Acoustics Bulletin

April 1986 Volume 11 Number 2

INSTITUTE OF ACOUSTICS

INSPECT OUR SPECS!

Get the right Sound Level Meter for your kind of noise problem — or even one to cope with every kind — —

Bruel & Kjaer Type no.		2232	2225	2226	2221	2222	2230	2233	2234	2235	2231[7]
Type of Noise	Continuous										
	Fluctuating, Erratic										
	Noise events										
	Impulsive										
Frequency Response	Linear	—	—	—	Peak only	Peak only	●	●	●	●	●
	Weighted	A	A	A	A	A	A;C	A;C	A;C	A;C	A;C
	Filters	—	—	—	—	—	1624/25	1624/25	1624/25	1624/25	1624/25/27
Measurement Modes	RMS[1]	F,S	F,S	F,S,I	—	—	F,S,I	F,S,I	F,S,I	F,S,I	F,S,I
	Peak	—	●	—	●	●	●	●	●	●	●
	Max. Hold	●	(Peak only)	●	F	S	●[3]	●	●[3]	●	●[3]
Averaging		—	60 s-L_{eq}	60 s-L_{eq}	L_{eq}, SEL	L_{eq}, SEL	L_{eq}, SEL	L_{eq}, SEL L_{FTm}, L_{Im}	L_{eq}, SEL	—	L_{eq}, SEL L_{Im}[8]
Dynamic range dB		70	60	60	60	60	70	70	70	70	70
Outputs		DC[9]	DC[10]	DC[10]	AC	AC	AC, DC	AC, DC	AC, DC	AC, DC	AC, DC Digital[4]
Complies with BS 5969 SLM standards and	IEC 804 (Draft) DIN 45655	—	2	2	1	1	1	1[2]	—[5]	1	1
	IEC 651/DIN Type	1	2[6]	2 (Imp)	1	1	1 (Imp)	1 (Imp)	—	1 (Imp)	1 (Imp)
	ANSI S1.4 Type	S1 A	S2 A	S2 A	S1 A	S1 A	S1	S1	—	S1	S1

1. RMS time constant: F = FAST, S = SLOW, I = IMPULSE. 2: Fulfils DIN 45645 (TA-Larm). 3: Plus Min. Hold. 4: Optional. 5: Complies with proposed JIS standard. 6: Except for RMS Max. Hold. 7: With Integrating Module BZ7100. 8: Plus LFTm with Module BZ7102. 9 & 10: AC instead of DC optional, 1624/25: 1/1 or 1/3 Octave, 1624/25/27: 1/1 or 1/3 Octave or Infra/Ultrasound.

Our "international team" of ten sound level meters covers every noise measuring requirement likely to be encountered in any kind of environment. Because we've been specialising in sound measurement for longer than anyone else in the world, we are well known by all the experts and professionals, but if you are neither of these and are more puzzled than excited by the above "specs", take heart; you are by no means alone! Find out more by sending for our free 24 page colour illustrated booklet entitled "Human Environment Measurements" and when you've read it you'll be welcome to contact us again for further advice without any kind of obligation.

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

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

Membership of The Institute of Acoustics

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

Honorary Fellow (HonFIOA)

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

Fellow (FIOA)

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

Member (MIOA)

Candidates for election to Member shall normally have attained the age of 25 years, must either (a) have obtained a degree or diploma acceptable to Council and have had experience of at least three years of responsible work in acoustics, or (b) possess an equivalent knowledge of acoustics and cognate subjects, have had experience for not less than seven years of responsible work in acoustics or its application, and must have been a Non-corporate member of the Institute in the class of Associate for not less than three years.

Associate

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

Student

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

Full details and membership application form are available from: The Secretary,
Institute of Acoustics
25 Chambers Street
Edinburgh EH1 1HU

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Presidents Letter

Institute of Acoustics

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AIRO, Hemel Hempstead

Dear Member,

There will be a different photograph at the top of this page in the next Bulletin. Orhan Berktay takes over as President after the AGM in April. You can look forward to a lively two years under his leadership. At the same time Chris Rice comes into office as the new President Elect and we can feel confident that the Institute will be in good hands over the next four years.

David Weston retires as immediate Past President after having served the Institute for many years and kept us under control in a quietly confident manner. Another major change is the retirement of John Bowsher, who has taken immense responsibility as Chairman of the Membership Committee, and personally studied and assessed every membership application.

I thank these, and other members of Council who have supported me during my term of office. But we are all dependent on the efforts of a very overworked Head Office. In particular, Cathy Mackenzie is subject to far more pressures and demands than we ought to expect of her, but responds magnificently.

Your Institute has progressed in several areas over the past two years. We are now nearing completion in our negotiations with the Engineering Council. We hope that these may be finalized shortly. The Noise Council is established in conjunction with other professional bodies concerned with noise and beginning to play its part. Meetings, which are the life of the Institute, both technically and financially, continue to flourish. The prospects look good, but we need your continued support to keep them this way.

Yours sincerely

Geoff Leventhall

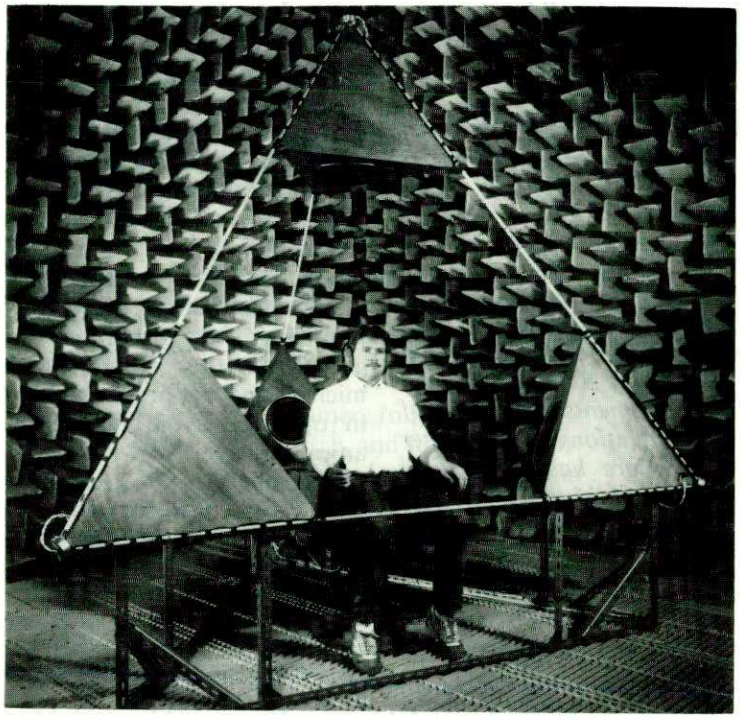

Figure 2 Hearing protector test rig

government departments. In recent years there has been a considerable increase in the number of regulations limiting noise levels and requiring noise levels to be measured. At the same time, with the introduction of digital instrumentation, the measurement of noise has become more sophisticated. As a result, there is a need to guide users on measurement practice and to produce adequate technical documentation at national and international levels.

The Section supports national efforts to develop improved type noise certification tests on aircraft. Of particular concern is the positioning of the measuring microphone in relation to the ground surface in order to achieve the best representation of the free-field sound spectrum of aircraft flyover noise. Noise measurements made at the conventional height of 1.2 m above the surface are subject to cancellation or augmentation due to interference between the incident and the ground-reflected waves, resulting in considerable distortion of the true free-field spectrum. An alternative method, which does not have these disadvantages, involves placing the microphone off-centre on a hard, rigid, circular baffle positioned flush with the ground surface. Experimental data obtained both in the laboratory and in the field have generally endorsed this method for measuring noise from light propeller-driven aircraft and the arrangement has been proposed to the International Civil Aviation Organisation. Further studies in conjunction with the aircraft industry are now in progress to assess the performance of ground-plane microphones in measuring the noise of other kinds of aircraft.

A computer model (AIRNOISE) has been developed for predicting noise contours around airfields. The immediate purpose is to produce user-friendly software for the Royal Air Force for routine use at military airfields. We are also active in international work to produce a standard specification for aircraft noise contour calculation. The European Civil Aviation Conference, the Society of Automotive Engineers and the International Civil Aviation Organisation have each had groups working on this topic, charged with producing drafts slanted to serve their own organization's particular purpose, and essential input to all three has been provided.

Research is being carried out to devise a standardized objective method of quantifying impulsive environmental noise. In a series of related experiments, the subjective annoyance reactions to controlled noise presented under simulated living-room conditions have been examined. In particular, the effects of repetition rate and impulse decay time have been investigated.

Under a contract from the Department of the Environment, a survey among local authorities is in progress to gather information on the equipment and manpower resources available to undertake noise measurements under statute, the kinds of measurements made, and their policies on independent calibration of instruments. Based on initial visits and discussions with selected local authorities, a postal questionnaire has been sent to a sample of one-in-three of all local authorities.

Speech

The aim of NPL work on speech audiometry is to introduce essential standardization into clinical speech tests used in hospitals both for diagnostic purposes and when fitting hearing aids, it being important that results obtained by different centres are compatible. A survey was carried out on behalf of the Department of Health and Social Security of the equipment and techniques in use for speech audiometry in NHS clinics, in order to establish baseline data from which to develop a future standardized test.

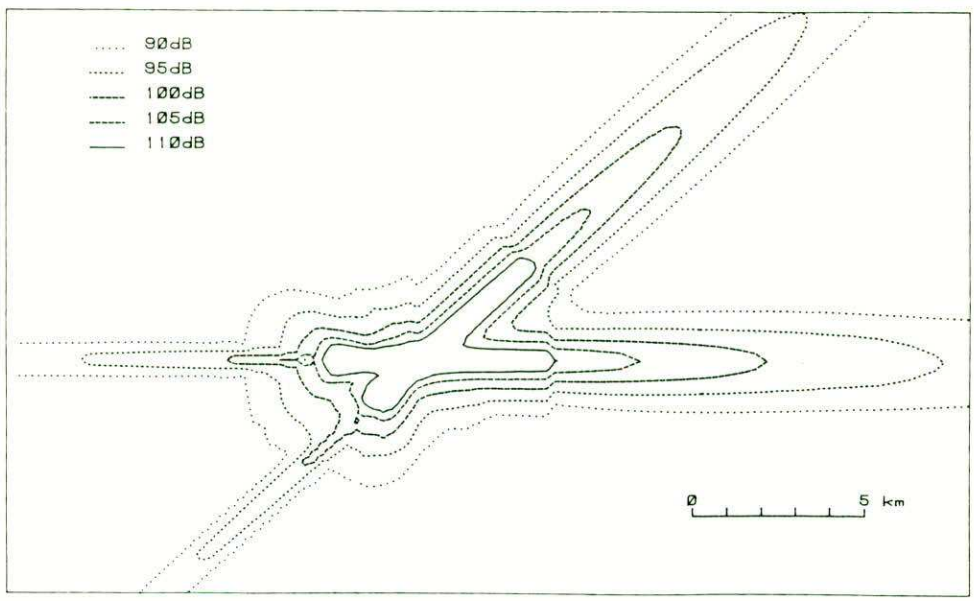

Figure 3 A typical set of airport noise contours

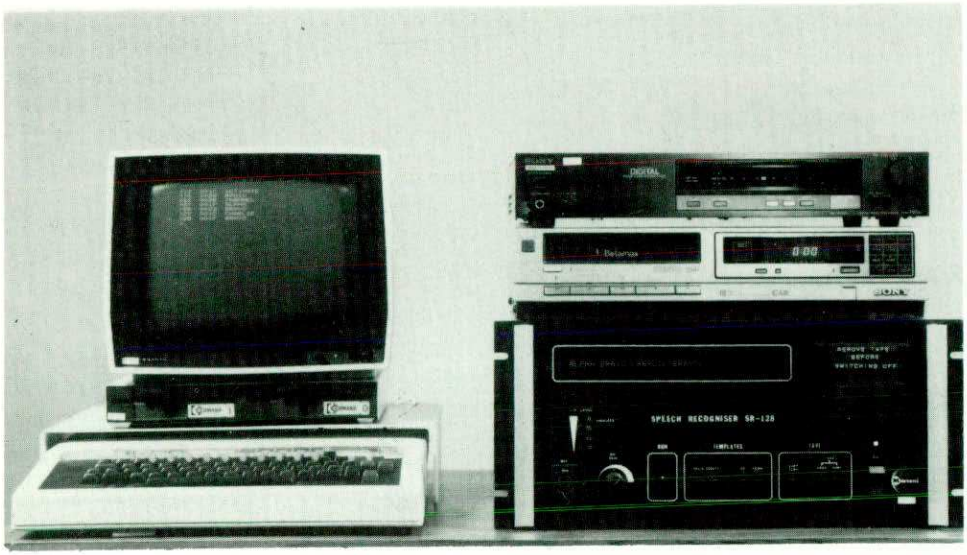

Figure 4 Evaluation of a commercial automatic speech recognizer

An area of rapid growth and great importance is automatic speech recognition for IT; manufacturers and users need well-based test procedures and material. Following an approach from the Speech Technology Assessment Group of the IOA, NPL is participating in a new project which is receiving support from the Alvey Directorate. This collaborative project, involving Logica UK, NPL, RSRE, Smiths Industries, and University College London, is directed towards the difficult problem of evaluating the performance of automatic speech recognizers. NPL has started to establish a national archive of speech data bases in the English language and is examining how these can best be used in the evaluation of speech recognizers.

Ultrasonics

The Ultrasonics Section is responsible for establishing the necessary national standards of measurement for determining the acoustic output of medical ultrasonic equipment. The application of medical ultrasound in UK hospitals has grown enormously over the last ten years. Patients are being exposed to a variety of ultrasonic fields: from high power fields employed in ultrasonic hyperthermia for the treatment of tumours, through intermediate powers used in physiotherapy for the treatment of damaged tissue, to low power (but high instantaneous peak pressures) used in diagnostic examination. It is therefore very important to be able to determine the acoustic output levels of equipment and their relevance to the interaction of ultrasound with human tissue.

Novel types of membrane hydrophone, made of polyvinylidene fluoride (pvdf) and developed jointly by NPL and GEC-Marconi, are an important feature; they are used as in-house transfer standards for the calibration of customers' hydrophones and for the characterization of ultrasonic fields using the beam-plotting facility as part of Ultrasound Measurement Service. Various techniques have been developed for the absolute calibration of reference standards but the primary standard technique involves the laser interferometer developed jointly by NPL and the Atomic Energy Research Establishment at Harwell with partial funding by the BCR. The method involves placing a thin pellicle in an ultrasonic field and determining its displacement with a laser interferometer. The acoustic pressure at the field point is derived from the displacement and the hydrophone is calibrated by placing it at the same point and measuring its output voltage.

Transfer of the primary calibration from reference hydrophones to working standard hydrophones is achieved through an intercomparison facility which makes use of the nonlinear propagation of ultrasound in water. Distortion leads to the generation of a sawtooth wave whose harmonic content can readily extend to over 25 MHz from a 1 MHz fundamental. Simply by comparing the sensitivities of several hydrophones at the harmonic frequencies, it is possible to provide a complete calibration of a hydrophone in a single set of measurements, provided that one of the devices is a calibrated reference device.

There is also considerable interest in the nonlinear process itself because it occurs in the fields generated by medical ultrasonic equipment and it is important to be able to characterize such fields. A simple theoretical model of the nonlinear propagation in a pulsed focused acoustic beam has been developed which predicts the distortion generated on the axis of a piston source. To simplify the theoretical modelling, it is advantageous to use a beam profile of Gaussian form and experimental data

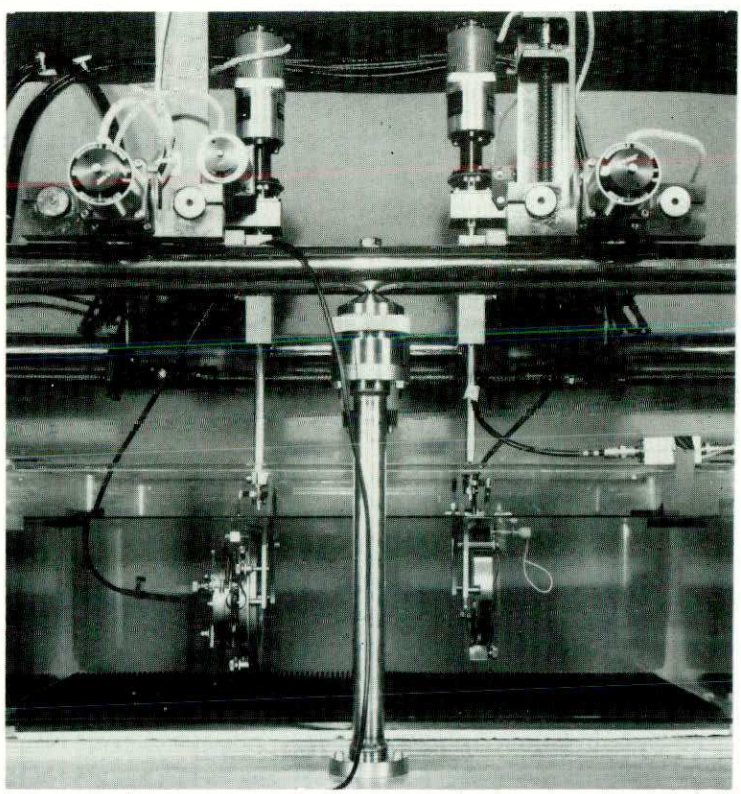

Figure 5 Close-up of the beam-plotting facility

have recently been obtained using such an arrangement.

More than 100 of the NPL/GEC-Marconi membrane hydrophones have been supplied to customers by the Marconi Research Centre over the past five years. Under an extramural DTI research contract, further efforts are being made to improve manufacturing techniques and already customers are benefiting by reduced delivery times. There is a need to produce devices made from thinner film and with active elements smaller than the current lower limit of 0.5 mm diameter.

A beam calibrator (BECA2) has been developed which will capture, display and analyse the signals received by a multi-element hydrophone. This system employs an IBM PC with dedicated 68000 processor, and allows rapid quantitative evaluation of beam profiles and the determination of absolute output parameters. With the current concern for the safety of medical ultrasonic equipment, BECA2 provides a unique measurement capability. A major step forward in this connection is the commercial exploitation and marketing of the system; a license has been granted to Frazer Nash Electronics Ltd whilst Nuclear Enterprises are responsible for marketing. Commercial launch of the system took place at the annual meeting of the British Medical Ultrasound Society at Southampton in December 1985 and created an amazingly high interest.

Test objects of tissue-mimicking phantoms are being increasingly used for the assessment of overall performance of diagnostic ultrasonic equipment. The reproducibility and the stability of the acoustical properties of the tissue-mimicking material is of crucial importance, with the consequent need for quality control during manufacture. A materials characterization rig has been assembled which can be used to determine ultrasonic attenuation and velocity by means of the through-transmission technique. This has recently been employed in a major programme of measurements for a commercial company of the attenuation of special fluids and for transducer beam characterization in the same fluids.

The NPL Ultrasound Measurement Service is currently handling about 50 items per year. Half of these involve the calibration of hydrophones, mostly of the membrane type for Marconi; as many of these are for foreign customers, the dissemination of NPL primary standards is now on a worldwide scale. In fact, NPL is the only calibration laboratory outside the USA which is accepted by the Federal Drug Administration to make the measurements required under their 510K Reporting Requirements on medical ultrasonic equipment.

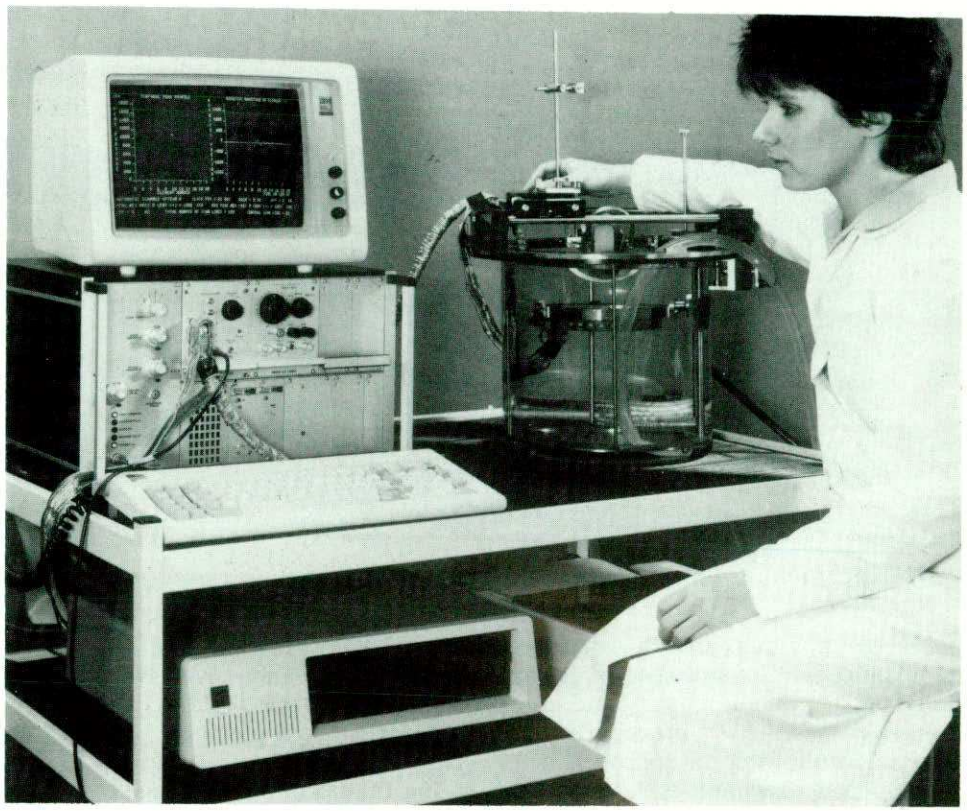

Figure 6 The NPL Ultrasound Beam Calibrator (BECA2)

Low frequency water-borne acoustical standards

NPL has been coming under increasing pressure from industry to provide traceable standards in the field of water-borne acoustics covering a wide range of frequencies. Various contacts have been established and visits made to a number of important establishments, resulting in the identification of both short- and long-term objectives. These include the need to investigate the possible extension of the existing ultrasound standards to frequencies well below 0.5 MHz and the extension of the NPL laser pistonphone to as high a frequency as possible. The first task is to establish a round-robin intercomparison in order to determine the current status of reference hydrophones in various UK establishments.

Further information

Publications available free of charge include:

NPL Measurement Services: Acoustics, 1984.

Seventeen technical handouts covering all aspects of NPL acoustical and ultrasound customer services.

Index of NPL Acoustics Publications 1971-80. NPL Acoustics Report Ac 95, 1981, with supplement listing publications to December 1985.

Division of Radiation Science and Acoustics, Annual Report 1985.□

American Standards

The Standards Secretariat of the Acoustical Society of America has produced its sixth revision of the ASA Standards Catalogue, which was first published in 1979. The Catalogue gives brief details of American Standards relating to Acoustics, Mechanical Shock and Vibration, Bioacoustics, and Noise, and includes a price list and order form. Contact Publications Sales, Dept STD, American Institute of Physics, 335 East 45th Street, New York NY10017, Tel (from Great Britain): 010 1 516 349-7800.□

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 16 May.

Proceedings of The Institute of Acoustics — Abstracts

Acoustics '86

1986 Spring Conference, 7-10 April at the University of Salford

Plenary Sessions

1986 A B Wood Medal Lecture
Dr P D Thorne

1986 R W B Stephens Lecture
Professor H Kuttruff

1986 Rayleigh Medal Lecture
Professor E J Richards OBE

Environmental Noise

Sound Propagation in City Streets

M M Radwan and D J Oldham
Department of Building Science, University of Sheffield

In order to control noise in urban areas it is necessary for planners to be able to accurately predict the noise levels resulting from a particular noise source for various arrangements of building form. However, the factors influencing the propagation of sound in urban areas are not well understood. This paper describes the results of a computer simulation of sound propagating down a city street using the technique of ray tracing.

Curves of sound attenuation versus source-receiver distance are compared with those obtained by Bullen and Fricke who analysed this type of sound field in terms of propagating modes. Some differences are observed between the results obtained by these two methods. The results obtained from the ray tracing work are used with another computer simulation model (one simulating the behaviour of road traffic) to investigate the so-called canyon effect.

Estimation and Modelling of Traffic Noise in Urban and Suburban Environments

K S Jraiw
School of Architecture and Building Engineering, University of Bath

The increasing importance of noise effects in built-up areas has not been matched by the development of comprehensive methods for assessing its significance. This study set out to use noise from urban and suburban traffic, and the parameters which characterize the environment, affect noise levels and are necessary to the work of designers and planners.

Based on a survey in the City of Bath, a prediction model has been developed relating noise level from non-free flowing traffic to variables of interest. Five predominant land uses were defined, i.e. suburban principal roads, residential, office, commerce and urban main routes at 204 sites chosen to give a representative sample of traffic conditions for each of these five types. Thirty minute noise level recordings were made hourly at each site between 7.00 and 19.00 hours. Other variables of interest were recorded simultaneously.

The final model is expressed in terms of L_{10} dB(A), and the most effective parameters such as locations of farside and nearside building facades, traffic flow and speed, percentage of medium and heavy vehicles and distance from proper junctions, i.e. traffic lights, roundabouts and priority junctions.

The model gave a good correlation R = 0.969, standard deviation = 0.770 and accuracy prediction within ±1.8 dB(A). It is comprehensive, simple and practical in order to save time and money.

The model validity was tested against data of Georgian building areas and showed high performance.

The proposed paper will deal with the reliability of the model.

Traffic-induced Ground-borne Vibration in Dwellings

G R Watts
Transport and Road Research Laboratory, Crowthorne, Berkshire

Investigations of ground-borne vibration were made at a number of houses where residents had previously been questioned about the problem of the nuisance caused by traffic-induced vibrations. In this earlier 50 site study it had been found that noise exposure levels measured at the facades of dwellings correlated reasonably well with assessments of vibration nuisance indicating the importance of acoustically coupled vibrations. However it was considered that some of the disturbance might result from the effects of ground-borne vibrations and this paper describes a study designed to address this problem.

Vibration and noise measurements were taken inside and outside dwellings located close to relatively large road surface irregularities. Measurements were taken during the passage of light and heavy vehicles and also a TRRL test lorry loaded close to the legal axle weight limit.

Results indicate that it is likely that only a relatively small number of dwellings at the 50 sites were affected by perceptible levels of ground-borne vibration. The disturbing effects of a surface irregularity have been related to its maximum profile height or depth and peak vibration levels have been compared with building damage thresholds.

The Environmental Impact of Road and Rail Noise on a small Housing Development in Bolton

Mrs L Duckworth
Environmental Services Department, Bolton MBC

The effects of environmental noise on people may be examined a) in the investigation of complaints or b) in terms of response to social survey questionnaires. In this paper social survey responses were used to assess the effects of road traffic and railway noise on a small residential development to the south of Bolton.

This site was chosen because the Environmental Health Department had been involved at the planning stage to ensure that precautions were incorporated into the development of the site so that residents were given some protection against environmental noise, in particular road traffic noise.

The paper attempts:

1) to show the degree of annoyance expressed by the residents due to road traffic noise in comparison to noise exposure.

2) to show the degree of annoyance expressed by the residents due to railway noise in comparison to noise exposure.

3) to show how a postal survey carried out on a small scale can be used as an effective means of collecting information and assessing noise impact.

4) to assess the effectiveness of Environmental Health involvement at the planning stage in the prevention of environmental noise problems, through the use of barrier blocks, aspecting of houses, and duel glazing to certain rooms.

Prediction of Road Construction Noise

B Buna
Institute of Transport Sciences, Budapest, Hungary

On the basis of measurements a method has been derived to predict the noise levels around road construction sites.

The method, developed for earthwork, earth stabilizing, asphalt/concrete pavement making and finishing operations, is based on an equation to predict the Leq level for each particular type of operation and the combination of them.

At the calculation of the propagation term all types of noise sources (point, line, surface) occurring on road construction sites are taken into account.

The reference operation noise levels have been measured by using a short Leq measuring device; therefore some information for noise source identification could also be given.

The model, offered for common use of the North-South Trans-European Motorway (TEM) — Countries, has both a simplified and a more detailed calculation chart.

Advances in Signal Design and their Value in Minimizing Environmental Noise

G J Coleman
Institute of Occupational Medicine, National Coal Board

Abstract not available.

EEC Article 100 Construction Equipment Noise Directives

M Hayter
Department of Trade and Industry

Abstract not available.

EEC Directives — the View of an Approved Body

R H Clough and P E Sacre
Wimpey Laboratories Ltd

Abstract not available.

Quality Control in Noise Testing

R F Higginson
National Physical Laboratory, Teddington, Middlesex

A requirement of the recent series of European Economic Community Directives on noise emitted by construction site machines is for Governments of member states to appoint 'approved bodies' for the conduct of machinery type examinations. In the UK, a pre-condition for approval is that test houses should be accredited for the conduct of the noise measurements through the National Measurement Accreditation Service (NAMAS). By this means, the competence of the testing laboratories to carry out the measurement work to a high standard is recognized. Accreditation involves the implementation of quality control practices covering the equipment, facilities and staff engaged in the work. Through the furnishing of a Quality Control Manual and a process of formal assessment, a laboratory has to demonstrate that it has a suitable management organization, including an individual with responsibility for quality control who has access to top management. Staff have to be technically qualified; suitable measuring equipment has to be available, the calibration of which is traceable to national standards of measurement; detailed records have to be kept of all work done; and test results have to be clearly presented. An accredited laboratory must be able to quantify the uncertainty associated with its test results. A number of the laboratories seeking accreditation for measurements according to the EEC Directives are keen to widen the scope of their accreditation to bring in a range of other acoustic test work.

A Survey of Local Authority Noise Measurements

B F Berry
National Physical Laboratory, Teddington, Middlesex

Abstract not available.

The Influence of Residual Noise on Community Disturbance from Aircraft Noise around Glasgow Airport

I D Diamond and J G Walker
University of Southampton

J B Critchley and G C Richmond
Directorate of Research, Civil Aviation Authority

This paper reports the results of a study to examine the relationship between community disturbance due to noise from aircraft and residual noise (noise from other sources): it has been hypothesized that disturbance from aircraft noise may be lower in areas with high exposure to noise from other sources.

The study was carried out around Glasgow Airport in May and June 1984, and was part of a larger study which included surveys in France and The Netherlands. To begin with, three Common Aircraft Noise Areas (CNAs) were identified. These were areas within which it was estimated that each aircraft noise event would not vary by more than (about) 3 dB within the area. These areas were chosen as 'High', 'Medium' and 'Low' aircraft noise areas. Within each of these, zones experiencing high and low residual noise (RNZs) were also identified. A social survey into noise disturbance was carried out among residents within each of the six RNZs: concurrently measurements of the noise exposure for each RNZ and CNA were made.

The results are presented in two sections: first a description of the results of the social survey which show the levels of disturbance in each CNA; second, the survey data are considered in conjunction with the noise measurements. The results do not support the initial hypothesis, ie, they indicate no evidence that disturbance is related to RNZ level.

Control of Noise from Heavy Goods Vehicles

J Anani, M Kenyon, J Roberts and M Vuillermoz
Polytechnic of the South Bank, London

The Greater London Council's proposed night-time (2100hrs to 0700hrs) and weekend ban on heavy goods vehicles exceeding 16½ tonnes gross weight on roads in the Greater London Area comes into effect on 31 January 1986. For vehicles which have a maximum permissible weight of between 7½ to 16½ tonnes, the GLC wishes to implement the EEC Council Directive 81/334/EEC and restrict drive-by noise to less than 88 dB(A) for vehicles of engine power exceeding 147 kw.

The GLC commissioned the Polytechnic of the South Bank in January 1985 to conduct drive-by noise tests on a selection of lorry-tractor units and to design 'Hush-Kits' to be fitted to the vehicles to reduce the noise output. The hush-kits basically consisted of bolt-on side panels fitted to the chassis and cab. An analysis of the results shows a reduction in the drive-by noise level of at least 2 dB(A) could be achieved with the design employed.

The drive-by tests of the noise emission from the heavy goods vehicles showed that the exhaust noise was subjectively important, but with certain vehicles — even new ones — the exhaust noise was so pronounced as to be the major factor determining the level of annoyance. In some cases the noise level from the exhaust gave a pronounced peak in a low octave band at least 12 dB greater than any other part of the sound spectrum.

The efficiency of exhaust silencers is known to be largely governed by their size, capital cost, effect upon engine performance and component compatibility. The paper discusses the development of a new generation of smaller active exhaust silencers which are particularly effective at low frequencies and fit into available space and with no adverse effect upon engine performance. The development of such devices using already available technology is underway and we are confident that a prototype which would give at least 10 dB reduction in the peak of the low frequency noise emitted in the stready-state could demonstrable by the end of March 1986.

The paper will report the progress made.

Underwater Acoustics

Eigenvector Rotation and its Application to High Resolution Spectrum Estimation

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This paper will discuss the application of source subspace eigenvector techniques to acoustic arrays. Most current eigenvector methods are based on the asymptotic orthogonality between the source and noise eigenvectors. An alternative and potentially more promising technique which relies on the rotation of source eigenvectors is presented. This direct approach has a number of potential advantages and also has superior performance to alternative techniques such as the MUSIC or Kumaresan and Tufts algorithms.

The proposed algorithm may be implemented in a number of different ways, ranging from a search type algorithm, similar to other spectral techniques, to a phase unwrapping version which enables the signal frequencies to be calculated directly.

The eigenvector rotation which is central to the proposed technique relies on the relationship between the exponential signal model and the source eigenvectors. These eigenvectors cannot be interpreted directly and must be transformed by an orthogonal matrix. Once this orthogonal matrix has been found, it is easy to transform back to obtain the required signal model.

Simulation results will be included which demonstrate the effectiveness of the technique, by comparison with alternative approaches. These demonstrate that the approach is very powerful and can achieve good results in very low signal to noise environments. This is very important, for it is in the low signal to noise situation that many techniques fail to give satisfactory results.

A Novel Approach for Direction Finding Problems Application to Multipath Environment

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In this paper, a new technique for narrowband, linear equal spaced array processing is derived which is based on what is known as the Toeplitz Approximation Method (TAM) of stochastic system identification. The proposed algorithm provides high resolution signal direction finding capability and allows accurate separation of directional components of received array data. The method is designed for an arbitrary noise, multipath signal environment, low signal to noise ratio (SNR), and as such, extends existing capability in fields such as passive sonar, radar and communications.

A novel direction finding algorithm, based on the reduced order approximation of an estimated spatial covariance matrix, is proposed. The estimated covariance matrix, in the case of source paths which are uncorrelated statistically, stationary, is the Toeplitz matrix.

In a multipath environment, the source paths are fully correlated; this covariance matrix is no longer to be Toeplitz. The Toeplitz structure can be guaranteed by employing spatial smoothing, which destroys cross correlation between directional components. In the TAM approach, the spatial data may be modelled as the output of a self generating ARMA process with poles, corresponding to arrival

directions, on the unit circle. A state space representation is estimated from a covariance matrix low order approximate. The algorithm used to obtain this low order matrix, which is based on the Singular Value Decomposition (SVD) of the spatial data matrix, has low sensitivity to data perturbation.

Maximum Likelihood Estimation of Time-Varying Delay

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This paper presents, for the first time, the complete theoretical solution to the problem of maximum likelihood (ML) estimation of time-varying delay d(t) between a random signal s(t) received at one point in the presence of uncorrelated noise and the time-delayed, scaled version as (t − d(t)) of that signal received at another point in the presence of uncorrelated noise. The signal is modelled as a sample function of a nonstationary Gaussian random process and the observation interval is arbitrary. The analysis of this paper represents a generalization of that of Knapp and Carter (1), who derived the ML estimator for the case that the delay is constant, $d(t) = d_0$, the signal process is stationary, and the receive processes are observed over the infinite interval (−oo, +oo).

We show that the ML processor can be implemented by any of four canonical forms, which, in general, are time-varying systems. We also show that our results reduce to a generalized cross correlator for the special case considered in (1).

The results presented here are applicable to many technical areas including, in particular, that of passive sonar signal processing.

Reference

1. Charles H Knapp and G Clifford Carter, *The Generalized Correlation Method for Estimation of Time Delay*, IEEE Transactions on Acoustics, Speech, and Signal Processing, Vol ASSP-24, No 4, August 1976, pp 320-327.

Adaptive Array Processing for Source Location in Fast Reactors

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UKAEA, Risley, Warrington

Acoustic surveillance techniques are being studied in the UK for application to the liquid metal cooled fast breeder reactor. It is planned to monitor the acoustic output of the reactor to obtain early warning of incipient faults such as the onset of boiling of the coolant in an overheated fuel channel. An approximate half scale model of the Prototype Fast Reactor is being used to investigate array techniques. It is monitored by an array of hydrophones. The outputs are fed to a computer based data acquisition system. The operating range is restricted to between 1 kHz and 10 kHz by tank resonances at the lower frequency and array dimensions at the upper frequency.

Various array processing techniques are being considered including the simple delay and sum beamformer, and its frequency domain equivalent, as well as adaptive techniques. The latter require a knowledge of the background noise field, and include the recent 'high resolution' methods based on the properties of the eigenvalues and eigenvectors of the cross-spectral density matrix. It is shown that these techniques are capable of locating an acoustic source to within the diameter of a modelled fuel channel in the presence of high background noise.

Self-Focused Ultrasonic Imaging Reconstruction Techniques

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Self-focusing is a method whereby the ultrasonic pressure pattern in an object plane, at a single frequency, can be derived from pressure measurements in a second (sampling) plane, without knowledge of the distance between the two planes.

One procedure involves the division of the measurements into in-phase and quadrature components prior to Fourier transformation into the spatial frequency domain. It is shown that the ultrasonic pressure distribution in the object plane, in the spatial frequency domain, can be derived from the resulting two Fourier transforms of measured values, without a knowledge of the separation, z, between the two planes.

The theoretical justification utilizes the Fresnel Integral to relate the pressure distribution in the sampling plane, in the space domain, to that in the object plane. The presence of a 180° phase ambiguity in individual spatial frequencies is demonstrated and algorithms designed to overcome this are included.

A second procedure based on processing in the spatial frequency domain is also included. Analysis of the relationship between the spatial frequencies in the object and sampling planes demonstrates the compatibility of the two methods and the inherent nature of the phase ambiguity.

Improvements of the Resolution of Acoustic Holography by using Phase Reconstruction

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Ultrasonic testing is known as a sensitive method for the detection and localization of reflectors as for example defects in solid materials or underwater objects. For the further description of the reflector geometry, size and orientation several imaging methods were proposed like focusing the phased array technique or synthetic aperture techniques. However, it is not possible to achieve an axial resolution of less than one wavelength, because applying these imaging techniques the time of flight is used as data for the image reconstruction.

On the other hand it can be shown, that, using a numerical acoustic-holographic reconstruction formalism considering only the phase angle, it is possible to achieve a resolution of less than one wavelength. In this way it will be possible not only to produce topographical contour maps of a reflector with high axial resolution but also to evaluate the deformation of a reflector caused by a thermal or mechanical strength with a resolution of less than a hundredth of a wavelength.

Phase and Amplitude Fluctuations in a Random Medium

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Predictions of the effect of the random nature of the sea-water medium on beampatterns of sonar transducers require knowledge of the levels of phase and amplitude fluctuations caused by the random medium, and their spatial correlation functions. Although the theoretical basis for estimating these parameters has existed for many years, experimental verification has been limited almost entirely to amplitude fluctuations. A series of experiments has been carried out to investigate both phase and amplitude fluctuations over the frequency range 70 kHz-160 kHz in a 3 m x 2 m x 2 m deep laboratory tank using any array of heaters to create a random temperature, and hence refractive index, structure. Results are presented which show good agreement between the predictions of the spherical wave formulation of Rytov's method for propagation in a random medium, and the observed fluctuation levels and correlations. It is confirmed that fluctuations are caused mostly by variations of refractive index on the smallest scale, whilst phase fluctuations are affected by variations over all scale sizes. This implies that any model of the refractive index structure in the ocean used to predict phase fluctuations must include large scale phenomena not previously considered for estimation of amplitude fluctuations only.

Analysis of the Effects of Platform Motion Errors upon Synthetic Aperture Sonar

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Aperture synthesis techniques are commonly used in radar applications but are rarely used in sonar. This is primarily because of the difficulties of defining or controlling sufficiently accurately the track of the sonar platform during the coherent synthesis process.

This paper presents the results of a computer simulation for a synthetic aperture sidescan sonar in which oscillatory platform motions are incorporated. The influences on the synthesized array receiving patterns of each six motions; roll, pitch, yaw, sway, heave and surge, are examined as functions of the amplitude and frequency of the oscillations.

A performance parameter is developed which quantifies various features of the degradation in the quality of the synthesized pattern. For each type of motion performance contours are computed as functions of the amplitude and frequency of the motion. These provide information on the required stability of the platform track for aperture synthesis to be useful. Alternatively they can be interpreted as giving the accuracy to which any particular platform motion needs to be monitored so as to facilitate corrections in the processing.

The computer model can also be used to ascertain the usefulness of a particular towed body as an array platform for a synthetic aperture system provided data is available on its towing characteristics.

Determination of Sediment Sound Speed from Measurements of the Vertical Directionality of Ambient Noise in the Water Column

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Acoustic propagation in the shallow ocean overlying the continental shelf is strongly influenced by the properties of the bottom. A method is presented in this paper whereby

the vertical coherence (directionality) of the ambient noise in the water column is used to infer the critical grazing angle of the bottom interface and hence the sound speed in the sediment. The basis of the technique is the theory of wind-generated noise directionality in shallow water (Ref 1), which shows that the modal component of the noise is symmetrically distributed in the angular region extending to α_c either side of the horizontal, where α_c is the critical grazing angle of the bottom. Measurements of the vertical directionality of the ambient noise at a number of sites around the UK coast have been made using vertical line array (VLA) sonobuoys deployed from research aircraft. Coherence functions for the ambient noise on each pair of hydrophones in the VLA have been plotted as functions of frequency, and a curve fitting algorithm based on the theoretical predictions has been developed. This algorithm yields a value for the critical grazing angle of the bottom. Comparison of the results obtained using the new method with data acquired independently using traditional methods shows very good agreement.

Reference

1. M J Buckingham, *A theoretical model of ambient noise in a low-loss, shallow water channel,* J Acoust Soc Am 67(4), 1186-1192, (1980).

Simulation of Acoustic Backscattering from a Random Surface using Optics

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An experiment is described in which diffuse laser light is normally incident on a randomly rough surface. The random backscattered field produces a speckle pattern which simulates the random spatial field that would be created in acoustic backscattering situations. However, it has the advantage over direct acoustic measurements of enabling a complete slice of the random field to be observed. Hence assessments may be easily made of the dependence of the random backscattered field on effects such as the degree and character of the roughness of the backscattering boundary and on any relative motions between the source and the scattering boundary.

The amplitude variations in the speckle pattern are collected by two methods.

i) A video camera and frame store is used to digitize the field for subsequent computer analysis. The field may also be displayed on a video monitor for qualitative observations.

ii) A number of photo-detectors are mounted on a precision x-y table. This technique allows the field to be slowly digitized over a much larger area with a greater accuracy.

Spatial correlations in the random field are also computed and compared with theoretical predictions.

Within-pulse Doppler Scanning using Frequency-domain Processing

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In conventional active sonars, when, for reasons of improving signal-to-noise ratios, a large time-bandwidth product signal is used, separate versions of the transmitted signal are stored. Parallel replica correlators then produce the outputs for each Doppler bin. The storage of all the separate replicas wastes memory space. Yassaie and Creasey (1) have developed a signal-processing scheme which enables the replicas to be generated serially by shifting time samples of the basebanded transmit signal down a delay line with non-uniform tapping points. A single correlator is then used on a multiplexed basis to produce the Doppler outputs. This paper shows that the time-domain system has a parallel in the frequency domain. In this system, samples of the spectrum of the baseband transmit signal are shifted down a non-uniform delay line to generate the spectrum of the required replicas for each Doppler bin. The Weiner-Khinchine theorem then enables the correlator outputs to be generated with a minimum of computing overheads.

Reference

1. Yassaie M H and Creasey D J, *Doppler scanning correlator* IEE Conference Digest 1985/47 *Digital Signal Processing for Sonar,* 7/1-7/9, April 1985, London.

A Wide Band Constant Beam Width Echo Sounder for Fish Abundance Estimation

E J Simmonds and P J Copland
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A wide band echo sounder has been developed to work in the range 27 to 54 kHz. The system is described in brief giving details of transducer construction, shading on transmit and receive and results of some beam pattern measurements. The echo sounder system has been used to carry out measurements on caged aggregations of live fish. These experiments are described and the results presented for fish with different sizes of swim bladder. Observations of fish were carried out using stereo underwater cameras to observe the swimming angles and distribution of fish within the cage. The frequency response results are discussed along with the behavioural information.

The 'in-situ' Target Strength Measurement of Fish using a Dual-Beam Method

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This paper describes an implementation of the dual beam method for the measurement of fish target strength *in situ* first proposed by Ehrenberg. The advantages of the technique in obtaining results independent of position within the acoustic beam are considered, as well as some of the limitations of the method, in particular the requirement for resolution of single echoes. Results of experiments on known targets are presented which confirm the theory of the technique and show the high degree of precision potentially attainable. A limited amount of data has been gathered on live fish in the wild, particularly herring and blue whiting, and this is discussed in relation to target strength information obtained by other methods for similar fish.

TVG Functions for Short Range Acoustic Measurement

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The time-varied-gain of a sonar compensates for the range dependence of echo strength. However, the usual '20 Log R' and '40 Log R' functions are exact only at infinite range. At short range, exact compensation requires more complicated TVG functions because of bandwidth related delays and the gain charge over a pulse length.

The thoery of echo formation is used to derive exact gain functions which make the echo energy integral independent of range, for the case of (a) an isolated target and (b) randomly distributed scatters. In each case the exact function is shown to be the infinite range expression multiplied by a polynomial in T/t (T = pulse length, t = time after transmission).

Analytic functions are given for systems with simple transfer functions. The significance of the pulse length bandwidth product is discussed. Numerical functions are derived for echo sounders used in fishery research and are compared with the measured gain variation. The error in the conventional TVG function may be significant at the short range of the reference target used for calibration.

The theory of exact TVG functions is not restricted to underwater acoustics. It is generally applicable to the measurement of reflected pulses in any medium, when the pulse length is a significant proportion of the target range.

A Scan Converter for a Sector Scanning Sonar

C M Carey-Smith and J W R Griffiths
Loughborough University of Technology

Previous papers by one of the authors have shown how the use of a scan converter with a sector scanning sonar considerably enhances its performance.

The present paper describes a further extension of this work making use of a high speed signal processing chip, the TMS320. Since the conversion to polar co-ordinates can be achieved in real-time it is possible to display a much larger sector than the sector being actively interrogated by the sonar. This gets over one of the problems associated with these sonars, ie in the initial design in order to limit the cost a compromise has to be made between angular resolution and the size of the scanned sector. The use of the scan converter with the polar conversion and wider display gives a much clearer picture to the operator of the environment in which he is operating. Of course only the sector currently insonified is up to date but with the slowly changing nature of the sonar scene this limitation is not too restrictive.

By interfacing this system with gyro information about the movement of the ship a stabilized display can be obtained.

A Flexible Sonar Transmitter

A D Goodson, J W R Griffiths and W J Wood
Loughborough University of Technology
J C Cook
Admiralty Research Establishment, Teddington, Middlesex

The paper will describe the design and development of a flexible sonar transmitter. In the present system 16 separate linear power amplifiers drive individual transducer elements. Separate computer memories supply the inputs to the power amplifiers via D/A converters and the memories are loaded from a dedicated microcomputer. The system is highly flexible in that a whole variety of different waveforms can be generated and transmitted. Examples include steered beams, ripple fire in which a succession of pulses are transmitted as the

transmitter beam is stepped across the sector, swept beams, focused beams, shading of the array, FM pulses, modulated pulses for NLA and so on. The main limitation to the flexibility is the bandwidth of the transducers, otherwise it would be possible to switch rapidly from one frequency to another.

In the paper we will describe the main components of the transmitter and show results of trials which have been carried out on the system at a local reservoir.

To keep the cost down the initial system was constructed with power amplifiers of only 100 watts per channel but even with this power NLA transmissions have been obtained. A much higher power version is under construction, together with an appropriate transducer array.

A Microcomputer-based Precision Mechanical Scanning Sonar

J W Goodge and J W R Griffiths
Loughborough University of Technology

The trade-off between high resolution and relatively slow image access has been a necessary compromise to researchers using precision mechanical scanning sonar systems for certain acoustic applications. Over the past five years or so, this factor has been somewhat offset by the emergence of microcomputer based equipment and associated intelligent peripherals, which has lead to the development of interesting solutions to underwater imaging problems.

An experimental system has been built at Loughborough comprising a computer controlled scanner and a high frequency, short pulse, pencil beam sonar, to gather high resolution images of underwater targets. The display and processing of image data is managed by a microprocessor based system which additionally oversees the control of incremental scanning, analogue/digital conversion' and data storage processes. The image display centres around an intelligent colour graphics controller whose framestore dimensions are 640 x 576 with 8-bit pixel definition. The sonar image is presented in a high resolution television format on a large screen colour c r t.

In the work described here a series of B-scan (bearing/range) intensity images, taken at different elevations, are digitized and filed in a framestore. Data processing techniques quickly compute and display an alternative array of two dimensional slices for immediate assimilation in colour or grey-scale presentation. This equipment provides a flexible and versatile tool for the visual oriented assessment of target echoes.

Summary of an Automatic Beamplotting System

P J Hill
Loughborough University of Technology

This paper describes a flexible computer-controlled beamplotting system for a sonar transducer, based around a BBC microcomputer which performs all the control and analysis functions.

The computer sends azimuth and elevation control signals to a stepper motor control unit, which directs the motors supporting the transmit array head. In this way the array is swept past a stationary hydrophone in programmable increments, transmitting on each bearing selected. The signal received from the hydrophone is fed via an external sample and hold unit to the BBC's inbuilt A/D converter and the BBC then plots in real time a graph of received amplitude against azimuth on the screen. This image can then be dumped to a printer and/or saved on a disc for later retrieval, a facility which is particularly useful in the field. All major parameters such as sweep angle and increment size are stored on disc so that they need not be re-entered each time the program is run.

The computer automatically calculates the 3 dB points of the beamplot and the associated beamwidth, both of which are optionally displayed on the screen. Both log and linear plots are available. The accuracy is principally limited by the resolution available on the BBC micro screen and the performance of the A/D unit.

Open Session

Models of Turbulent Noise Sources in the Vocal Tract

Christine H Shadle
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The acoustic mechanism of fricative consonants such as 's' and 'sh' was studied by the use of mechanical models. In the vocal tract, turbulence is generated at a narrow constriction, typically formed by the tongue, and the resultant jet is in some cases directed at an obstacle such as the teeth. These functions were duplicated in the mechanical models by a cylindrical constriction positioned inside a tube, with a semi-circular disk positioned downstream and normal to the flow. The source model derived from sound spectra measured when the obstacle was not enclosed by the duct was based on the dipole-like directivity pattern. When this source model was used at the location of the obstacle in a one-dimensional model of sound propagation in the vocal tract, predicted spectra closely matched the spectra of the sound generated by air passing through the mechanical model. Comparison with speech spectra revealed this to be a good model for 's' and 'sh'. For other fricatives, where the jet does not directly impinge on the teeth, it appears that spatially distributed rather than localized flow dipoles are the dominant source mechanism.

A Study of Sound Transmission Loss in a Rectangular Attenuator lined with a Parabolic Wall Conductance

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National Institute of Standards
Hany Selim
IBM Cairo Scientific Center, Cairo, Egypt

The sound attenuation in a free path rectangular duct of constant cross-sectional area was theoretically studied for the case of a parabolic change of wall conductance. The solution of the obtained Bessel differential equation consists of a combination of modified Hankel functions of the order ⅓.

The attenuator characteristics at a certain frequency were found to depend only on the duct length (L) and an attenuator characteristic area (A_c) defined as:

$$A_c = \frac{s}{g_o};$$

where s = actual attenuator cross-sectional area,

and g_o = normalized wall conductance at a distance of 1 cm from attenuator input.

When this attenuator is introduced as a termination to a hard duct, an input reflection coefficient of the order of 0.1 and a transmission loss of the order of 30 dB were calculated for a frequency > 100 HZ and L = 150 cm and A_c = 1000 cm^2.

Experimental results were in good agreement with the theoretical results.

Parabolic changes of the wall conductance can be realized by means of a homogeneous sound absorbing flow resistance together with a slit which changes parabolically along the length of the attenuator. By the experimental implementation of this slit a variable perforation area having the same dependence on length and a perforation ratio of 35% or more was used.

This attenuator, which can be easily realized, allows a wide frequency band operation due to the frequency independence of its lining. Having free path and constant cross-sectional area it can have many applications; as for example an attenuator for airconditioning ducts or as an anechoic termination for machine testing with non zero flow by the induct method.

The Response of a Resonator under a Turbulent Boundary Layer to a High Amplitude Non-harmonic Sound Field

A Cummings
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There are many situations, for example in jet aircraft engine duct liners and in the exhaust silencers of internal combustion engines, where resonators exposed to grazing mean gas flow are used to attenuate intense sound waves. Both mean flow and high amplitude effects are felt in determining the resistance and inertance of the resonator orifice(s). This paper describes a time-domain solution for the response of a resonator excited by a complex periodic sound field. A quasi-steady orifice resistance and a frequency and mean flow dependent inertance are embodied in the models. The resistance term is determined both by the particle velocity in the orifice and by the mean flow velocity and boundary-layer thickness. A Strouhal number based on frequency, orifice dimensions and mean flow wall friction velocity determines the inertance. Predictions and measurements of the resonator response to the sound field are presented, and agreement between the two is satisfactorily good. The solution scheme could equally well be used for random or transient excitation, though the treatment of the inertance in these cases is not entirely clear. With suitable modifications, the model could also be applied to perforated plates or pipes backed by regions of distributed impedance.

Optical Probe Microphone

R Ohba
Department of Instrumentation and Analytical Science, UMIST, Manchester, and Hakkaido University, Sapporo, Japan

It is well known that the displacement of the diaphragm of a microphone when stimulated by sound pressure is proportional to the cube of its diameter and that its detection is extremely difficult with a conventional electrical means if the diaphragm is less than 2 mm in diameter.

The author has proposed an opto-electronic method of making a very small probe-microphone by using a coherent light and an optical fibre. The diaphragm is combined with the end of an optical fibre to form a Fabry-Perot cavity, the resonant peaks of which are related to diaphragm movement and are detected optically using a coherent light source.

A pilot model, constructed to illustrate the feasibility of this proposal, has shown high sensitivity but there are two outstanding problems to be solved before it can be implemented practically. Both problems are direct results of underlying principle, the periodicity of the resonant characteristics with respect to displacement due to the interference of light waves. Efforts for their improvements have been continued.

In this talk, revisions successfully carried out to improve these problems will be presented.

A Neuronal Process Involved in Involuntary Detection of Environmental Changes

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Event-related brain potential (ERP) studies have revealed a component called the mismatch negativity (MMN) in response to occasional deviant stimuli presented in a sequence of homogenous repetitive, 'standard' stimulus (the 'oddball' paradigm). This negativity probably reflects a neuronal mismatch process between some neuronal representation of the standard stimulus. The existence of a neuronal-mismatch process implies a neuronal representation of a stimulus. This is established by repeating the same 'standard' stimulus with short intervals (ISI), eg, 1-2 sec. The neuronal representation, inferred from the MMN data forms the neurophysiological basis for the short-term memory called sensory register in cognitive psychology. This is characterized as an automatic passive system with large capacity which contains rapidly decaying raw sensory data.

The present study addresses the duration of the assumed neuronal representations and the persistence of MMN in noise. This was studied by varying the stimulation rate (ISI) in the oddball paradigm. Two noise levels were used: weak (background pink noise 60 dB(A) and impulse noise 75 dB) and loud (background pink noise 75 dB and impulse noise 90 dB). The idea is that a deviant tone (pitch deviance) can elicit a mismatch negativity only when the neuronal representation of the previous standard tone is still alive (stand = 1000 Hz, deviant = 1150 Hz; 30 msec, 65 dB(A); probability of stand = 90% and dev = 10%).

By applying this 'probing method', the duration of the neuronal representation involved appears to be up to 4 sec in the silent conditions since a clear MMN was elicited by the deviant tone when the ISI was short, 1 and 2 sec, whereas no MMN appeared to emerge when the ISI was long, 4 or 8 sec. In the noise conditions, the MMN amplitude was dramatically reduced in each of the ISI conditions except in the short ISIs, in those situations in which the loud impulse noise burst coincided with the deviant tone. However, this was not the case when the impulse noise coincided with the standard tone. Performance of the subjects in detecting the deviant tone was poorest in loud noise especially when the stimulation rate was slow.

The MMN could be interpreted as reflecting passive and involuntary (not active and voluntary) detection of environmental changes. Loud varying and impulsive noise can catch the subject's attention and distract on-going cognitive processes.

Room Acoustics

Speech in Theatres: What are the Important Considerations?

M Barron
Department of Architecture, Cambridge

To be able to predict speech intelligibility in theatres, at least six influences need to be considered:

- Theatre impulse response
- Speaker orientation
- Frequency effects
- Speech level at listener position (due to theatre)
- Speaker sound power
- Background noise level

Arguments have also been put forward that speech intelligibility is not the only important consideration in rooms. This paper will endeavour to show which of the influences listed deserve the major attention in theatre design. Most of the data discussed was derived in an extensive objective survey of 12 British theatres and a complementary subjective survey of three of these theatres.

Objective Room Acoustic Parameters using 2-channel Analysis

K Højbjerg
Brüel & Kjær, Nærum, Denmark

Measurements in room acoustics have until now been carried out as simple signal analysis using noise bursts or a non ideal impulse. By using a dual-channel FFT analyser it is now possible to perform system analysis in room acoustics. Measuring the impulse response this way the influence of a non ideal excitation signal is cancelled, by the coherence function a measure for the quality of the measurement is obtained and the phase information is maintained and therefore further analysis is possible.

From the impulse response obtained with this technique objective parameters such as clarity, point of gravity time, signal to noise ratio, EDT, reverberation time and several others can be derived. It is also possible to calculate the Complex Modulation Transfer Function and from that the Speech Transmission Index is derived. Theory and measurement results will be presented.

Variable Acoustics in the Orchestra Rehearsal and Recording Hall of the Hong Kong Academy for Performing Arts

J Miller
Bickerdike Allen Partners

In 1983, Bickerdike Allen Partners were engaged by the Royal Hong Kong Jockey Club to advise on acoustics and noise control in the proposed Academy for Performing Arts in Wanchai, Hong Kong. The building was handed over to the user in November 1985.

Amongst the many specially acoustically-designed spaces is a hall designed for the rehearsal and recording of orchestral music. The written brief called for consideration of the acoustic conditions for each of these proposed uses and suggested that it may be necessary to provide a variable reverberation time in the range 1.5 to 2.5 seconds.

This paper will describe the acoustic and practical design considerations which led to the adopted solution — a system of absorber boxes and mechanical flaps — and report the early reactions of the building users.

Refurbishment of Albert Hall (Chamber Concert Hall)

D Templeton
Building Design Partnership — Acoustics Unit, Manchester

The serious fire of November 1981 destroyed the civic hall within the Town Hall, Bolton, Lancashire. Whilst the double-cubed hall was impressively large to suit the organ recitals fashionable in the late nineteenth century, the original hall had become something of a 'white elephant': under-used because of its poor environmental conditions, great volume, poor vision from uncomfortable wooden seats on flat floor, limited platform depth, and problematic acoustics.

A radical form of refurbishment was undertaken by the division of the hall into an upper concert chamber (continuing to be called the Albert Hall) and a lower hall (named the Festival Hall), as a positive approach to improving acoustics through improvement in the basic acoustical properties rather than remedial devices installed to a problematic space.

The brief defined in the proposal reports was to create suitable conditions for chamber orchestra concerts as a first priority in a main hall, but with brass band concerts, pop-concerts, ballroom dancing, fashion shows, conferences, speech days, banquets, and spectator sports, all as likely additional venues.

This paper describes the standards achieved by the completed new arrangement, as found in recent commissioning tests on reverberation characteristics, seating, ventilation noise, and sound systems.

Acoustic Problems and Solutions of New Studios for Central TV

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Sound Research Laboratories Ltd, Colchester, Essex

Central Television recently extended facilities at their Birmingham Studios to include two new studios — an 1100 m^3 Music Studio and an 100 m^3 News Studio — together with their associated Control Rooms. The design of these Studios presented significant problems regarding sound intrusion and sound transmission. The Music Studio was located on top of a car park, under the main plantroom for the building and adjacent to technical areas and open plan offices. The News Studio was located at the end of the News Operations Room and underneath the main Reprographics Room. Furthermore the News Studio was open into the News Operations Room. This paper describes the acoustic problems of the two Studios, how they were designed to overcome the problems and results of tests on the completed Studios.

Building Acoustics

Simplified Measurement of Sound Insulation (ISO Standards)

R K Mackenzie
Heriot-Watt University, Edinburgh

Abstract not available.

In-situ Measurements of Sound Insulation using a Portable Sound Intensity Analyser

K B Ginn
Brüel & Kjær, Nærum, Denmark

This paper presents a small, battery-operated intensity analyser which enables field measurement to be conveniently performed. The microphone probe used with the analyser is fitted with microphones equipped with phase correctors.

Analysis may be performed in octaves or broadband and the measurement results may be outputted via the interface.

To illustrate the use of this portable sound intensity analyser in practice the direct and the flanking sound insulation between two newly built terraced houses were measured and the results compared with a classical insulation measurement. The effect of discrete point and sweep measurement techniques on the results was also investigated.

The Use of Time Delay Spectrometry in determining Sound Insulation Performance

A S Munro
Munro Associates, London

The measurement of the performance of barriers for sound isolation has traditionally been based on single port analysis, ie a known source is set up one side of a barrier and a single or multiplexed system of transducers is used to analyse the energy received on the other side.

In using a two port system, a swept sine wave is fed to the sending room and the resulting energy is picked up in the receiving room by a bandwidth filter tracking the original sine wave by a specific time offset. By varying the time offset it is possible to identify energy arriving by different path lengths and to analyse the frequency — energy relationship of each discrete arrival.

By using the Heyser Transform the TDS analyser will display energy as a function of time with controlled frequency range.

By considering the real and imaginary components of the received signal it is possible to extrapolate impulse and phase measurements which give direct indications of the behaviour of the materials and construction method under scrutiny.

By using slow sweep rates and narrow band filters extremely good noise rejection is possible enabling measurements to be made in the presence of high ambient noise.

Sound Insulation by Absorber Barriers

F P Mechel
Fraunhofer-Institut für Bauphysik, Stuttgart

There exist situations where the sound insulation cannot be realized by walls. One example thereof is the sound transmission through the plenum-chamber between the massive and suspended ceiling, and similar situations exist in the air spaces between floors and access floors. The sound insulation cannot be performed in these cases by walls or panels due to the large number of pipes, ducts and cables in those interspaces. Finally, safety openings for explosive overpressures cannot be isolated by walls.

In all these cases, barriers made out of piles of acoustical absorber material can give the needed sound insulation and the easy fit to complicated contours and a sound insulation with a minimum of material weight.

The sound insulation of such absorber barriers was investigated theoretically and experimentally for a number of absorber materials, barrier thicknesses and for different grades of sealing towards the surrounding walls. The results of these investigations will be reported.

Sound Insulation for Sealed Double and Triple Glazings

Birgit Rasmussen
Danish Acoustical Institute, Lyngby, Denmark

Basically the sound insulation of a window depends on glass thicknesses, laminating, interpane spacing(s) and filling(s). Moreover, the sound insulation is influenced by the edge conditions of the glazing, the type of frame and sash, the tightenings, and the size of the window. In addition, the importance of each construction detail is connected with different frequency regions, but the significance is dependent on the other details, too. This confusing effect is especially pronounced for windows. Unfortunately, the theoretical models for walls are not particularly suitable for windows.

The Danish Acoustical Institute is carrying out a project series comprising investigations of sealed glazings and frame/sash-constructions. Until now, double and triple glazings have been investigated. The influence of glass thicknesses, laminating, interpane spacing(s) and gas-filling on the sound reduction has been examined. The aim of the experiments is to give window and glazing manufacturers better possibilities to optimize the sound insulation in relation to total weight, thickness or price of the glazing.

The experiments showed that an optimization of the glazing details can result in a 3 to 5 dB higher sound insulation (R_W-value), alternatively a lower weight, thickness or price. Special attention should be paid to the combination of gas filling and interpane spacing(s). Generally the best sound insulation is obtained for asymmetric constructions.

Determination of Random Incident Sound Absorption Coefficient of Acoustics Materials using Sound Intensity Measurement

J Belza
National Research Institute for Machine Design, Běchovice, Czechoslovakia

This paper shows how the random incident sound absorption coefficient of acoustics materials can be calculated from values of reactivity of the sound field measured near the absorbing material. A simple utilization of a two-channel measurement technique is presented. The evaluation of the reactivity of the sound field near the absorbing material is achieved by measuring the sound pressure and sound intensity with a two-microphone probe. The main advantages of this method are a simple procedure and smaller area of the investigated pattern of absorbing material. Errors of the determination of sound absorption coefficient are discussed.

New Building Regulations for Sound Insulation

L C Fothergill
Building Research Establishment, Garston, Watford

New Building Regulations for England and Wales were introduced during November 1985. In the case of sound insulation the old Part G has been superseded by Part E, but the changes have more significance than just a new name. The old Regulations were contained in a Statutory Instrument and could only be changed with the consent of Parliament. The new Regulations are in the form of functional requirements listed in a Statutory Instrument but ways of satisfying the requirements are suggested in supporting Approved Documents which are not Statutory Instruments. An advantage of the new system is that the ADs can be updated without consulting Parliament, but a consequence is that the solutions they contain are not deemed-to-satisfy the requirements.

In Part E the opportunity has been taken to incorporate solutions making use of up-to-date research. Several new construction types have been included as has a special provision for party walls between stepped or staggered dwellings. It has also been found that window openings in external walls can reduce flanking transmission via the inner leaf and this makes use of thermally efficient blockwork acceptable. The technical basis of these additions and changes will be described in the full Paper.

Sound Control for Homes (What the Approved Document doesn't say)

J Miller
Bickerdike Allen Partners, London

Approved Document E 1/2/3 contains much useful and detailed advice on the construction of separating walls and floors to optimize their sound insulation and thus tend to meet the requirements of the Building Regulations (1985). This information will undoubtedly be valuable to architects and builders. If they observe the details this will undoubtedly do much to eliminate the poor field performance witnessed by the Building Research Establishment during their survey of dwellings built in the 1970s.

The Building Regulations have emphasized the sound insulation of separating walls and floors to the exclusion of all other aspects of building acoustics. Consequently, the data base for anything other than separating walls and floors is lacking and not available in an appropriate form for the practising architect.

The Construction Industry Research and Information Association have engaged Bickerdike Allen Partners to prepare a 'state-of-the-art' manual on all aspects of domestic noise control for architects. The objective is to enable the architect to deal with straightforward noise and sound insulation design problems himself.

The paper will illustrate the scope and content of the designers' manual and discuss some of the practical aspects of meeting the requirements of the Building Regulations.

Control of Sound Insulation in 'Change of Use' Situations Affecting Houses or Flats

S Maslivec
Environmental Services Department, Bolton MBC

This paper attempts to identify, quantify and suggest controls for the problems of unwanted airborne sound transmission between flats in houses and buildings which have undergone conversion, and between flats and adjacent dwelling houses or even commercial and other uses.

In recent years the demand for small housing units has increased, and this is being met in part by the conversion and subdivision of older, larger properties into numerous self-contained flats. On conversion, it is common for walls and floors which once separated rooms in houses initially built for single occupancy, to become separating structures between the newly formed dwellings. Often, these structures fall short of the sound insulation provisions of the current Building Regulations, usually resulting in loss of amenity due to noise between households.

The problem is further compounded by the fact that the 'adequate' sound insulation provision of the Regulations does not apply to conversions, and on occasions there is incompatibility of room layout eg noise sensitive rooms, such as the bedroom of one dwelling, sharing a wall or floor with a noise producing room of an adjacent dwelling, such as a living room or kitchen.

A degree of control, however, may be exercised by the District Planning Authority when determining planning applications for conversions. Satisfactory room arrangement and room layout in adjacent dwellings needs to be taken into account, and in some cases a sound insulation improvement scheme is necessary.

Two improvements often recommended by local authorities are based on the advice of the Building Research Establishment in respect of the wall lining method and the independent ceiling for floors.

This paper, then, considers the controls used in Planning and describes the results of field tests to determine the airborne sound insulation qualities of a number of walls and floors which separate dwellings or rooms.

The Effect of Workmanship on Structure-borne Sound Transmission

R J M Craik and D I Evans
Department of Building, Heriot-Watt University, Edinburgh

Although a building is a very complex structure it is not always built with the greatest care. As a result it is sometimes found that two buildings or parts of buildings which appear to be identical do not perform acoustically in the same way. If this difference in performance cannot be attributed to differences in design or material properties then it must be somehow related to workmanship.

In order to determine whether there was such an unexplainable variation in performance detailed measurements were made of structure-borne sound transmission in a building. Structure-borne measurements were chosen because they are much easier to predict and flanking paths are usually less important.

It was found that between walls or floors which were nominally identical there was a difference in performance. The variation was approximately 2 dB (standard deviation) and did not vary between five different types of joint construction that were tested. At low frequencies the variation is higher due to the small numbers of resonant modes which do not always have the same frequencies in different walls.

It is therefore concluded that there is a variation in performance between nominally identical structures and that this variation is about 2 dB for the structure type that was studied.

Sound Insulation in Multi-plex Cinemas

D W Templeton
BDP Acoustics Unit

P E Jones
British Gypsum (Research and Development Dept)

British Gypsum have been involved in a number of schemes involving the subdivision of large cinemas to several small studio cinemas. BG and BDP have co-operated on a new complex, now open in Milton Keynes. This is the UK's first integrated entertainment centre by Bass Leisure and American Multi-Cinema, coping for an attendance of 5000 per night. Nearly half of this number are catered for by 10 studio cinemas. This offered a great sound insulation challenge which led to the development of a high performance triple leaf metal stud partition. An optimal specification was tested in BG's laboratories, installed with careful supervision, and room-to-room transmission commissioning measurements taken on site.

A further 10-screen centre is proposed by AMC in Bristol, so BDP and BG are carrying out further development work.

This paper principally described the performance of types of double and triple leaved plasterboard partitioning as well as touching on other acoustics aspects of multi-plex cinemas — noise from ventilation plant, sound systems and reverberation characteristics.

Using Statistical Energy Analysis for Structure-borne Sound Transmission at Low Frequencies

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Department of Building, Heriot-Watt University, Edinburgh

One of the fundamental limitations, when using Statistical Energy Analysis to predict sound transmission through structures, is the need to have enough resonant modes in any frequency band for the theory to be applicable. This is particularly relevant for structural transmission involving small walls or floors where there may often be very few modes in the lower bands of interest.

To establish a lower limit to the number of modes necessary to use Statistical Energy Analysis, detailed measurements were made in a building for a range of joint types and wall sizes. These have been compared with the best available predictions.

It has been found that modes in the receiving wall appear to dominate transmission behaviour, and that between 1 and 5 modes per 1/3 octave band, or a modal overlap of about 0.3 is necessary for reasonable agreement with predictions. It is also noted that low-frequency predictions of modal frequencies and modal density are not very accurate for these walls.

A Theoretical and Experimental Investigation of the Bending Vibration of Connected Rectangular Plates

B M Gibbs and Y Shen
University of Liverpool

Results are presented of an investigation into the bending vibrational response of a combination of plates to a point force. A comparison is made of predicted vibration level difference obtained by means of a computer model and measurement obtained by means of scale models. Level differences are indicated as functions of frequency over a range 0 - 2 kHz with a resolution of 20 Hz for the prediction and 5 Hz for the measurement. The computer model allows prediction of level differences at points on the same plate or across one or more junctions.

Two non-coupled edge conditions are considered, one of which approximates the simply supported condition and the other the clamped condition and the effects of receiver position, complex plate bending stiffness and complex edge rotational stiffness have been considered. A L-combination of plates is investigated and agreement between prediction and measurement is promising. The discrepancies which occur at low frequencies for accelerometer positions near to edges were thought, in the main, to result from experimental problems.

The mathematical formulation in which bending vibration only is assumed gives fair agreement with measurement for the frequency range investigated. This represents, in the computer model, the organization of 20 eigen modes for the L-combinations of beams perpendicular to the junction and 7 eigen modes of the single beams parallel to the junction; therefore, 140 co-ordinate function vectors are used to calculate the forced vibration. This represents, in full scale structures, an upper-limit well into the frequency range where Statistical Energy Analysis can be applied with confidence.

Industrial Noise

Factors affecting Annoyance due to Combinations of Noise Sources

C G Rice
ISVR, University of Southampton

Abstract not available.

Predicting the Noise Radiation from Built-up Machinery Structures — an Engineering Approach using Statistical Energy Analysis

G J Stimpson
ISVR, University of Southampton

Statistical Energy Analysis (SEA) methods have been used in conjunction with energy accountancy ideas to develop a technique for the prediction of sound power radiation from machinery and other built-up structures. The methods enable calculation and optimization of the changes in noise radiation associated with modifications to individual parts of a coupled structure. The techniques have been applied to predict the noise radiation from a number of structures including a simple structure composed of two plates welded at right angles and a model of a complete power press structure. Predictions of overall noise generally within 1 or 2 dB have been obtained compared with measurements using the surface velocity

technique on individual plates of the structures both in undamped and damped conditions.

Practical Industrial Methods of Increasing Structural Damping in Machinery

L C Chow and R J Pinnington
ISVR, University of Southampton

There is frequently a need to reduce sound radiation due to resonant flexural vibrations of stiff machinery panels. This can be achieved by the use of an appropriate damping treatment. Conventionally viscoelastic damping materials are used but such materials are often not ideally suited for use on industrial machinery which often may incorporate thick material sections, operate at elevated temperature, be subject to oil or other contamination or rough handling. Alternative damping treatments are currently being researched at ISVR and include frictional treatments, granular infill materials and squeeze film treatments. The advantages of these treatments will be discussed with emphasis placed on the squeeze film treatment. In this treatment a thin layer of fluid is trapped between two parallel plates; during vibration the fluid is pumped laterally between the modal cavities dissipating vibrational energy due to viscous losses. Experimental and theoretical data will be presented for the treatment with air as the fluid medium; the relative merits of using other more viscous mediums, ie, oil, will also be discussed.

Practical Experience of Factory Noise Propagation Modelling

D N Lewis
Unilever Research

Abstract not available.

The Prediction of Sound Radiation from Buildings

K Attenborough and N Heap
Open University

D Oldham
Sheffield University

R J Orlowski
Salford University

There is an important need to develop methods for accurately predicting noise levels outside buildings which house noisy activities. These prediction methods are essential if such buildings are to be appropriately designed and the environment suitably planned.

Considerable work has been carried out on the prediction of sound fields within factory spaces. The nature of these sound fields will affect the vibration and subsequent reradiation of noise from the factory shell. The problem of radiation from apertures and from panels has also been studied by Shen and Oldham and by Gomperts.

However this work has assumed either normally incident plane waves or diffuse fields. Research has shown that the sound fields within factory spaces neither conform to diffuse field theory nor can be represented by plane waves. Beyond the factory shell the sound will be influenced by ground and meteorological effects. Theories of outdoor propagation so far have been confined to incoherent point sources. Thus the problem of sound radiation from buildings will require both extensions to models of propagation, transmission and radiation and careful experimental validation.

Design Philosophies on a Cooling System Test Rig for appraising Low Noise High Performance Cooling Fans

J S B Mather
University of Nottingham

S G Bennett
Mining Research and Development Establishment

Abstract not available.

Improving Sound Insulation in Existing Buildings

19 February at the Polytechnic of the South Bank

Acoustic Privacy in Offices — Real and Imagined

P H Allaway
Grootenhuis Allaway Associates

Some details of constructions found between existing offices will be presented with particular reference to partition and ceiling transmission. Test results for a few of these constructions will be shown and a description given of the types of solutions which are easily available.

The question of criteria for acoustic privacy needs sceptical review; the use of Open Plan offices with, at best, partial barriers between workstations provides a minimum of acoustic privacy and yet is found satisfactory in many locations. The influence of background noise and its level appears strong if considering extreme cases but is often marginal in real life.

Some Experiences of Improving the Sound Insulation of Timber Joist Floors in Dwellings

R S Alphey
Building Research Establishment, Garston, Watford

During the 1980s there has been an increasing demand for the conversion of large single dwelling houses into flats; these conversions have all too frequently given rise to tenants' complaints of unsatisfactory sound insulation between units. Investigations into such complaints have shown a primary cause to be a lack of adequate floor insulation, but secondary considerations such as inappropriate room layout (eg kitchens over bedrooms), inadequate detailing (eg service holes through party walls), and poor workmanship (eg air paths through wall and floors) have also contributed.

The Building Research Station has been actively engaged on the problem of upgrading the sound insulation of timber joist floors in conjunction with several housing authorities by designing floors to meet their requirements and conducting sound insulation measurements after installation; to ensure that the correct construction procedures have been followed effective site control has proved to be essential and as conversions are, generally, 'one-offs' monitoring and measurements have entailed multiple site visits.

In this paper reference will be made to the improvement of the sound insulation of walls as this is conceptually simpler than for floors but mainly the paper will be devoted to describing the more complex problem of improving the sound insulation properties of timber joist floors.

The performance of a floor may be improved in three ways:

(i) by enhancing the surface of the floor
(ii) by treating the cavity
(iii) by modifying the ceiling

All three methods will be discussed individually and in various combinations; where possible field data will be presented.

It will be concluded that, in general, modest improvements in the sound insulation of floors may be achieved quite cheaply but that higher standards may require more expensive constructions, often requiring additional wall treatment to reduce flanking transmission.

An Experience in Extensive Sound Testing and Enforcement

J Blair
City of Glasgow Environmental Health Department

This paper is unashamedly anecdotal. Its aim is to describe the three year experience of enforcement Officers in the City of Glasgow, Environmental Health Officers and Building Control Officers, and their attempts to utilize the provisions of current legislation to stem the tide of the increasing numbers of noise complaints caused by poor sound insulation between dwellings, or between dwellings and commercial property in the same building.

The legislation being enforced is the Building Standards (Scotland) Regulations 1981 and the Control of Pollution Act 1974.

Since first involving themselves in this problem, the two Departments have been

responsible for carrying out approximately 1,000 part tests over a 3-year period.

A part test is where an impact and/or airborne test is carried out between one pair of apartments. These tests have been carried out in approximately 650 different locations and appear to have been accepted by the Courts as a valid indicator of the likelihood of compliance.

There is no doubt whatsoever that the text book specifications do work in the overwhelming number of cases, but the technical ability to solve a sound insulation problem has, in my opinion, never been in doubt. It is the belated application of the 'expert' to the problem and the very real financial constraints imposed on the public or private sector house builder in a climate where poor sound insulation is just emerging to gain wide public recognition as another major deficiency in an already grossly deficient housing stock.

If the acoustician is involved at the drawing board stage of a project, if the architect is permitted 'his' specification, if site control is reasonable, there should be no widespread occurrence of poor sound insulation in new, converted or rehabilitated property.

Complaints emerging suggest that people living in property of this type are no longer willing to tolerate being able to hear a neighbour 'stirring his tea' or 'living in a pressure cooker' where poor sound insulation causes a complete absence of privacy.

The solutions already exist, the expertise to find those solutions already exists. The one remaining question is: 'Does society wish to pay for these solutions and for this expertise?'

Case Studies of Sound Insulation Improvement in Converted Properties

T Curson and J Morrison
London Borough of Southwark

Grosvenor Terrace, London SE17, is a four-storey, brick built, Victorian terrace. The property under study had previously been laterally converted into flats. This involved the blocking of alternate front doors in the terrace, the remaining ones giving access to flats in the original property and also through the old party wall. In this way, each pair of houses was converted into eight flats, with access through one communal front door.

Prior to treatment all rooms contained traditional suspended timber floors. The original lath and plaster ceilings had been removed during an earlier refurbishment; all ceilings were simply plasterboard with uncovered plain-edged floorboards.

Two methods of insulation investigated were as follows: independent ceiling between first floor and ground floor flats; floating floor with pugging between ground floor and basement. A 12 mm layer of fibreboard was laid over all floors after treatment and this was considered as part of the treatment for test purposes.

The improvement of sound insulation is considered for each treatment and their limitations discussed.

Footfall-noise Insulation of Staircases in Terraced houses

H Ertel
Fraunhofer-Institut für Bauphysik, Stuttgart

The foot-traffic noise transmission of stairs in terraced houses or in semi-detached houses is for the dwellers in these houses a major reason of disturbance of privacy. Since the house-partition walls are often also the walls where the staircases are mounted, the impact-noise transmission into the adjacent house can be intensive. Out of a greater pool of footfall-noise transmission data the impact-insulation rating numbers TSM (Trittschallschutzmass) were compared with the airborne-insulation ratings of the party walls. Faultlessly built up double-leaf party walls show a sufficient impact-insulation whereas faulty double-leaf walls with flanking paths for structure-borne noise and single-leaf party walls do not meet the basic requirements according to German standards. Possibilities of improving the impact insulation by means of elastically supported staircase-steps and by resilient mountings of the staircases on the wall will be discussed.

The Principles and Practice of Noise Insulation

G Jackson
Atkins Research and Development, Epsom

A short introduction will describe the principles of noise and vibration in buildings. A few case studies will be used to illustrate the most important aspects, such as the difference between sound transmission loss and sound absorption, the importance of attention to detail and a short checklist of points to watch during the refurbishment of buildings.

Improving Sound Insulation of Floors in Flats — A Case Study

A J Jones
AIRO, Hemel Hempstead

Complaints from residents about excessive airborne sound transmission between vertically disposed dwellings in a purpose built development of flats and maisonettes led to an investigation of the alleged problem. Measurements of sound insulation were conducted in a large proportion of the dwellings to ascertain the degree and nature of any shortcomings, and a scheme of works was devised with a view to effecting a significant improvement in sound insulation within the practical constraints imposed in an existing building. Retesting in a sample of dwellings following completion of the works demonstrated that a satisfactory outcome was achieved.

Plaster Block-walls: A New Departure

J Mathys
Acoustical Adviser, PVBA

Plaster block-walls performed rather poorly in past decades for the acoustical insulation and have a bad transmission loss. Even double walls showed poor characteristics and had serious problems due to leakage and flanking.

A new method for constructing plaster walls has been developed with the CSTC (the Belgian Building Research Establishment for the Construction Industries) and used in a large private office building. The characteristics are first explained on a theoretical base and then the measured results in laboratory will be shown. The global performance is checked after installation *in situ* and the measured performance compared to the expected results. This is done for direct TL and flanking paths.

Improving Sound Insulation of Walls by Linings

F P Mechel
Fraunhofer-Institut für Bauphysik, Stuttgart

Linings are applied to walls more and more not for acoustical reasons but with the intention of improving thermal insulation. It has been known for a number of years that such linings may increase or decrease the sound protection between rooms. We have tested in our Institute the influence of a greater number of linings not only on the transversal sound transmission but at the same time on the flanking sound transmission, also. The parameters changed were: thickness and material of the cover plates (eg chipboard, plasterboard), thickness and nature of the insulating material (eg glass fibres, different foams), the way of mounting (without any contact, plastered point-wise or along lines, screwed), and the covered area ratio of the flanking wall and the distance to the T-joint of the transversal wall. It was found that the improvement of a lining is different for transversal and for flanking sound transmission, respectively. A very interesting finding was the influence of the distance to the T-joint in connection with brick walls.

Sound Insulation Improvements to a Dry-lined Blockwork Separating Wall

J Miller
Bickerdike Allen Partners, London

Bickerdike Allen Partners were engaged to investigate a problem of poor sound insulation horizontally between flats in two new blocks in Torquay. The party wall construction was of 220 mm lightweight concrete blocks with dry linings both sides. This was sitting on a continuous concrete waffle slab supporting a plasterboard ceiling. The paper will describe the detailed measurements undertaken to assess direct and flanking transmission, the results of an initial pilot study and the finally-implemented treatment which improved the airborne sound insulation from 145 dB AAD to 0 dB AAD.

Some Economic and Legal Considerations of Improving the Sound Insulation of Party Floors in Converted Dwellings.

S Rintoul
London Borough of Lewisham

The author considers the scale of the problem of inadequate sound insulation in converted dwellings; costs the two techniques most widely used, including considerations of scale and decant costs. Legal considerations covered include: prevention, remedy, common law and Control of Pollution Act 1974.

Improvement of Sound Insulation of Timber Floors: a Study of the Relative Significance of Mass, Resonance and Resilience in the System

R K Mackenzie
Heriot-Watt University, Edinburgh

Abstract not available.

Ultrasound in Medicine

International Conference organized by The Institute of Acoustics and The Institute of Physical Sciences in Medicines 7 — 8 April 1986 at the University of Bath

Invited Paper: Limitations on Precision in the Quantization of Acoustic Characteristics of Living Tissues: an Anecdotal Discussion

C R Hill, S M Badaway, J C Bamber, D K Nassiri, D Nicholas and M C Tristam

Coherent Scattering Measurement in Penetrable Inhomogeneous Media

J Adach, L W Anson and R C Chivers
Physics Department, University of Surrey, Guildford

The possibility of making ultrasonic field measurements directly in tissues using miniature needle-type hydrophones was shown by Lewin in 1981, in which the focusing of a beam in beef muscle was investigated. It is of particular interest to identify the phenomenology of the scattering that takes place in an inhomogeneous medium such as tissue.

A novel method is proposed, based on the analytical form of axial fields from focused bowl transducers which permits measurement of the absorption coefficient in homogeneous liquids, and of the coherent scattering contribution to the attenuation in inhomogeneous systems. The method has been tested on a model system and shown to give results in good agreement with the appropriate multiple scattering theory. The instrumental requirements for application to intact tissue are discussed and shown to present no serious impediment to the exploitation of the technique in diagnostic ultrasonic laboratory studies.

Computer Simulation of Ultrasonic M-Mode Image Formation

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Department of Medical Physics, St George's Hospital, London

M Tristam
Joint Physics Department, Institute of Cancer Research, Royal Marsden Hospital, Sutton, Surrey

Ultrasound provides a unique means of studying and documenting response of soft tissue to either normal or artificially induced movement. Although the potential of studying tissue movement by ultrasound has been reported by some investigators, more systematic study of this topic is essential.

With the aim of studying the effect of various system and processing variables, this paper describes a computer model for ultrasonic M-mode image formation. In this model, soft tissue is assumed to be a visco-elastic medium of known characteristics. The scattering structure of this medium is composed of rigid, isotopic, point scatterers, positioned randomly in three dimensions.

The predicted results from this model will be compared with the results of some physical models.

Analysis of Fine Structure in Ultrasound Images

T J Hall
Thorn-EMI, Teddington, Middlesex

J C Bamber
Physics Department, Institute of Cancer Research, Royal Marsden Hospital, Sutton, Surrey

An experiment has been built which models the way fine echo structure, (also called parenchymal echoes and speckle), is formed in medical ultrasound images. This process is not well understood and depends in a complicated way on the interaction between the variable structure of the tissue and the imaging system parameters. These include the transducer pulse and beam shapes (which define the resolution cell of the transducer), the scanning geometry, and the signal processing used. This simplified model allows the effect of the above features to be studied separately, as far as this is possible.

The salient features of the experiment are as follows. The tissue is modelled as a random distribution of small scatterers in a gelatine substrate. Its 'structure' therefore is described by the mean separation between the scatterers and their distribution. A range of transducers of the sort used clinically in static 'B' scanners is used. They have been characterized separately using a hydrophone. The scanning method was a simple rectilinear 'B' scan taking a series of horizontal 'slices' which build up to a particular volume within the model. The geometry was repeatable for each transducer. The rf signal for each 'A' scan line was digitized. All subsequent signal processing (such as envelope detection) was done by a computer. The resulting ultrasound images were analysed both visually and by using well known image measures based on the 2-dimensional Fourier transform and Autocorrelation function.

The results of this analysis will be presented. The models had a mean scatterer separation which ranged from greater than a resolution cell to less than a wavelength of the transducer pulse. The volume scanned had dimensions of 20 x 20 x 10 mm. The transducers had pulse frequencies between 3 and 5 MHz. A number of artifacts (system effects) were identified which are believed to be common to other ultrasound imaging systems. Certain characterizing features will be compared and the ability of this particular system to resolve model structure will be shown.

Inverse Scatter Imaging

S Leeman and V C Roberts
King's College School of Medicine and Dentistry, Dulwich Hospital, London

Many new techniques have been proposed for the imaging of the human body by the processing and manipulation of ultrasound data acquired from the scattering of incident fields within the region of interest. A physics-oriented view of these methods is developed, and it is shown that a strong unity underlies all the methods proposed up to now.

Some new results on the validity of approximations such as those of Born and Rytov are presented.

The vexed problem of multiple scattering is also addressed, and it is suggested that there may well be methods available for tackling this difficulty.

The Mechanisms of Absorption of Ultrasound in Protein Solutions, in the Frequency range 100 kHz - 50 MHz

J A Evans, Department of Medical Physics University of Leeds, Leeds General Infirmary

C Barnes and T J Lewis
Institute of Molecular and Biomolecular Electronics, University College of North Wales, Bangor

Speculation about the mechanisms of ultrasonic absorption in tissue has persisted for several decades. It now seems clear that, in the medical frequency range, absorption constitutes at least 80% of the total attenuation and that most of the absorption occurs at a macromolecular level.

Relaxational processes have been invoked as explaining, in general terms, the relatively slow change in absorption with frequency although specific molecular processes have often not been identified.

The broad frequency spread of these processes makes it important to characterize the materials over several decades of frequency but there is a lack of data below 1 MHz, due mainly to problems in developing suitable measurement techniques. In the study, we have used a spherical resonator facility for measurements down to 100 kHz.

Results obtained from two globular proteins, bovine serum albumin (BSA) and haemoglobin, are presented. They show a peak in the absorption per wavelength $\alpha\lambda$ under acid conditions at about 350 kHz. Similar results have been obtained by other workers for alkaline conditions in the low megahertz range.

Further measurements on these proteins under neutral conditions have shown $\alpha\lambda$ peaks at the same frequencies when one denaturing agent, guanidine hydrochloride, was added but not with other denaturants. It is speculated that proton-transfer processes are responsible for these peaks and therefore protein hydration and structure are relatively unimportant in determining the absorption in this frequency range.

Invited paper: Nonlinear Propagation of Acoustic Waves in Fluids: an Overview

H O Berktay
University of Bath

Non-linear Ultrasonic Fields: Theory and Experiment

D R Bacon
Division of Radiation Science and Acoustics, National Physical Laboratory, Teddington, Middlesex

The central problem in the theoretical modelling of non-linear ultrasonic fields is the fact that the three processes of diffraction, non-linear distortion and attenuation have to be accounted for simultaneously. One approach that has been employed successfully to overcome this difficulty is the use of a Gaussian beamshape to model the field. This method has the advantage that the problem can be analysed in terms of modes that both satisfy the diffraction conditions and propagate independently until the distortion becomes severe.

A general method of describing the propagation will be given which accounts for the phase variation occurring within the near field zone and which can be used when the distortion is severe. The results of measurements in transducer fields, including those with a Gaussian shading function, will also be presented.

Harmonic Generation due to Non-linear Propagation in a focused Ultrasonic Field

V F Humphrey, M Burgess and N Sampson

Abstract not available.

Light Diffraction by Ultrasound as Evidence of Finite Amplitude Distortion

D H Follett
Electronics Unit, Bristol General Hospital

A continuous wave ultrasound beam can be regarded as a phase contrast diffraction grating for a coherent light beam perpendicular to it and a Schlieren beam visualization system enables the resultant diffraction patterns to be readily observed under Fraunhofer conditions.

It was observed that the diffraction patterns from a 2 MHz ultrasound beam became progressively more asymmetrical as sound intensity was increased. Comparison with the output of a PVDF hydrophone showed there was good qualitative agreement between the degree of asymmetry and the amount of waveform distortion, with no effects visible at sound pressures below 140 KPa but very marked effects at twice this value.

Observation of Fraunhofer diffraction thus appears to provide evidence for finite amplitude distortion independently of hydrophone measurements although at present the technique is not quantitative.

Measurement of Acoustic Non-linear Parameter and Sound Speed in Human Tissues

C M Sehgal and J F Greenleaf
Department of Physiology and Biophysics, Mayo Clinic/Foundation, Rochester USA

In this paper we will discuss a thermodynamic method that is suitable for measuring acoustic non-linearity parameter, B/A, of tissues. The method consists of following the time course of the phase changes of a transmitted sound signal as the hydrostatic pressure on the medium is altered. From the instantaneous and the equilibrium phase changes during the pressure release, isentropic and isothermal components of B/A are determined without *a priori* knowledge of the thermodynamic constants of the tissues. This method of measuring B/A was used to determine acoustic non-linearity of excised, normal and diseased, human livers. Sound speed in each tissue sample was also measured. A portion of each sample of liver was analysed for fat and water content. A close relationship between acoustic parameters and fat-water composition was observed. We believe that by using this relationship it is possible to predict tissue composition from the acoustic parameters. Finally, we will present our preliminary results in imaging B/A in transmission ultrasonic computer-assisted tomography. This work was supported in part by National Science Foundation ECS 8310626 and National Cancer Institute CA 24085.

Observations of Finite-amplitude Distortion in Tissue

F A Duck and H C Starritt

Abstract not available.

Non-linear Effects with Focused Ultrasound in Tissues: an Improved Model

W Swindell

Previous work has predicted that non-linear effects associated with focused ultrasound in tissue will result in an elevation in the absorbed-power deposition rate at the focus over that which would be expected in the absence of non-linear propagation. This is caused by the increased absorption of the higher harmonics that are produced by the conversion of acoustic energy from the fundamental frequency into the higher modes.

It was pointed out that the model used could, and should, be improved in at least two ways. i) The differing phase propagation terms of the higher harmonics should be considered and ii) the focusing properties of each harmonic should be considered separately.

The present work describes some of the results obtained when these improvements are made. In summary, it is observed that i) additionally increased enhancement ratios are predicted in the region of the focus and ii) the predicted pressure waveform in the region of focus more closely matches that which would be expected on the grounds of diffraction theory.

An Experimental Search for Non-linear Propagation on Absorption of Ultrasound

R L Clarke, G R ter Haar, and W Swindell

It has been predicted that focused, high-intensity ultrasound propagating through a non-linear medium will produce higher harmonics of the incident wave and that under these non-linear conditions a region of enhanced energy deposition (relative to a linear situation) will appear. This peaking in energy deposition is near the geometrical focus of the beam. The phenomenon may have a bearing on the heating of tissues in ultrasound-induced hyperthermia.

An experimental search is being performed to verify the existence of this enhanced heating effect. A focused system consisting of a 12.5 cm diameter PZT transducer and a perspex lens with a focal length of 14 cm is employed. 600 watts of amplifier power is available, in either tone burst or continuous mode. The transducer is run at its fundamental frequency of 535 kHz. These operating parameters are close to those chosen in the reference calculation by Swindell. Field amplitudes are measured using a PVDF membrane hydrophone. Arrays of miniature thermocouples measure the temperature rises.

Preliminary experiments have shown a non-linear heating effect with increasing power levels. Work is continuing to positively identify this enhancement with non-linear propagation. The experiment and current results will be discussed.

Non-linear Propagation Models in Ultrasound Hyperthermia

P A Lewin, M E Schafer and M E Haven

Abstract not available.

Finite-amplitude Wave Effects in the Focal Region of an Ellipsoid

L Bjorno, N Krebs, J Roed and C Rützou

Abstract not available.

Invited Paper: Absolute Calibration Methods for Ultrasonic Fields

R Preston

Diffraction Effects in the Pulsed and Continuous Wave Fields

J P Weight and Miss M Restori

The field radiated by an ultrasonic transducer has recently been described in terms of interactions between plane waves which propagate in the geometric region straight ahead of the transducer face and diverging edge waves which propagate from its periphery. This description has been used to predict the field patterns of transducers emitting pulses of various lengths. Experimental confirmation of such patterns has been provided by schlieren visualizations which will be shown as video recording.

The multi-pulse pressure waveforms at various points in the field and the corresponding transverse beam profiles that the plane and edge waves give rise to, have been measured using minature receivers and the results have been compared with calculated results made using the impulse response method.

In the transmit receive mode, pulses reflected from small targets can give rise to complex echo responses which are liable to misinterpretation. An understanding of the plane- and edge-wave structure greatly aids in the interpretation of these responses and hence in the interpretation of beam profile measurements obtained using a small target to probe the pulsed field. In addition, such an understanding aids in explaining some of the limitations in the resolution that can be obtained from conventional, un-focused transducers. Attempts to overcome these limitations using newly-developed transducers will be illustrated by means of B-scans of simple test objects.

Measurement with, and Calibration of, Transducer Fields

S Leeman, E T Costa and P C A Richardson
King's College School of Medicine and Dentistry, London and Department of Electrical Engineering, UNICAMP, Campinas, Brazil

Pulsed fields from real transducers are very different from the idealized one-dimensional

entities that form the basis for many measurement and calibration schemes.

We show here a new technique whereby equivalent one-dimensional measurements may be made of real, three-dimensional pulsed fields. The results are of particular importance for two applications: (a) measurement of attenuation and (b) field calibration and output measurements.

The construction of a specially designed hydrophone is outlined, and results of measurements made to illustrate its practical advantages are presented.

The Importance of the Frequency Response of a Hydrophone for Characterizing Medical Ultrasonic Fields

R A Smith
National Physical Laboratory, Teddington Middlesex

The increasing concern about the safety of diagnostic ultrasound is prompting interest in the acoustic output levels from medical ultrasonic equipment. The most widely used and convenient device for determining the spatial and temporal distribution of acoustic pressure within an ultrasonic field is the miniature piezoelectric hydrophone.

The sensitivity of these hydrophones changes with frequency and this variation must be determined before reliable measurements of waveforms can be made.

A new technique for the rapid intercomparison of hydrophones is being developed at NPL using the distorted waveforms produced by the nonlinear propagation of ultrasound in water. During the validation of this technique various types of probe and membrane hydrophones have been calibrated.

This paper describes the technique and presents some measured frequency responses. The relative merits of the different hydrophones in the light of these and other measurements are discussed with regard to their use for characterizing medical ultrasonic fields.

Measurement of Ispta and Isppa from Real-time Scanning Systems

K Martin
Medical Physics Department, Newcastle General Hospital, Newcastle-upon-Tyne

In assessing the acoustic output from diagnostic ultrasound machines, two relevant parameters to measure are the spatial peak, temporal average intensity (Ispta) and the spatial peak pulse average intensity (Isppa). The relative locations of these two parameters depend on the type of system being investigated. For single element transducers, Ispta and Isppa are at the same point in the beam whereas in the case of real-time systems Ispta and Isppa are often in different locations. For example, in a linear array the largest pulse is found at or near the focus of the beam whereas points closer to the transducer are exposed to a greater number of smaller pulses per field due to the greater beam width. This can result in a greater time averaged intensity. In systems with multiple zone focusing, the maximum Ispta and the maximum Isppa may be found under different focal conditions.

Examples of Ispta and Isppa measurements on various types of real-time scanning systems will be presented showing the effects of electronic focusing and aperture size on the locations of these parameters.

Intravellular DNA Breakage: an Investigation of Thresholds

W Whish and F A Duck

Abstract not available.

Effects of Therapeutic Ultrasound on Animal and Human Models of Inflammation

S J Bulstrode and A J Collins

Abstract not available.

Thermally-induced Haemolysis *in vivo*

A R Williams, D R Gross and D L Miller
Department of Medicial Biophysics, University of Manchester Medical School

Wong and Watmough (1983) reported that therapeutic intensities of ultrasound directed towards the hearts of rats through the liver and diaphragm *in vivo* resulted in the liberation of free haemoglobin into the plasma. They ascribed this result to the development of cavitational activity which ruptured some of the erythrocytes within the beating heart.

We have confirmed their observations but found that we were unable to get the ultrasound into the heart because some lung tissue is present between the heart and the diaphragm in the rat. Microscopical examination of the blood from sonicated animals revealed the presence of haemoglobin-fluid microspheres similar to those observed when normal blood is heated to more than 49°C *in vitro*. The amount of haemoglobin released into the plasma increased with increasing intensity of exposure above a 'threshold' value and was the same if the same time averaged intensity was delivered either as a continuous wave or as pulses of high spatial peak intensity. Cooling the animals virtually eliminated the haemolytic effect.

Thus, the haemolysis appears to be the result of thermal damage to the erythrocytes as they perfuse the microvasculature of anatomical structures being heated by the ultrasound beam.

Invited Paper: Cavitation in Medical Ultrasound

L A Crum et al

Bubble Formation in Guinea Pigs and Agar Gels during Ultrasonic Irradiation

S Daniels and Gail ter Haar
Oxford Hyperbaric Group, Physical Chemistry Laboratory, Oxford and Department of Physics, Institute of Cancer Research, Sutton, Surrey

The widespread use of ultrasound in medicine, both for diagnosis and therapy, requires that the interaction of ultrasound with tissue should be thoroughly understood. The mechanisms by which ultrasound produces biological effects are usually divided into thermal and non-thermal, with the principle source of non-thermal effects attributed to acoustic cavitation. We have shown that 0.75 MHz continuous wave ultrasound at intensities below 1 $W.cm^{-2}$ (spatial, temporal average) will produce stable bubbles larger than 10 μm diameter in guinea pigs (ter Haar and Daniels, 1981; ter Haar *et al*, 1982). In a recent series of experiments the effects of temperature and ambient pressure on the formation of bubbles in guinea pigs during ultrasonic irradiation have been investigated. Bubbles were detected in anaesthetized guinea pigs using an 8 MHz pulse-echo diagnostic imaging system (Daniels *et al*, 1979). The guinea pigs were irradiated with 0.75 MHz continuous wave ultrasound for 5 min at each of four intensities; 60, 180, 300 and 680 $mW.cm^{-2}$ (spatial, temporal average). Three series of experiments were performed; a) Irradiation at 37°C, b) Irradiation at 43°C, c) Irradiation at 37°C and 150 kPa. It was found that at the higher temperature the threshold intensity before bubbles formed was not altered, but that above the threshold more bubbles formed in the 5 min observation period than was the case at 37°C. Raising the ambient pressure increased the intensity threshold.

Because of the difficulties inherent in studying bubble formation *in vivo* a suitable model system has been sought. It was known that gelatin bubbled in a similar manner to animals after reductions in ambient pressure (Yount and Strauss, 1976) and a gel allows bubbles to be observed directly using optical microscopy. We have found that 1.75% agar gels have similar intensity thresholds to guinea pigs at both 37 and 43°C. We have also investigated the effect of irradiation of the agar gels with short pulses of ultrasound; where the pulse length was 0.95 μs, the pulse repetition frequency was 384 s^{-1} and the peak positive pressure 3.7 MPa and the peak negative pressure −2.3 MPa. It was found that stable bubbles are formed when the temperature of the gel is raised above 41°C. Further experiments are in progress in which different frequencies of continuous wave ultrasound and various pulse regimes will be investigated.

Inter-Noise 87

The Sixteenth International Conference on Noise Control Engineering will be held at the Science Hall in Beijing, China from 15 to 17 September 1987. The Conference, sponsored by I/INCE, is organized by the Acoustical Society of China and the Institute of Acoustics, Academia Sinical, in co-operation with the China International Conference Center for Science and Technology, China Association for Science and Technology. The theme will be **Noise Control in Industry**, and the official language of the conference will be English. Contributed papers in all areas of noise control engineering are welcome. Abstracts, not exceeding 200 words in length, should reach the Inter-Noise 87 Secretariat, 5 Zhongguancun Street, PO Box 2712, Beijing, China not later than 16 November 1986. An exhibition and technical visits will be arranged and a travel service will be available in the Beijing area for participants and their guests. Copies of the First Announcement and Call for Papers are available from Mrs Cathy Mackenzie at IOA HQ in Edinburgh.□

Non contact Generation and Detection of Ultrasound

One-day meeting organized by the Physical Acoustics Group, held at Institute of Physics Headquarters on November 14, 1985

Non destructive testing is, like everything else, changing with the times. A heavy emphasis is now being placed on the automation of any testing technique thus removing the human error. In addition testing requirements are becoming more stringent and tests have to be carried out on materials that are either very hot or very rough. The testing of components that are moving rapidly along the production line only adds to the problem.

The standard ultrasonic transducer grease coupled to the test piece is therefore not able to cope with every problem. There is an increasing need to develop techniques that allow both the ultrasonic transmitter and receiver to be placed remote from the component under test. The interest in this field of work was demonstrated by the number of groups presenting work at this one-day meeting and by the animated discussion sessions after each paper.

The meeting was opened by Dr Gerhand-Multhaupt who described a series of experiments carried out on polymer films at AT and T Bell Labs. Using picosecond laser pulses he was able to generate pulses of acoustic energy which were sufficiently short ($\sim$ 0.5 n sec) to allow the thickness of $\sim$ 16μm polymer films to be measured. In addition the broad-band nature of the acoustic pulse allowed the attenuation to be measured from 10 MHz to 1 GHz. The following two papers, by Dr Scruby from Harwell and Dr Arnold from Saarbrucken, considered the application of laser generated ultrasound to the study of microstructural parameters. Scruby used a laser interferometer as detector and his totally remote system was readily able to distinguish between steels of different grain sizes by a comparison of the frequency spectrum of the transmitted ultrasound. Arnold also used the broad-band nature of the acoustic pulse to give an estimate of the grain size in his sheet steel samples.

The morning session was concluded by a presentation from the Hull University group of the capability of laser generated ultrasound to detect delaminations in carbon-reinforced plastics. Remote detection is more of a problem in this case due to the non reflecting, non conducting nature of the surface.

The first part of the afternoon session concentrated on the use of laser interferometers to detect the ultrasound. Dr Bacon from NPL compared the Harwell interferometer with the standard hydrophone used for beam profile measurements. It was fair to conclude that in certain cases the advantages of spatial resolution, broad frequency response and high absolute accuracy outweighed the high cost and low dynamic range of the interferometer. Dr Emmony from Loughborough University reported some very elegant home built interferometers with sensitivities of 15 pm and bandwidth exceeding 10 MHz.

The closest approach to a real industrial application was described by Dr Hasing from BFI, Dusseldorf. They have purchased a very expensive laser generation/laser detection system from Krautkramer which they are trying to use on hot steel samples fresh from the continuous casting process. They have succeeded in making measurements on steels up to 1200°C with rough surfaces in a dusty turbulent air stream. Don't get too excited, however, you would need to win the football pools a few times to persuade Krautkramer's to build one for you.

The meeting closed with two different approaches to the non contact problem. Dr Martin from Harwell described the development of an ultrasonic thickness gauge based on electromagnetic acoustic transducers (EMATS). Although the stand-off distance is only a few millimetres this is perfectly adequate to measure for example the residual metal wall thickness in boiler tubes. Finally Dr Davies from Cambridge presented a very comprehensive account of his use of the chopped electron beam, from a scanning electron microscope, as a generator of ultrasound. Although the energy per pulse is a factor of at least a 1000 down on the laser case, very usable ultrasonic pulses are generated. Applications range from the study of magnetic domains to fault finding in integrated circuits.

In summary then a very successful and stimulating meeting, exemplified by Professor Berger who travelled all the way from the USA for the day and, if the rumours I hear are correct, some recruits to the ranks of members of the Institute from among the audience.□

S Palmer

Congratulations

We offer our congratulations to Professor Peter Fellgett FIOA, Professor of Cybernetics at the University of Reading, who was recently elected a Fellow of the Royal Society. News of this honour was received too late for detailed inclusion in this Bulletin; a fuller account will be given in the next issue.□

Instrumentation and Coarticulation

IOA Speech Group Conference held on 16 and 17 December, 1985 at IBM UK Scientific Centre, Winchester

IBM were hosts at this recent Speech Group meeting held at their UK Scientific Centre in Winchester, and it proved to be a most productive and enjoyable event. By extending the meeting over a two-day period, the organizers were able to include in the programme, in addition to the usual verbal presentations, actual demonstrations of specific items of equipment for speech analysis, as well as a conducted tour of IBM's extensive speech laboratories. Papers covered a range of topics including descriptions of new analytic instrumentation and techniques, acoustic and physiological aspects of coarticulation and recent developments in speech synthesis. The practical demonstrations included the new Holmes interactive soft-ware for speech synthesis, the Fourcin Laryngograph and Voiscope microcomputer-based system, the IBM SAY speech analyser and the Reading microcomputer-based Electro-palatograph.

The relevance of the theme of the meeting for commercially important areas such as automatic speech recognition and synthesis was reflected in the fact that the meeting was considerably over-subscribed and had to be limited to 50. Delegates came from a wide range of disciplines including engineering, computing, phonetics, linguistics, physics and psychology.

Full credit is due to IBM for their extremely efficient running of the conference and for their generous hospitality in providing not just lunches and teas through the two-day period but also a full scale 4 course banquet for delegates on the first evening.

Summaries of the presentations are given below.

W J Hardcastle

Laryngograph and Voiscope Microcomputer-based Analyses, by D M Howard, M Goonwardane, S Nevard and A J Fourcin of University College London

A laryngograph and Voiscope microcomputer-based system, which has been developed over many years at UCL, for quantitative analyses relating to many aspects of voice production will be discussed.

A Data Processing System for Quantitative Analysis in Speech Production, by Ailbhe Ni Chasaide of the Centre for Language and Communication Studies, Trinity College, Dublin

The system described is envisaged as an expandable and flexible tool for the display and analysis of speech production data. Details are given of the hardware interface and of software design, and research implications are discussed.

SAY - A PC Based Speech Analysis Tool, by P R Alderson, J Bennett, G J Calder, G Kaye and D A Sinclair of IBM UK Scientific Centre

The IBM UKSC Speech Analyser (SAY) is based on a PC-XT system enhanced by a range of special purpose hardware features.

The paper presented here will review the design criteria used for the speech analyser in the context of the PC environment and show how the aim of providing a powerful and flexible speech analyser has been fulfilled. This will be a precursor to detailed demonstration of the system.

Speech Spectrogram and Other Grey Scale Output Using Bi-level Display Devices, by J A Angus of the University of York

Many aspects of speech processing research require grey level displays. Examples include displays such as spectrograms, cepstrograms, DTW scoring paths and many others. Unfortunately many computer graphics devices, such as dot matrix printers and bit addressable graphics, produce either bi-level or crudely quantized (4 or 16 level) displays. Displays which can produce a grey scale output are made; however, they are more expensive and are less readily available than the bi-level output devices. The grey scale output devices also have disadvantages. This contribution will describe work carried out at York to produce speech spectrograms on bi-level display devices.

Towards Real Time Digital Signal Processing on a PC, by A G Constantinides of Imperial College London

There are many operations that are fundamental in digital signal processing and which underpin many activities in speech signal analysis. Such operations are needed to be carried out at real time speeds in addition to having to be flexible and adaptive to changing requirements. Normal software implementations of these operations are too slow, even for large array processor assisted mainframe realizations, to be of any significant use in real time applications. There is therefore a particular need to develop special hardware to bring these operations to the realm of real, or almost real time speeds.

This contribution will describe such hardware and illustrate several of the above operations including a spectrographic system realization.

Articulatory and Communicative Factors in Phonetic Decoding for ASR, by W J Barry of the Speech Laboratory, Dept of Engineering, Cambridge University

Two interacting but distinguishable sources of coarticulation in speech production are discussed:

1. Physiological constraints of a complex articulatory system of mechanically linked components.
2. The 'economy game': effort saving *vs* communicative effectiveness.

The need to incorporate more phonetic knowledge in speech recognition is widely accepted. An arguable consequence of the above distinction is a two-level phonological component within an ASR system, one for fine phonetic labelling and a second stage for word recognition.

A Sociophonetic Study of Connected Speech Processes in Cambridge English, by Paul E Kerswill of the Department of Linguistics, University of Cambridge

The paper will report the theoretical background and some preliminary findings of a project on the coarticulatory phenomena of connected speech processes, recently begun at the Department of Linguistics, Cambridge University, and funded by the ESRC. In this project,we lay particular emphasis on defining speech style, which we consider to be a combination of the effects of rate, attention and sociolinguistic factors.

Lingual Coarticulation in VCV Sequences, by A Butcher of the Department of Linguistic Science, University of Reading

Information on coarticulation at the physiological level may prove just as useful to the speech engineer as information about the acoustic consequences. One of the basic issues has always been that of the domain of coarticulatory influence, and in particular, whether this is confined to the 'syllable' or not. This study looks at tongue movement in simple vowel-stop-vowel sequences.

Laryngeal Coarticulation Effects in Intervocalic Consonants, by Geoffrey Lindsey, Peter Davies, Evelyn Abberton and Adrian Fourcin of the Department of Phonetics and Linguistics University College London

Coarticulation phenomena are most often discussed with reference to supraglottal contrastive changes. The realization of changing place and manner targets, however, is also associated with changes at the laryngeal level. The present data are discussed with a view to making a preliminary classification of the larynx activity variations which accompany minimal contrasts involving the alveolar consonants of English in different vocalic environments.

Some Prosodic and Syntactic Constraints on Lingual Coarticulation During /kl/ Sequences, by W J Hardcastle of the Department of Linguistic Science, University of Reading

The effects of syntactic juncture and rate of articulation on anticipatory coarticulation in /kl/ sequences were studied with the technique of electropalatography (EPG) which records details of the location and timing of tongue contacts with the hard palate during speech. Implications of the results for models of speech production and for the automatic detection of cues to word boundaries are discussed.

Coarticulation and Formant Frequencies in CVC Contexts, by J B Pickering, IBM UK Scientific Centre

It is well known that vowel formant frequencies are affected by consonantal

context (Stevens & House, 1963, ia; Lindblom, 1963). On the articulatory level, two main hypotheses have been proposed: (i) vowels in context will tend to centralize towards schwa as the vocal tract moves to a more neutral setting (Stevens & House; Joos, 1948) and (ii) vowels in context are reduced, not necessarily to schwa, as the vocal tract moves to a setting appropriate for the adjacent segment (Lindblom). Both of these positions are examined to explore possible ways of predicting vowel formant frequencies in /CVC/ contexts.

Idiosyncrasy in Coarticulatory Strategies, by F Nolan of the Department of Linguistics, University of Cambridge

This paper will examine the speaker-specific nature of certain low-level phonetic phenomena. The implications of findings in these areas for speaker recognition will be discussed, as well as the way in which the phenomena should be accommodated in a model of speech production.

Control of Speech Synthesizer Parameters, by R D Wright and S J Elliott of ISVR, University of Southampton

Coarticulation can be interpreted as motion from one speech segment toward the next, or transition paths between extrinsic allophones. This interpretation is of special interest for speech synthesis, in which case such motion is not just studied: it is created. Just how this act of creation is accomplished is a function of the type of synthesizer (type of parametric representation) being used. A comparison has been made of parameter transitions in six types of speech synthesizer. Data will be presented using standard interpolation methods between several sound combinations.

Convenient Interactive Software for Phonetic Research Based on the Holmes-Mattingly-Shearme Synthesis by Rule Algorithm, by John N Holmes, Speech Technology Consultant.

Speech synthesis is a very valuable tool for research in speech production and perception, and speech synthesizers are also useful for teaching speech science and for their obvious purpose of machine voice output. In the experimental phases of all these applications, convenience of control by the user is extremely important. If the results are to be relevant to real human speech communication, convenience must be combined with the ability of the synthesizer and control software to produce and manipulate extremely high quality speech.

Mapping Phonetic Features onto Formant Contours in Segmental Synthesis, by Mark A Huckvale of the Department of Phonetics and Linguistics, University College London

Speech synthesis by rule systems that explicitly model the realizations of segments have fundamentally the same architecture: hypothesized *target* values for formant frequencies for each segment, transition data calculated from phonetic features plus a *continuity* model that generates smooth formant contours. In the classic Holmes, Mattingly and Shearme model the parameters required to synthesize a segment in context are for each synthesizer parameter: a TARGET value, a BOUNDARY value, an ENTRY transition duration and an EXIT transition duration. In this paper I shall describe a rule formalism that can be used to map a phonetic feature description of the segment string onto these model parameters.□

New Materials for Sonar Transducers

A colloquium entitled New material for sonar transducers, organized by the Institution of Electrical Engineers in collaboration with The Institute of Acoustics, will be held at Savoy Place, London, on Thursday 24 April 1986. The meeting will review developments in the range of new materials which are now finding application in underwater acoustics transducers. Further details are available from: P Walmesley Esq, DBE Technology Ltd, Eastern Road, Aldershot, Hants GU12 4TD or from the IEE.□

Electronics for Ocean Technology

This Fifth International Conference is being organized by the Institution of Electronic and Radio Engineers in association with, among others, the Institute of Acoustics, and is to be held from 15 to 18 December 1986 at Heriot-Watt University, Edinburgh. A broad range of topics is expected to feature and contributions of synopses of possible papers are now invited, to be with the IERE by 1 June. Further details are available from: The Conference Secretariat, Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1 6AZ, Tel: 01-388 3071.□

NON-INSTITUTE MEETINGS

1986

12—16 May. Course: *Principles of Sonar Systems Engineering*. Sunne, Sweden. Contact: CEI-Europe, Rorstorpsvagen 5, S-612 00 Finspang, Sweden.

3—6 June. *The Practice of Noise and Vibration Control* (5th Hungarian Seminar and Exhibition). Szeged, Hungary. Contact: Seminar Secretariat, OPAKFI, H-1061 Budapest, Anker koz 1, Hungary.

3—7 June. *Acoustics & Signal 86 China*. Beijing, China. Contact: Associated Trade Fairs Ltd, GPO Box 784, Central, Hong Kong.

23—27 June. Course: *Adaptive Signal Processing*. Uppsala, Sweden. Contact: CEI—Europe, Rorstorpsvagen 5, S-612 00 Finspang, Sweden.

9—10 July. *Novel Techniques of Non-Destructive Examination and Validation*. London. Contact: The Royal Society, London.

21—23 July. *Internoise 86*. MIT, USA. Contact: Inter-Noise 86 Secretariat, MIT Special Events Office, Room 7-111, Cambridge, Massachusetts 02139, USA.

24—31 July. *12th ICA*. Toronto, Canada. Contact: 12 ICA Secretariat, PO Box 123, Station Q, Toronto, Canada M4T 2L7.

25—29 August. *Comp '86 Symposium*. Patras, Greece. Contact: Prof SA Paipetis, COMP '86 Symposium, Dept of Mechanical Engineering, University of Patras, Patras 260 01, Greece.

2—6 September. *6th FASE Symposium: Subjective Evaluation of Objective Acoustical Phenomena*. Sopron, Hungary. Contact: 6th FASE Symposium Secretariat, OPAKFI, H-1061 Budapest, Anker Koz 1, Hungary.

22 October. *SEECO 86. Environmental Stress Screening*. Coventry. Contact: SEE, Owles Hall, Buntingford, Herts SG9 9PL.

Details of other meetings in Great Britain, and of Inter-Noise '87, appear elsewhere in this Bulletin.

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

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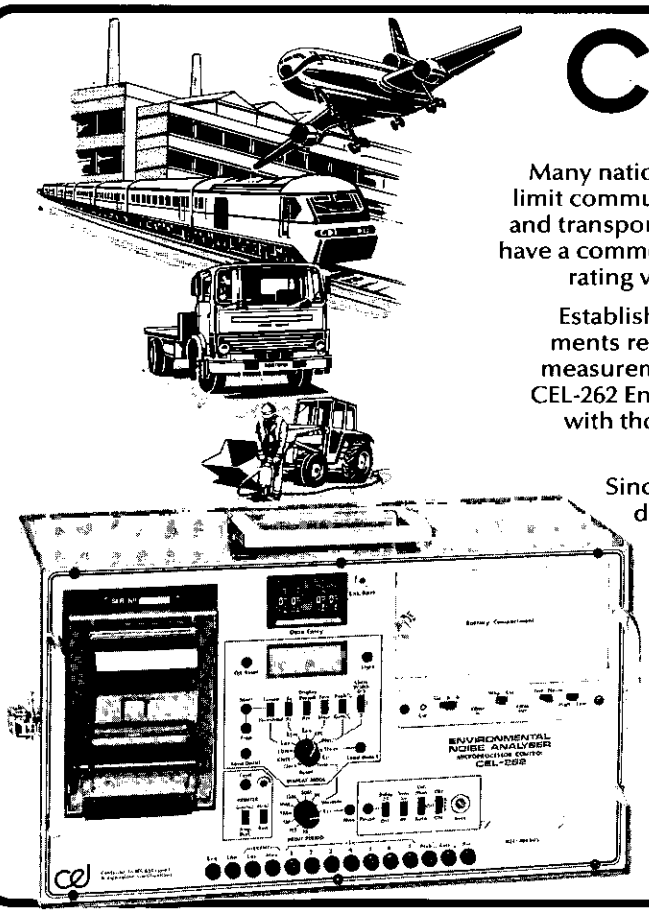

Community Noise

Many national and international standards have now been enacted to limit community noise levels generated by factories, construction sites and transportation systems. Such standards although differing in detail have a common objective in requiring the derivation of a single number rating value for each location from the time varying noise pattern.

Establishment of such levels and investigation of possible infringements requires long term noise monitoring using portable versatile measurement equipment. It is for this type of measurement that the CEL-262 Environmental Noise Analyser is intended and it will find use with those organisations with responsibility for establishment and enforcement of these levels.

Since there are many different standards the CEL-262 has been developed to be extremely versatile and capable of meeting UK, European and American measurement requirements.

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cel INSTRUMENTS

BRANCH AND GROUP NEWS

Physical Acoustics Group

In its first year in existence this joint IOA/IOP Group has been active in the organization of the four meetings, on Acoustic Microscopes, Physics in Medical Ultrasound, Current Research in Physical Acoustics and Non-Contact generation and reception of Ultrasound. Further meetings planned for 1986 are included in the list of Meetings inside the back cover of this Bulletin.

Unfortunately, because of ill health, Dr Haslett has had to curtail his activities in furthering liaison between IOA members and the embryo group, and the Institute is therefore looking for someone who would like to take his place. If you feel that you could contribute significantly to the Institute's interests in this field, please contact the Vice-President, Groups and Branches, Geoff Kerry, at the University of Salford.

Southern Branch

The Southern Branch has enjoyed three excellent presentations during the winter season. In October, at Portsmouth Polytechnic, Raf Orlowski of Salford University gave a most interesting account of a research programme into the form of acoustic fields in very large industrial spaces, and means of reducing noise levels by suspended baffles and barriers: much of this work was done on models at Cambridge University.

A joint meeting with the Chartered Institute of Building Services Engineers were entertained in November in Southampton to a most amusing and down-to-earth review of noise and vibration problems in buildings by those experienced Consultants Mr A Fry and Mr P Allaway. A joint meeting of the IOA and the local branch of the Institute of Environmental Health Officers were privileged to learn of the *Code of Practice on Sound Levels in Discotheques* from the 'horse's mouth', when the instigator, John Bickerdike of Leeds Polytechnic, visited the offices of the New Forest District Council in January. The large audience enjoyed a most informative and authoritative discourse on the subject.

A projected visit to new premises of IAC has been postponed until next season, and the visit to Gatwick has been brought forward to 14 May.

Frank Fahy

North East Branch

Our Autumn meeting was held in October at Newcastle General Hospital in the Department of Medical Ultrasonics where a guided tour was given by Dr Tony Whittingham. A group of twelve, the maximum allowable number, was shown the equipment and facilities in the very well appointed and efficient Department.

Newcastle Polytechnic was the venue for November. A lecture was given, to a very well attended meeting, by Dr Ian Craighead who is conducting research into Vibration Monitoring. The lecture was followed by laboratory demonstrations.

Forthcoming Branch activity includes our Annual General Meeting at the end of February and it is hoped to arrange a joint meeting with other groups in the area on non-contact methods of strain and vibration measurement.

Ross Bainbridge

North West Branch

The North West Branch Annual General Meeting was held on the 16th January and was the best attended AGM in the history of the branch. The new committee comprises Mike Ankers as Chairman, Geoff Kerry as Honorary Treasurer, with Chris Waites replacing John Dinsdale as Honorary Secretary. Our thanks go to John Dinsdale and Don Baines who have provided such a valuable contribution to the running of the branch. Sue Ridler and John Houldsworth were re-elected and we welcome two new members: John Lyons and Ian Fraser.

With the official business over the branch listened to an enlightening talk by Dr Raf Orlowski, of Salford University, on **Acoustics and Noise Control in Factories.** After introducing the basic concepts in terms of the sound propagation curve, he pointed out the inadequacies of Sabine's theory when applied to the behaviour of sound in factories. He proposed three more appropriate methods for predicting noise levels, ie empirically based formulae, mathematical/computer model prediction techniques, and physical scale models.

The empirical method recommended is based upon measurements made by Rockwool AB of Sweden in 140 factories. The resulting calculation procedure includes many of the important factors. The noise is reduced by treating the ceiling with absorbent material. The method has the advantage of being relatively simple, however it only works at 1 kHz and predicts linear attenuation with distance.

UNIVERSITY OF SALFORD ACOUSTICS SOCIETY

Department of Applied Acoustics, Salford M5 4WT

The academic year 1985/86 is promising to be a very successful one for the Department of Applied Acoustics at the University of Salford. Not only is it to be the venue for the IOA Spring Conference but it can now claim to be the birthplace of the first student society within the world of acoustics.

In November 1985, as a group of final year students, we decided to form the 'Acoustics Society', enrolling both students and staff as members. Our first aim was to become affiliated to the IOA and this has already been achieved with the Society now being represented through the North-West Branch. We also played a major role in reducing the student membership fee to £5, which it is hoped will encourage more students to join and find out about the work of the Institute.

The second aim was to make the industrial world aware of the existence of the undergraduate course in Electroacoustics at Salford and to bring the students into contact with relevant industries. We are attempting to achieve this by persuading engineers, experienced in the world of acoustics, to come and talk to Society members and also to allow groups to visit their places of work. We would be interested to hear from anyone willing to participate in this way. Please contact the Liaison Secretary of the Group at the above address if you feel you can help.

It is hoped that the Society will be successfully continued by future generations of students in the department, encouraging better communication between the academics and the industrialists in our field.□

Susie Williams
Liaison Secretary

The mathematical/computer models considered are based on the method of image sources. The factory is represented by two parallel planes that act as partially reflecting surfaces. The space between the planes is filled with scattering objects and distributed acoustic sources representing machines. This technique is under development at Salford University, where acoustic absorption measurements are being made on a wide range of materials. These results together with on-site measurements in factories are being used to test and improve the models.

There followed a slide presentation illustrating physical scale models of typical factory buildings. Investigations are being made into how well the acoustic behaviour of the model correlates with that of the building. The effectiveness of suspended absorbers, barriers and multiple barriers is under evaluation.

Finally Raf pointed out that treating the factory was not the only way to solve the problem; ear muffs and plugs can often provide an effective economic solution. There followed a lively question and answer session rounding off the evening.□

C Waites

Letter from the Vice-President Groups and Branches

In my last letter I reported the concern shown by many branch representatives at the low level of attendance at many meetings. Recently two branch secretaries reported very low attendance at committee meetings. The two are not disconnected. Without an enthusiasitc committee it is difficult for one or two individuals to sustain a varied programme that will attract the wider membership.

I am sure there is an untapped source of ideas and enthusiasm in the younger members. On behalf of all branch secretaries can I ask for volunteers to come forward and inject some new blood where it is badly needed.

Fortunately all is not doom and despondency at branch level. I recently attended the NW Branch AGM, where there were nearly 30 people to listen to Raf Orlowski talk on **'Noise Control in factory buildings'**. This is the second time in six months that Raf has given this talk, the previous occasion being a Southern Branch meeting with an equally good attendance. Raf's second effort was a direct result of the suggestion made at the annual Group and Branch representatives meeting about enticing good speakers to repeat performances.

Reporting branch meetings in the Bulletin will not only let members know what they have missed but could give other branches' committee members some ideas for the future.

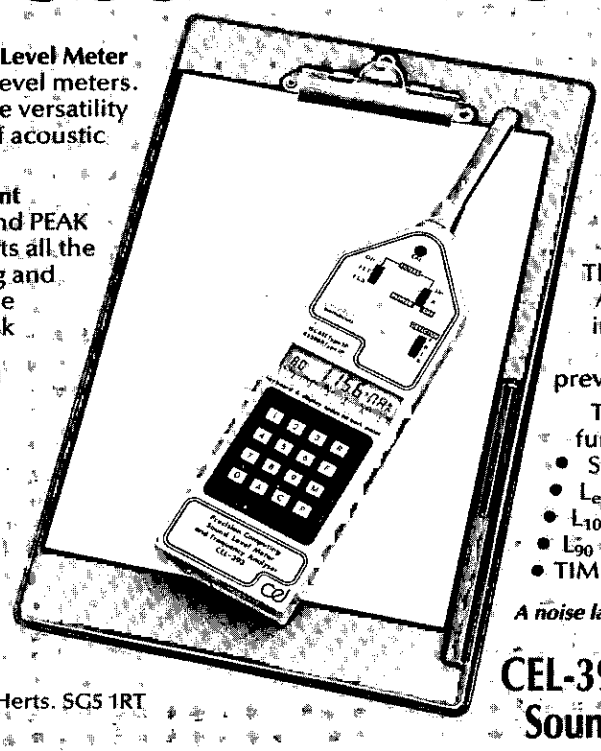
Finally I can report that the undergraduates studying Electroacoustics at Salford have formed an acoustics society which has become affiliated to the Institute. NW Branch will provide the liaison and it is anticipated that a number of joint meetings will be held.□

Geoff Kerry

IOA Diploma Exam

The examinations for the IOA Diploma will take place this year on Thursday and Friday, 12 and 13 June 1986.

A Measure of Silence?



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A NEW concept in sound level meters. This slim line meter has the versatility to deal with a vast range of acoustic problems.

Industrial noise measurement
With its TYPE 1 accuracy and PEAK response the CEL-393 meets all the relevent standards existing and proposed. Readouts for the assessment of deafness risk can be in SPL, L_{eq} or L_{max} and by using the on-board data store a profile of the days' L_{eq} exposure can be made.

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Pocket sized and powered from a single PP3 battery the CEL-393 will allow users to carry out surveys to assess pollution impact on FACTORIES, TRAFFIC, AIRCRAFT and RAILWAYS. The meter will provide readings of L_{eq} L_{10} L_{50} L_{90} L_{AX} and TIME and place the results in memory at user-defined intervals.

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- SPL
- L_{eq}
- L_{10}
- L_{90}
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cel INSTRUMENTS

New Elections

At its recent meetings Council approved the following elections to corporate and non-corporate membership.

Fellow

R W Guy
N G Pace
P J Roach

Member

J K Anani
N L Baines
D W Barbour
D S Barke
H T Chui
P Esparcieux
A J Franks
J Gray
G Izzudain
K M Lam
A J Rigby
D R Robinson
G A A Rock
S Rosen
B V Smith
W K Szeto

Associate

N J Barrett
A R Brassington
R J Chuter
I C Critchley
J Dominguez
C W Dungate
J H Hamilton
P Henson
S Kaye
S L H Litobarski
M C Maharaj
B F Mawson
A T Moorhouse
B Phillips
P S Ramsden
P R Redell
P R Sawyer
B N Smith
T J Smith
S J Swingler
S Walker
M C Walton
F L Watson
R P Williamson
L P Wong
W K F Wong

Student

C Fleming
K R Harris
D Havergill
T H Lewers
M A Rowell
Subagio
H C Sullivan
S A Williams

Special Announcement

We are pleased to announce that, after its long illness and despite a considerable period of uncertainty, the Scientific Services Branch of the Greater London Council is now showing signs of recovery and from 1st April will be convalescing in the London Residuary Body. One or two of its members have taken the opportunity to start a new life elsewhere but the rest remain and can be found, for the time being, at the usual County Hall address. The long term prognosis is unclear at the moment, particularly as a permanent administrative home is still being sought. Nevertheless, it will continue to function, initially under the title London Scientific Services, and it is looking forward to renewing old acquaintances and making new friends.□

Calls for Papers

The Meetings Committee of the Institute of Acoustics welcomes offers of contributions to its Meetings. Papers are particularly invited for the following:

The Control of Entertainment and Recreation Noise

(In collaboration with the Institution of Environmental Health Officers and the Royal Environmental Health Institute of Scotland)

12 September 1986 at the Society of Chemical Industry, Belgrave Square, London

Meeting Organizer: Dr J C Goodchild MIOA,
Acoustics Group, Physics Department, Liverpool Polytechnic,
Byrom Street, Liverpool L3 3AF

(50-200 word abstracts as soon as possible)

Noise in Mechanical Services

(In collaboration with the Chartered Institution of Building Services Engineers, the Institution of Mechanical Engineers and the Chartered Institute of Building)

6 October 1986 at the Society of Chemical Industry, Belgrave Square, London

Meeting Organizer: Mr K R Tompsett MIOA,
Atkins Research and Development,
Woodcote Grove, Ashley Road, Epsom, Surrey KT18 5BW

(100-200 word abstracts as soon as possible)

Reproduced Sound

(In collaboration with the AES, ASCE, EMA, APRS and ABTT)

6-9 November 1986 at the Hydro Hotel, Windermere

Conference Organizer: Dr R Lawrence FIOA,
Acoustics Group, Liverpool Polytechnic,
Byrom Street, Liverpool L3 3AF

(100 word abstracts by 30 April)

Autumn Conference: Speech and Hearing

(In collaboration with the British Society of Audiology)

28-29 November 1986 at the Hydro Hotel, Windermere

Conference Organizer: Dr R Lawrence FIOA.
Abstracts to the Programme Committee Chairman:
Dr W A Ainsworth FIOA,
Department of Communication and Neuroscience,
University of Keele, Staffs ST5 5EG
(100-200 word abstracts by 1 June)

Fluctuation Phenomena in Underwater Acoustics

9-10 December 1986 in the Hotel Prince Regent, Weymouth, Dorset

Conference Chairman: Mr P F Dobbins MIOA,
British Aerospace, Underwater Research and Engineering Unit,
Hampshire Road, Weymouth, Dorset DT4 9TZ
(200 word abstracts by 27 June)

A THEATRE OF YOUR OWN?

As many people will know, two one-eighth scale acoustic models have been housed since 1975 in a glasshouse belonging to the Department of Architecture in Cambridge. The models of the Olivier Theatre, National Theatre (illustrated) and the Barbican Concert Hall were originally built at the Building Research Station, Watford, and moved to Cambridge to form the basis of a research programme into acoustic modelling of auditoria. Two sorts of test have been undertaken in the models: so-called objective tests which produce numerical results, and subjective tests which involve playing speech or music through the model (speeded up 8 times) and listening to the recorded response at normal speed. As well as being used for research purposes, tests were undertaken in both models to elucidate acoustic behaviour in the real spaces. The models still offer considerable potential for further research work.

Unfortunately glasshouses do not last for ever and it is now necessary to vacate the building, which is already leaking seriously. We are still looking for a new home for the Olivier Theatre model. The model is large enough to clamber around inside and requires 5.4 x 5.4 m of floor space. Anyone interested in this 'unique opportunity' to own a theatre, please telephone Mike Barron, (0223) 69501 ext 290.□

BRE Digests

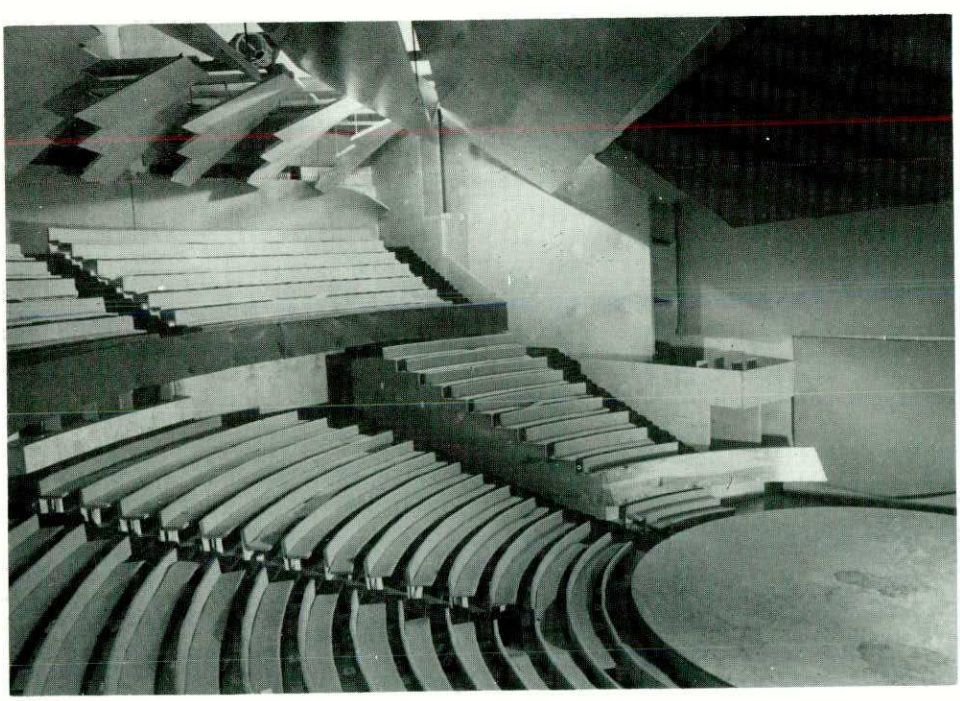
Building Research Establishment Digests are now available in four bound volumes, each dealing with a major aspect of construction.

Volume 1: Building Structure and Services, covers everything from initial site investigation and foundation design to the provision of energy efficient lighting.

Volume 2: Building Components and Materials, gives practical assessments of the various materials used by the construction industry and a guide to aid informed selection of the most suitable components for use in particular circumstances.

Volume 3: Building Performance, is an analysis and description of all the factors which affect the satisfactory performance of a complete structure. It considers both internal and external environments, and gives practical guides to the identification and elimination of undesirable characteristics. Subjects covered include thermal, visual and acoustic requirements.

Volume 4: Design and Site Procedures, Defects and Repairs gives advice on how to minimize potential problem areas and deal with difficulties when they arise. The BRE Digests, which are illustrated with photographs, charts, diagrams and drawings, are available from HMSO.□



Interior of the 1:8 scale acoustic model of the Olivier Theatre, National Theatre, London

Living with Airfields, Now and in the Future

This repeat of the conference first held in March, organized by the Airfields Environment Federation, will be held at the Institution of Civil Engineers in Great George Street, London SW1 on 28 April 1986. The Conference will set out to examine what planning, noise control, operational and technical measures can do to secure a better environmental fit for the smaller airports. The present position and views of the future will be explored and papers submitted by experts in each field will be followed by individual workshop sessions, led by the speakers, to pursue the discussion with delegates. Enquiries should be addressed to the official Conference Organizer: Miss Mary F Muir, Conference Organization and Management Division, Lopex Public Relations Ltd, Hulton House, 161-166 Fleet Street, London EC4A 2DP. Tel: 01-353 7781.□

Secure Communication Systems

This International Conference is to be held by the Institution of Electrical Engineers in London on 28 and 29 October 1986. It has been organized in the light of the increasing need for secure communications for the transmission of information in both military and civilian applications and the associated acceleration of research and development work in this field. Papers will cover a wide range of theoretical and practical aspects of Secure Communications. Copies of the Call for Papers with relevant information are available from IOA HQ in Edinburgh.□

Condition Monitoring 87

Synopses (200 - 300 words) of proposed papers for this conference are invited and should reach the organizing secretary by 1 May 1986. The Conference, which is co-sponsored by the IOA, will cover: Vibration measuring techniques and analysis; Wear debris analysis; Acoustic emission and ultrasonic techniques; Winding fault diagnosis of induction motors; Performance monitoring techniques; Maintenance information management; and economic benefits. For further details contact the Organizing Secretary, Mervin H Jones, at the Department of Mechanical Engineering, University College of Swansea, Singleton Park, Swansea, SA2 8PP, tel: Swansea 205678.□

New Products

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

Metrosonics db 308 Sound Analyser

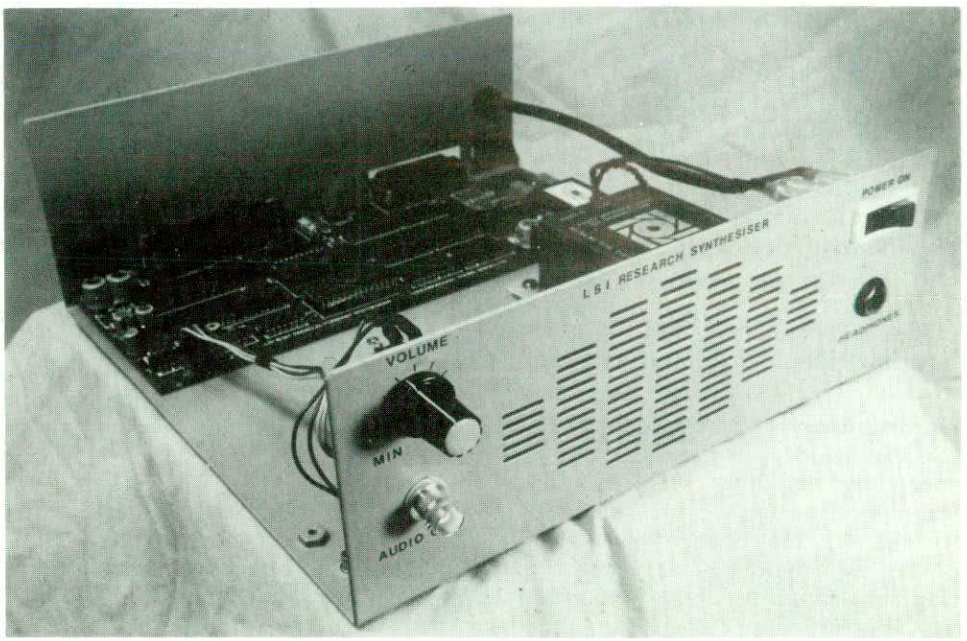
The new Metrosonics db 308 Sound Analyser is a multiple purpose level analyser which can serve as a personal noise exposure meter, an integrating sound level meter, an amplitude distribution analyser, and a time history monitor over a 95 dB dynamic range. This analyser can be used to provide all the survey and exposure data required for hearing conservation and community noise surveys.

The dB 308 is microprocessor based, and may be read out directly from its 32-character LCD display, to a remote printer, or to a computer via its RS 232-C output. The data read may be either real-time or logged information stored in its digital memory. When connected to a serial printer, a set of completely formatted test reports are automatically produced, including graphics, full calendar and time of day correlation, pre- and post-test calibration details, and items specifically noted for the individual test. Automatic start stop times can be pre-programmed, and a secure mode prevents unauthorized tamper with the data. The dB 308 measures 160 mm long x 80 mm wide x 35 mm thick, and is powered for at least 40 hours by a single 9 volt battery.

Further details from Industrial & Marine Acoustics Ltd, PO Box 8, Newcastle under Lyme, Staffs ST5 2TR. Telephone: 0782 630793.

LSI Research Synthesiser

The Synthesiser uses the parallel-format method, which has been pioneered by the British Joint Speech Research Unit. This method offers individual control over format amplitudes, and can deal with the full range of speech sounds without re-configuration. The unit



The LSI Research Synthesiser

Courses

A short course on **Workplace Noise Control: The EEC Directive** will take place at the Centre for Extension Studies (Loughborough University) from 6 to 9 May 1986. The course will discuss the implications for industry of the Noise Directive agreed by EEC Member countries and will show how the cost of complying with the Directive can be anticipated and minimized. The fee, inclusive of residence and all course material, is £350. Details from Mrs Sonia M Withers, Course Tutor, Centre for Extension Studies, University of Technology, Loughborough, Leics LE11 3TU.

The Guest Lecturer at the Cranfield Institute of Technology short course on **Applied Signal Processing for Engineers** is to be Allan G Piersol, whose primary areas of interest are the measurement, analysis and prediction of mechanical shock, vibration and acoustic environments and studies of equipment reliability in such environments. The course, from 19 - 22 May 1986, includes an introduction to signal processing, system identification techniques and engineering applications. Three-day short courses on **Basic Practical Signal Processing,** will be held on 23 - 25 April and 5 - 7 November. Details for all courses available from Andy Tomlinson, Signal Processing and Applications Group, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL.

Also to take place at Cranfield is a two-day short Course on **Shock Testing for Technicians and Engineers.** This course, held jointly by Cranfield and the SEE on 10 and 11 September 1986, will provide a practical introduction to shock testing techniques and will cover the principles of shock testing machines and the artificial generation and measurement of shock environments, together with a review of analysis techniques and the interpretation of shock data in relation to standards and specification. Further details from the SEE or from Cranfield Institute of Technology (see above).□

German Standards in English

Almost the entire series of standards making up DIN 45 635 is now available in English. In addition to these Standards, on the measurement of noise emitted by machines, many other German Standards for building and civil engineering have been translated into English; sectional lists of these can be obtained from the DIN Translation Section in Berlin. DIN 45 635 in English is available from BSI Sales, Linford Wood, Milton Keynes MK14 6LE.□

interfaces using Centronics Parallel Printer Port and software is available for IBM PC, Apple II series and Acorn BBC microcomputers.

Further details from Loughborough Sound Images Ltd, The Technology Centre, Epinal Way, Loughborough, Leicestershire LE11 0QE. Telephone: 0509 231843.

Hand-Held Vibration Measuring Instrument VT1

D J Birchall Limited announced their VT1 hand-held vibration monitoring instrument which measures only 197 mm x 84 mm x 40 mm and weighs 350 gm.

The only controls necessary to give autoranging, true RMS digital indication of acceleration, velocity and displacement are three parameter soft touch buttons and an on/off switch.

Acceleration, velocity and displacement signals are also continuously available for further analysis, or recording via 4 case mounted sockets. Primarily intended for periodic inspection of rotating machinery, to give a reliable indication of the mechanical condition of bearing, gearboxes etc, the VT1 can also be effectively employed in any situation where vibration needs to be accurately and speedily measured with a minimum of equipment and freedom from the restraints of a suitable power supply.

A charge amplifier at the input stage makes the VT1 immune from cable capacitance and gain accuracy errors found on other input circuits.

It has a range from 0.02 g to 200 g RMS and a frequency bandwidth from 4 Hz to 50 Hz (Acceleration).

Further details from D J Birchall Ltd, 102 Bath Road, Cheltenham, Glos GL53 7JX. Telephone: 0242 518588.

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Vibration Analyser type 2515 has been designed to provide a means of accurately seeking out and analysing mechanical malfunctions in machinery, so that its day to day use can prevent breakdowns in the future by indicating the danger signs of the present. The 2515 is a portable battery operated instrument which is dustproof and water-resistant and will withstand mechanical shocks as high as 75 g. B & K's system of Speed Compensated Constant Percentage Bandwidth spectrum comparison is employed for the detection of significant increases in machine vibration. The following functions are available: *Time Mode* — instantaneous time function, expanded time function, average time function, RMS spectrum of the averaged time function, cepstrum of the spectrum, total RMS level of the displayed function. *Frequency Mode (linear axis)* — RMS or Energy spectral density spectrum, zoom spectrum and averaging, cepstrum of these spectra, time function corresponding to spectrum, total RMS or energy level of displayed function, phase at cursor position. *Frequency Mode (log axis — 6% or 23% syntheses)* — RMS or energy spectral density spectrum and averaging, total RMS or energy level of displayed log spectrum.

RASTI System

The B & K 3361 'RASTI' system comprises a transmitter, type 4225, and a receiver, type 4419; these make use of a new method which is in the course of IEC Standardization to Rapidly Assess the Speech Transmission Index — hence the name RASTI.

The Brüel & Kjær 1986 Short Form Catalogue and details on the 2515 and the 3361 are available from Brüel & Kjær (UK) Ltd, 92, Uxbridge Road, Harrow, Middlesex HA3 6BZ. Telephone: 01-945 2366.□

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

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Institute of Environmental Engineering

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(part-time courses)

The recent House of Lords Select Committee on Science and Technology has recommended that all district councils should have at least one EHO with a post-graduate qualification in acoustics. The South Bank Polytechnic offers two part-time courses to meet this requirement:

Diploma of the Institute of Acoustics: one afternoon and evening for one year. Successful completion of the course gives full academic exemption for corporate membership of the Institute of Acoustics. Entry requirements are generally an appropriate HNC/D, degree or professional qualification. The course commences September 1986. (subject to R.A.C. approval)

Masters Degree or Postgraduate Diploma in Environmental Acoustics: one day and evening per week. Successful completion of the first year taught programme leads to the award of PgDp. A mutually agreed project is undertaken in the second year for those who wish to continue to Master's level.

The course commences in January 1987 and covers subjective acoustics, environmental acoustics, acoustic measurement, acoustic theory, engineering acoustics and the law and noise.

A preliminary course in acoustics and mathematics, for those who require it, begins this September.

Further details from: Dr Max Vuillermoz
South Bank Polytechnic
London SE1 0AA.
Tel: 01 928 8989 Ext. 2109/2105

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cel INSTRUMENTS

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Salaries will be commensurate with qualifications and experience. Please write, giving brief details of career and experience to:- The Personnel Officer, Wimpey Laboratories Limited, Beaconsfield Road, Hayes, Middlesex UB4 0LS.

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954 2366

Institute of Acoustics Meetings

1986			
14 May	SB	Visit to Gatwick Airport — Apply to Southern Branch	Gatwick
June	ING/EMB	Noise and Vibration in the Aircraft and Spacecraft Industry	
17 July	PAG	Acoustics and Ultrasonics as Probes of Emulsions and Dispersions	IOP, London
12 September	M	Legal Aspects of Entertainment Noise	Society of Chemical Industry, London
25 September	PAG	Current Research in Physical Acoustics and Group **AGM**	University College London
6 October	M	Noise in Mechanical Services. Joint with the Chartered Institution of Building Services, the Institution of Mechanical Engineers and the Chartered Institute of Building	Society of Chemical Industry, London
6—9 November	M	Reproduced Sound. Joint with the Audio Engineering Society, the Association of Sound and Communication Engineers, the Electro-acoustic Music Association, the Association of Professional Recording Studios and the Association of British Theatre Technicians	Hydro Hotel, Windermere
28—29 November	M	Autumn Conference: Speech and Hearing. Joint with the British Society of Audiology	Hydro Hotel, Windermere
9—10 December	UAG	Fluctuation Phenomena in Underwater Acoustics	Weymouth
1987			
13—16 April	**M**	**Spring Conference: Acoustics '87. IOA AGM**	**Portsmouth Polytechnic**

Key:

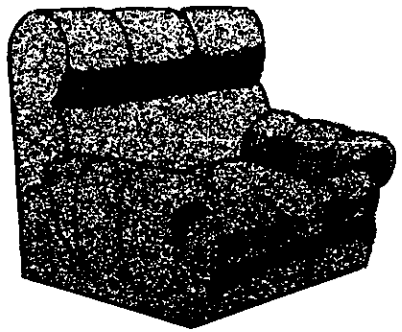
M = Meetings Committee Programme
BAG = Building Acoustics Group
ING = Industrial Noise Group
MAG = Musical Acoustics Group
PAG = Physical Acoustics Group
SG = Speech Group
UAG = Underwater Acoustics Group
LEM = London Evening Meeting

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

Professional Career Opportunities



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SALARY

☐ 0-£6000 ☐ £6-10000 ☐ £10-15000 ☐ £15000+

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