together with 'localisation' difficulties which can occur when hearing defenders are in use.

Paul Clarke of Inspec then continued the evening with a broad overview of the four-part British Standard 6344 and concluded that information provided in the past with hearing defenders had been inadequate for the correct use and care of the product. Paul described laboratory testing of hearing defenders, taken in batches of six for variability, through British Standard 5108 and the method of objective insertion loss measurement. Details of mechanical testing at laboratory temperatures of 23°C ±5°C, together with comfort testing, were also explained in some detail. Questions asked of both speakers included the percentage number of failures now and in the past, any correlation between acoustic testing in both anechoic chambers and reverberant rooms, perspiration problems suffered by wearers, cold temperature testing and apparent considerable differences in the acoustic performance of products when random incidence and plane wave testing was performed.

The meeting concluded with a brief guided tour of the Department of Applied Acoustics facilities now that a move has occurred from Meadow Road into the Brindley Building and opportunities were provided for several individuals to try out the hearing defender testing rig in the anechoic chamber in Meadow Road, as subjects. □

John Dinsdale

NON-INSTITUTE MEETINGS

1985

13—17 May. *Rehabilitation of Hearing Impaired Adults.* Harwich/Esbjerg. Contact: Mr B A Blatch, Institute of Laryngology and Otology, 330/332 Grays Inn Road, London WC1 8EE.

3—5 June. *NOISE-CON'85.* Ohio. Contact: R Singh, Mechanical Engineering Dept, Ohio State University, 206 West 18th Avenue, Columbus, OH 43210.

11—13 June. *International Conference on Product Design Assurance in Engineering.* London. Contact: Society of Environmental Engineers.

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.

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

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

16—18 July. *8th Conference on Communication, Speech and Hearing* of European Association of Audiophonological Centres. London. Contact: Ms V Hazan, Dept of Phonetics & Linguistics, University College London, 4 Stephenson Way, London NW1 2HE.

4—8 August. 4ème Conférence Internationale de Photoacoustique Thermique. Montreal. Contact: L Bertrand, Département de Génie Physique, Ecole Polytechnique, Campus de l'Université de Montréal, CP 6079, Succurade A, Montreal H3C 3A.

4—9 August. *International Congress on Education of the Deaf.* Manchester. Contact: I C Taylor, Department of Audiology and Education of the Deaf, University of Manchester, Oxford Road, Manchester, M13 9PL.

27—29 August. *5th FASE Symposium.* Thessaloniki, Greece. Details in Jan 85 Acoustics Bulletin.

18—20 September. *INTERNOISE '85.* Munich. Details in Jan 85 Acoustics Bulletin.

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

New Products

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

Modular Precision Sound Level Meter B & K Type 2231

The 2231 is a hand held meter which in its standard form is fitted with a module enabling it to operate as a Precision Integrating Sound Level Meter. In this form it can simultaneously display Maximum Peak Hold; Maximum Peak in 1 second periods, Sampled RMS in 1 second periods; Maximum SPL Hold; Minimum SPL Hold; Leq; SEL; LIm with impulse time weighting; and IEL with impulse time weighting. There is a choice of three time responses and four frequency weightings. Special functions include automatic digital read-out after predetermined intervals and DC output to obtain histograms of Leq v time.

A second module enables the 2231 to act as a Statistical Analyser which can display the same parameters but in addition it can calculate and display L_{99}, L_{90}, L_{50}, L_{10}, L_1 or L_N with a value of N selectable in 0.1% steps. It also calculates and displays cumulative and probability distributions with 0.5 dB resolution for any measurement period.

A third module enables the 2231 to perform various measurements conforming with DIN45655.

Additional modules will shortly be available to extend the use of the instrument into various other fields such as Building Acoustics Analysis. Each module is supplied with its own detachable face plate which clips over the push buttons on the front panel of the instrument and indicates their functions related to the module fitted.

The instrument has a 4 digit liquid crystal display with 0.1 dB resolution plus a quasi-analog display.

Vibration Reference Source B & K Type 4294

The 4294 is a hand held battery powered vibration reference source for rapid calibration checking of vibration measurement, monitoring and recording systems. It is intended for use with piezoelectric accelerometers and other types of vibration transducer having a mass of up to 70 grammes. The 4294 produces a reference vibration level of 10 m/s^2 at a frequency of 159.2 Hz (1000 rad/s). This also allows calibration to be carried out at a constant velocity of 10 mm/s or displacement of 10 μm.

Further details from Brüel & Kjær (UK) Ltd, Cross Lances Road, Hounslow, TW3 2AE. Telephone: 01-570 7774.

Combined Dosimeter and Sound Level Meter Type 700

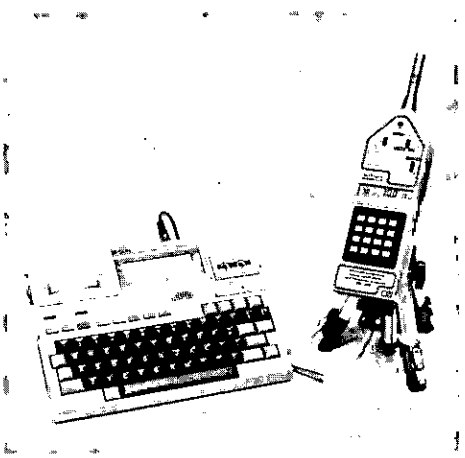
The Model 700 combined Dosimeter and Type 2 Sound Level Meter has a dynamic range of 110 dB and can communicate with most computers via the RS 232 compatible interface provided with every instrument. It can also communicate with any RS 232 printer without the need of a computer. A built-in precision clock and calendar allows the Model 700 to be turned on and off automatically.

The instrument memory is non-volatile and data is preserved through battery changes. All collected data may be down-loaded and stored on a cassette recorder.

Outputs available from the Model 700 include Dose, Projected Dose, Leq, SPL, Lmin and Lmax. It also includes a range of detector modes including fast, slow, impulse and peak.

Further details from Industrial Monitoring Equipment Ltd, Penn House, Penn Place, Rickmansworth, Herts, WD3 1SN. Tel: 0923 721155.

Computer Software for CEL 393 Hand Held Noise Meter



The CEL 393B Precision Computing Sound Level Meter which is equipped with a CEL Low Power Digital interface can now be connected to a battery powered EPSON HX-20 portable computer using the CEL 4351 Interface Kit. Included in this kit are two programs for the HX-20 stored on a microcassette. The first reads data over the RS 232 interface which can be displayed or printed and also filed by the microcassette system. The second program reads back from microcassette files.

An application note describing the use of the CEL 393B with the HX-20 is available from CEL Instruments, 35 Bury Mead Road, Hitchin, Herts, SG5 1RT. Tel: 0462 52731

Reverberation Time Meter RT1/LS1

The RT1 reverberation time meter was developed by the Building Research Establishment to fill the need for a simple, fast, cost effective way of measuring reverberation times. The RT1 is an add-on unit which will operate with a wide range of sound level meters and is designed to be used in conjunction with the LS1 noise source.

Gracey and Associates have the licence to manufacture the RT1/LS1 and are now marketing the system. The RT1 sells for £600 and the LS1 noise generator/loudspeaker costs £300.

Further details from Gracey & Associates, High Street, Chelveston, Northants NN9 6AS. Tel: 0933.624212.

Magnetic Pads for Noise Damping

A new means of noise control for use on grinding and fettling operations is available from Industrial and Marine Acoustics Ltd in the form of Magadamp, a flexible magnetic sheet. The Magadamp sheet is easy to use on surfaces which are flat or which have a single plane of curvature, being soft and pliable. Its strong magnetic properties make it convenient to remove and re-apply. Measurement tests on typical applications involving hand grinding tools have given results indicating noise level reductions of 7 to 10 dB(A).

Industrial & Marine Acoustics, PO Box 8, Cheadle, Stoke-on-Trent ST10 4LH; for further information please contact Barry Watkins - Tel: 0538 723537.

Gypglas

Gyproc Insulation have published leaflets on the insulation of partitions using Gypglas 1200 and the use of Gypglas 3611 in the construction of floating floors. These leaflets can be

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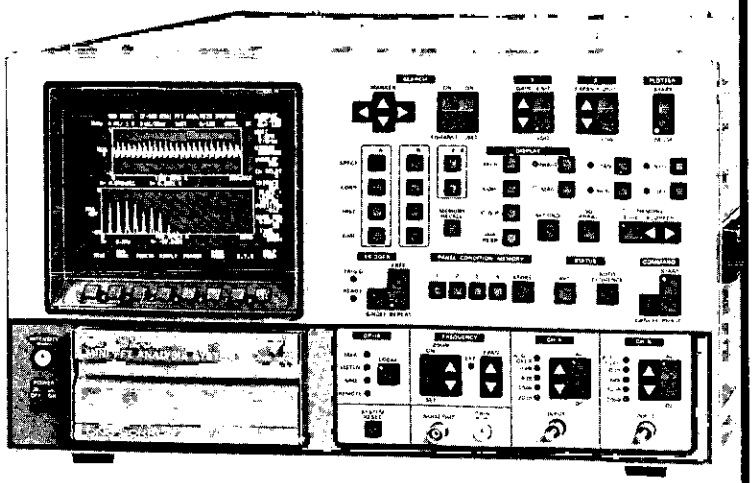

CF-920 100kHz mini-FFT Analyser

For further information and free demonstration contact:

CEL Instruments Limited
35 Bury Mead Road, Hitchin, Herts. SG5 1RT
Tel: Hitchin (0462) 52731 Telex: 826615 CEL G

INSTRUMENTS

obtained from Gyproc Glass Fibre Insulation Ltd, Whitehouse Industrial Estate, Runcorn, Cheshire WA7 3DP. Telephone: 0928 712627.

Noise Control Computer Program

For the past four years, Trox noise control engineers have been using a suite of computer programs to assist them with the time consuming task of analysing ventilation system ductwork.

The suite written by one of their own noise control engineers consists of programs to carry out Roomside, Atmospheric side Crosstalk and Breakout analyses; attenuator selections and various other acoustic calculations. These advanced programs are suitable for micro-computers running CP/M or MS-DOS.

The Noise Control Division of Trox Brothers Limited are now pleased to offer to members of the Institute, free of charge, copies of these programs which will help cut the time taken to solve building services noise calculations. In the first instance, those members wishing to have copies excluding for obvious reasons competitors, please write to Terry Metcalfe, Trox Brothers Ltd, Caxton Way, Thetford, Norfolk IP24 3SQ. □

2nd International Congress on Acoustic Intensity

Sponsored by International/INCE and GALF, the 2nd International Congress on Acoustic Intensity will be held at CETIM, Senlis, France, 23—26 September 1985.

The aim of this meeting is to inform both the research workers and the growing number of users on the state of the art and to offer opportunities for extended discussion between specialists. Papers, to be presented in French or English (with simultaneous translation), will cover the following areas: general concepts of vector fields, recent developments in instrumentation, localisation and characterisation of sound sources, sound power determination, transmission loss and absorption of panels, energy propagation in fluids and structures, standardisation.

Proceedings of the congress will be available at the congress. Further information can be obtained from Dr M Bockhoff, CETIM, B P 67, F-60304 Senlis, France; Tel: (33) (4) 453.32.66.

Material for the July issue of Acoustics Bulletin should reach Mrs F A Hill at 25 Elm Drive, St Albans, Herts AL4 0EJ, no later than Friday 24 May.

ISVR Short Courses

ISVR continues to run short courses on acoustics related topics. The programme for Summer/Autumn 1985 is as follows.

17—21 June: Instrumentation and measurement techniques for noise control

2—6 Sept: Advanced Noise and Vibration

9—13 Sept: Industrial audiology and hearing conservation

16—20 Sept: Technical audiology course

23—27 Sept: Applied digital signal processing

October: CONCAWE

Further information may be obtained from Mrs M Z Strickland, ISVR, The University, Southampton SO9 5NH. Tel: 0703 559122 ext 2310. □

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Institute of Acoustics Meetings

1985			
24 April	MAG	Visit to BBC Research Department, Kingswood Warren, Tadworth	Surrey
24 April	NEB & ScB	Joint Meeting	Carlisle
2 May	LEM	Acoustics and Audiology	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**	**Autumn Conference**	Windermere
1986			
7 — 10 April	**M**	**Acoustics 86**	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

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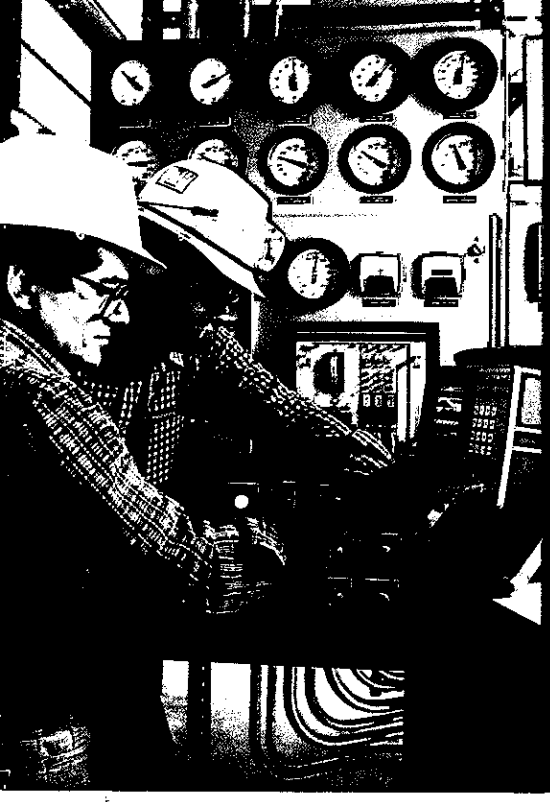

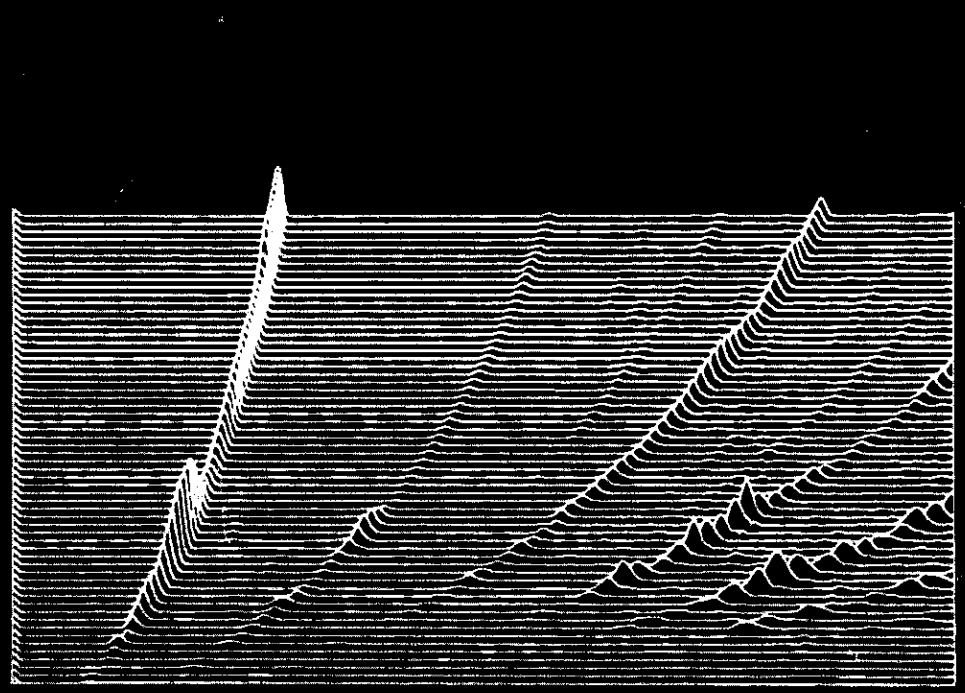

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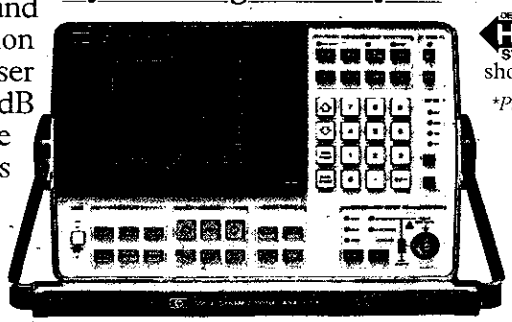

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