



Acoustics Bulletin

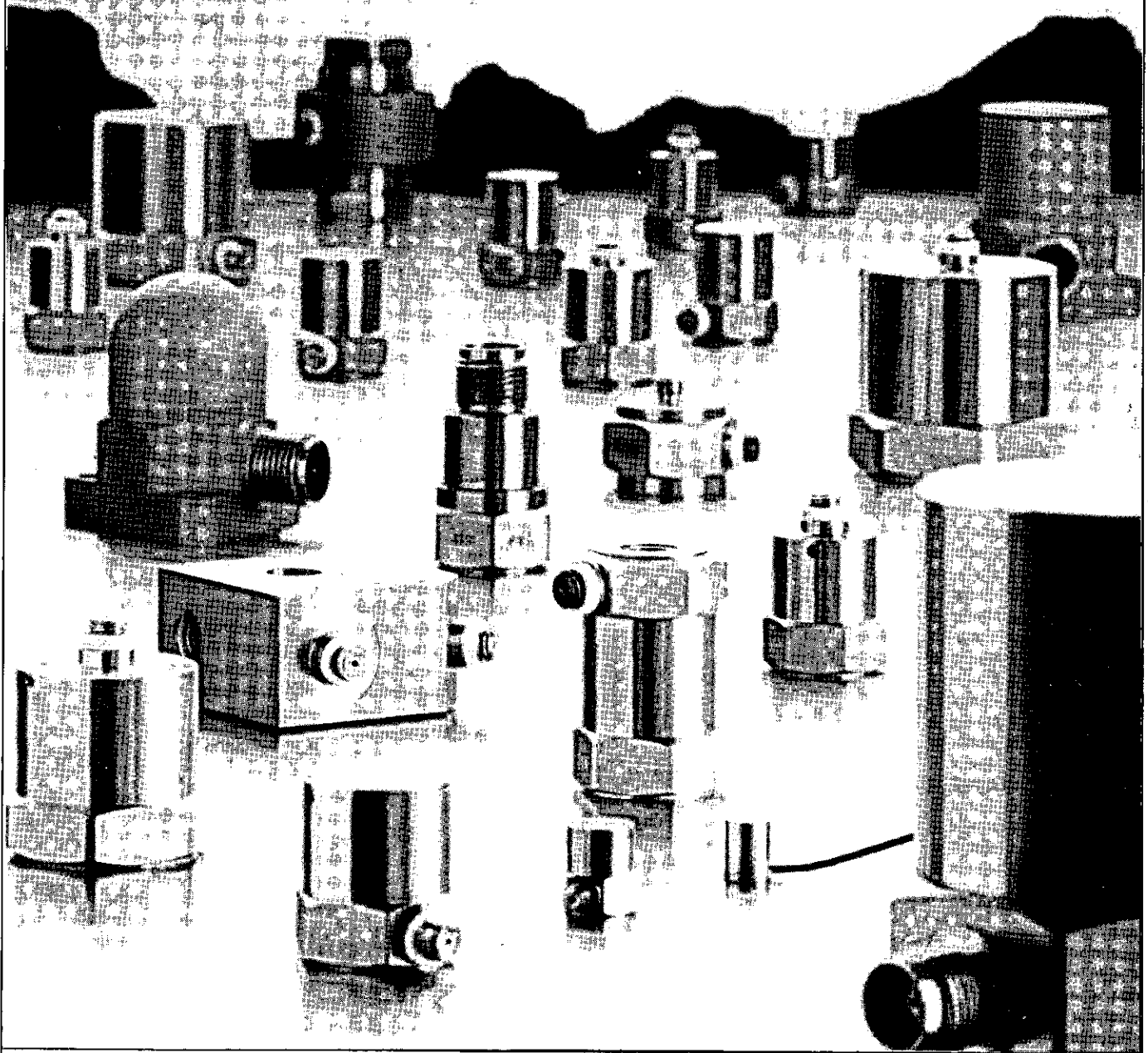
October 1985 Volume 10 Number 4

INSTITUTE OF ACOUSTICS

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

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

Membership of The Institute of Acoustics

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

Honorary Fellow (HonFIOA)

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

Fellow (FIOA)

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

Member (MIOA)

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

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

Associate

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

Student

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

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

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Dear Member,

There has been movement in two areas of importance to the Institute.

We have had discussions with the Institution of Environmental Health Officers on the formation of a Joint Noise Council, which will be independent of government and commerce. The main aims are to promote and respond to issues relating to noise and vibration, to progress noise and vibration control in a professional manner and to make the expertise of our members available to bodies concerned with noise and vibration. The EHOs will discuss the proposal at their meeting at the end of September, whilst our Council will consider it early in October. At the time of writing, for a late August copy date, it is not possible to say more than that both organisations have expressed warm interest in the joint venture.

A committee of the Engineering Council visited the Institute in August, in order to assess our application to become a nominated body. We felt that a full and sympathetic understanding of our strengths and limitations developed during the course of the visit. There are clearly facets of the Institute which do not fit into the conventional mould of a nominated body. It is possible that, to become accepted, we may need to make some small changes in the way in which we organise ourselves, in order to identify the main paths to registration for those of our members who are eligible for chartered status as acoustical engineers. This is another matter which, at the time of writing, has not reached a conclusion, but should be resolved in a few months. We will keep you informed.

Yours sincerely

Hearing Protector Standard Measurements

M S Shipton

National Physical Laboratory

Measurement of the attenuation characteristics of hearing protectors helps to ensure that users are not exposed to excessive noise levels. Kitemarking of muffs ensures their efficiency when in use.

NOISE-INDUCED deafness has been recognised for many years but only in the last 30 years have active steps to minimise its effects been taken. Up to two million people in the United Kingdom are exposed to potentially hazardous noise levels during the course of their daily work but people differ widely in their susceptibility to noise and it is not possible to be dogmatic over what constitutes a safe level. The present UK criterion of 90 dB(A) for the working day would have to be considerably reduced to be certain that no one individual was likely to suffer hearing damage.

The damaging effects of high noise levels on the ear are cumulative; most of the hearing loss it causes is irreversible and much of the damage occurs in the early years of exposure. Design of quieter machinery is obviously the ideal way of reducing the noise exposure although this approach is likely to be long term and may not be cost effective. Noise reduction using enclosures, screens and silencers can be effective but when such engineering approaches are not appropriate then, as a last resort, the employees must be protected individually from the noise. In many industries personal hearing protection is the only practical and cost effective solution.

There are two basic types of protector, earmuffs and earplugs, but there are many variants. Earmuffs have a metal or plastic headband supporting two plastic shells, each fitted with a soft cushion to provide an effective seal against the side of the head. The cushions enclose a foam plastic or a non-toxic liquid in a soft plastic outer skin. Similarly plugs are made in many different materials, some are preformed in soft rubber or plastic and may be re-used whilst others are made from a very fine glass fibre down or plastic foam and are disposable. Another type of plug is individually moulded to the shape of the ear canal, similar to the ear-

piece familiar to hearing aid users, but of course without the central hole.

The attenuation performance of the protector is influenced by the material, the method of construction and the ability of the device to provide an effective seal. The limiting factor, however, may be the human head itself rather than the protector since flanking transmission through the skin and bone occurs. This alternative transmission path probably limits the attenuation of any protector to around 50 dB at frequencies between 3 and 8 kHz.

Since hearing protectors are worn by so many people and litigation concerning undue noise exposure has proved to be expensive, it is important that the attenuation characteristics are accurately quantified. It is also important that users have confidence in the ability of the product to provide the stated protection after continued usage.

Test Methods

NPL has played an important part in drawing up the present British and International Standards for testing of personal hearing protectors. The assess-

ment of protector attenuation for hearing conservation purposes is made using a minimum of 10 subjects and the procedure is to determine the free field threshold of hearing of each test subject both with and without the protector in position. The attenuation of the device is then taken to be the mean difference between the two threshold values, in decibels. At NPL, to ensure that the sound field at the subject's head is sufficiently diffuse, we use a tetrahedral array of loudspeakers. Measurements are made over the frequency range 63 to 8000 Hz using 1/3-octave bands of noise and the problem of coherence is overcome by using four independent noise generators each with its own set of filters, amplifiers and attenuators. The acoustical requirements of the standard are particularly demanding and along with NPL only two other laboratories in the United Kingdom make these measurements.

The NPL test rig is now based on a commercially available test box which provides independent control of frequency and amplitude for each channel and the system is controlled by a micro-computer. The software for the system has been developed by the Walker-Beak-Mason partnership to NPL requirements and, to allow the system to be adapted to meet changing specifications, a modular approach has been adopted. Full calibration routines for use on a daily, occasional and full system check have been incorporated. The hearing threshold levels are measured using a self recording method (Figure 1) and the system incorporates an NPL developed algorithm to interpret responses; at each frequency the test ends when sufficient data have been obtained to ensure a reliable estimate of hearing threshold level.

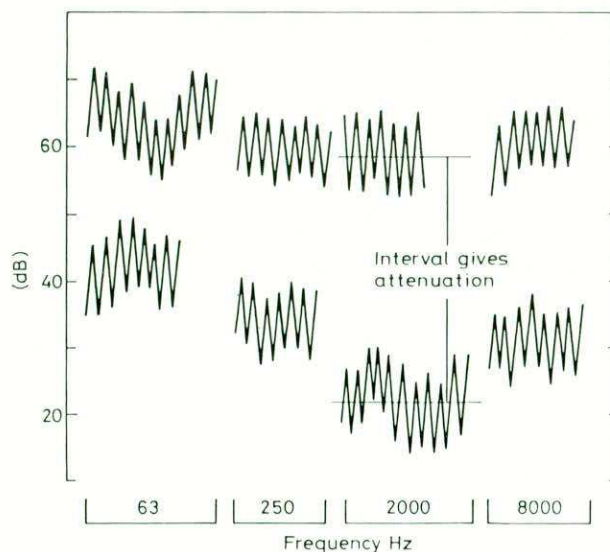


Figure 1 Section from typical self-recording trace

Recognising that the subjective test method is time consuming, an ISO working group has produced a simplified objective method of measuring the insertion loss of muffs. Shown in Figure 2, the acoustic test fixture is a shaped block of metal with a microphone set into one end-face.

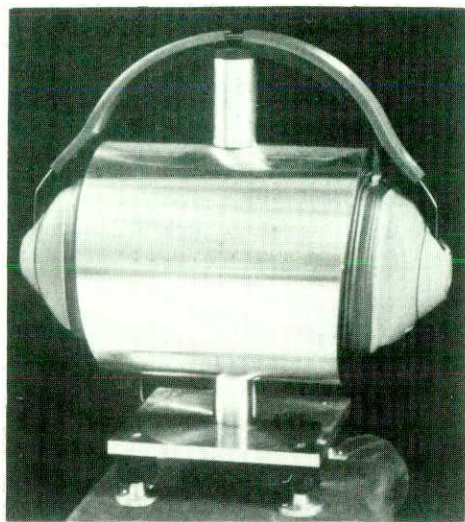


Figure 2 Acoustic test fixture

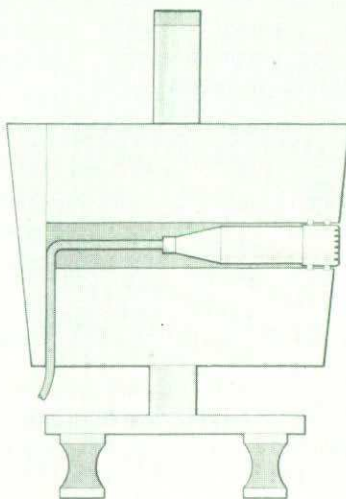
Although the device makes no attempt to simulate the characteristics of a human head, the test procedure used is similar to that of the subjective test method. Results from this objective test differ from those of the subjective test and can be used only for quality control and monitoring purposes.

The objective test method forms the basis of the British Standards-Kitemark test for muffs. Introduced only last year, ten manufacturers have already been granted licences covering some twenty products. With typical production batches of 1500 to 2000 muffs, it is estimated that Kitemarking adds up to 5% to the cost of muffs which have a unit price ranging from £15 to £20.

EEC Intercomparison

The subjective test method described is widely used in Europe and, as muffs from a manufacturer may be sold in different countries, it is important to ensure that test data from different national laboratories agree. To this end the Community Bureau of Reference of the European Economic Community has funded a five-laboratory intercomparison of muffs and plugs, comparing the test results obtained by both the subjective and objective test methods. As the central co-ordinating laboratory, NPL measured the attenuation and insertion loss characteristics of a number of different samples of four different types of muff and of one type of ear plug. Participating laboratories

in Denmark, France, Germany and the Netherlands then made similar measurements on subsets of these protectors and the results have been compared. All participants recorded similar random errors, typically 1 dB standard error for the muffs but somewhat larger for the plugs. Repeat testing at NPL using the



same twenty test subjects has demonstrated the reliability of the test method when using the same muff and also for repeated measurements on one type of earplug when using the same well defined fitting procedure. In neither of the two cases are the replication differences statistically significant, but for some plug types the depth of insertion of the plug may affect the result by as much as 20 dB.

The intercomparison has revealed possible systematic differences in the subjective test between laboratories — at two frequencies this was traced to an over-correction for ambient noise made by a participant, whilst in another case it was almost certainly due to harmonic distortion in the test signal.

Unfortunately measurements of insertion loss made on the acoustic test fixture are surprisingly variable for such an inherently stable test device. In the short term (a few minutes) measurements with a standard error of 0.25 dB and less are possible but this can rise to as high as 1.4 dB for no accountable reason. Over longer time periods (3 months or more) mean shifts as high as 10 dB have been observed. Much of the observed variance must result from small changes to the mechanical characteristics of the muff, eg volume and cushion stiffness, brought about by slightly different fitting positions on the test fixture. In fact cushion characteristics are a crucial factor in muff design and it has been known for a manufacturer to change the cushion filler without appreciating the consequent change to measured insertion loss. If the cushion damping is too low, even negative insertion losses may be recorded at frequencies around 200 Hz, (the mechanical resonance frequency), ie the recorded sound level is actually higher with the earmuff in position than it was without! Figure 3 shows typical values of the attenuation (subjective) and insertion loss (objective) for a muff measured at NPL.

Practical Implications

Results of laboratory measurements provide a ready means of comparing the potential effectiveness of different protector types but are less helpful to the employer who needs to know how well the protectors will work in day-to-day situations and on different individuals. Assuming the spread of attenuation values on different individuals is approximately Gaussian, the concept of assumed protection is widely used when selecting muffs. Using the distribution of the subjective test results, the percentage of the population protected to a

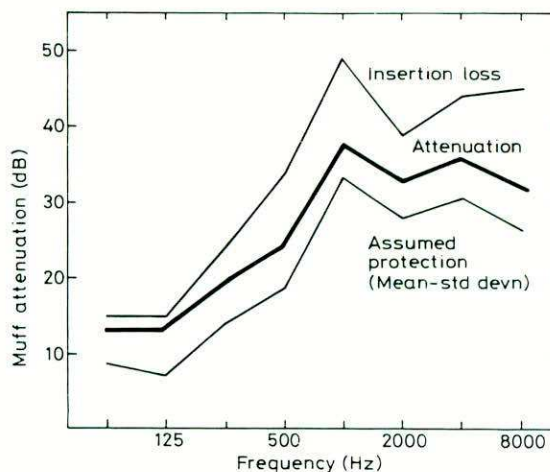


Figure 3 Acoustical characteristics of a muff tested at NPL

given level is readily calculated. The assumed protection of a protector at a particular frequency is commonly taken as the mean value minus one standard deviation (see also Figure 3), which means that when worn correctly protectors may be expected to give some 84% of the population this or a higher level of attenuation.

For hearing protectors to be fully effective in a noisy environment it is im-

perative that they are worn *all* the time. Hearing damage is energy related and if muffs are removed for just 1% of the time the effective attenuation of a muff giving an attenuation of 30 dB is reduced to 20 dB. Although more effective and comfortable muffs are being developed, in the final analysis the effectiveness of the protector must depend on how conscientiously the person exposed to the potentially damaging noise cares for, and wears, his hearing protectors. □

GLC Aircraft Noiseline

Stephen Turner
Greater London Council

It is over a year now since the Aircraft Noiseline opened in the Scientific Services Branch of the GLC. Noiseline provides a single telephone number and address to which Londoners can complain when disturbed by any form of aircraft or helicopter noise. The setting up of Noiseline is described here and an analysis of the first year's complaints is given.

GIVEN the location of Heathrow Airport, it is clear that many people in London are affected by aircraft noise. In addition, there are the smaller airports of Northolt and Biggin Hill, the network of helicopter routes across the Capital, and the Heliport at Battersea and the other Helistops. But, just how widespread is the problem? Are some Boroughs more affected by helicopters than aircraft? Is there a particular time of the day when people find aircraft noise particularly disturbing? Having the answers to these and other similar questions would be valuable in assisting the Local Authorities in London with their aviation planning policies. Yet to obtain this information prior to Noiseline was virtually impossible as it was distributed amongst a number of different authorities. Londoners had a choice of at least six different addresses to which they could complain about aircraft or helicopter noise, the correct one depending on where the aircraft/helicopter was, and what it was doing (ie landing/taking off or flying over). Consequently, the complainants themselves would have had to find the correct address for their complaints to be registered and, if they were not successful, it would mean that the true extent of the disturbance was not being recorded.

There was, therefore, a two-fold purpose in setting up Noiseline: to obtain information; and to act as a 'clearing house' for complaints.

The GLC has no jurisdiction for controlling aircraft and helicopter operations in London so arrangements were made with the various relevant authorities, the DTp, CAA, BAA, MOD, etc, for the complaints to be passed on once they are recorded. These authorities could then respond to the complaints in their normal way. With the help of an automatic answering machine Noiseline is a 24-hour service. During office hours the telephone is attended whenever it is possible, so that the complainant can give the details of the disturbance directly. Those who leave a message on the answering machine are telephoned (as long as they have left their telephone number on the tape) so that the details can be clarified and they can be sure that the complaint has been registered.

Being able to speak to someone who has just been disturbed by a noisy aircraft has been found to be very helpful. Although acousticians may measure the noise and say something like 'from social surveys at this noise level 50% of the population would be very annoyed by it' this really is a fairly abstract statement. To talk to a mother who has been failing to send her baby to sleep because aircraft are flying over every two minutes, brings the meaning of this type of noise disturbance to life.

In the case of helicopters, arrangements have been made with the British Helicopters Advisory Board for Noiseline to contact helicopter operators directly when a number of

complaints have been attributed to the same operation. Noiseline has also been well supported by Westland Aircraft Limited, who operate Battersea Heliport. In particular, the ability to contact the pilots through air traffic control has been helpful in alleviating the discomfort felt. For example, it was possible to identify in one case a helicopter, and in another case an airship at the time when they were causing disturbance. In both cases it was possible to tell the complainants what the helicopter/airship was doing and how much longer the operation was likely to continue, and this seemed to be appreciated. At the same time, through Westlands, the pilot was made aware of the problem.

Care, of course, must always be taken when using complaints statistics for developing policy as they may not truly reflect the general attitude. This meant that there was the difficult problem to solve of publicising the service. On the one hand, people had to know about Noiseline, but on the other, generating complaints just because they had been requested had to be avoided. When Noiseline opened on 16 July 1984, it received a reasonable amount of media coverage. The telephone number appeared in the *Londoner*, which is distributed to most homes in the Capital, and posters were sent to public libraries for display. Throughout the year, Noiseline received, from time to time, enquiries from various local newspapers and radio; but still, it seems that many people have not heard of Noiseline, let alone know the telephone number.

Nevertheless, Noiseline recorded 1265 complaints in the first year. These consisted of:

<i>Complaints about</i>	<i>Number</i>
Aircraft only	803 (63%)
Helicopters only	344 (27%)
Aircraft and helicopters	81 (6%)
Others (eg airships, ground-running of aircraft)	37 (3%)

All the complaints mentioned the noise of the aircraft or helicopter, but of course there were other factors which the complainants did not like.

<i>Factor</i>	<i>Number</i>
Height of aircraft/helicopter	441 (35%)
Frequency of flyover	351 (28%)
The route taken by aircraft/helicopter	36 (3%)

Of those who complained about aircraft noise (884) these were particular areas of concern:

<i>Area of concern</i>	<i>Number</i>
Early morning flights	226 (26%)
Late evening flights	164 (18%)
Total (early and late flights)	390 (44%)
Desiring secondary glazing	83 (9%)
Concorde	77 (9%)

The distribution of complaints across the London Boroughs was:

<i>Borough</i>	<i>Number</i>
Richmond	252 (20%)
Hounslow	219 (17%)
Ealing	175 (14%)
Bromley	88 (7%)
Hillingdon	82 (7%)
Tower Hamlets	46 (4%)
Hammersmith	38 (3%)
Southwark	28 (2%)
Croydon	27 (2%)
Greenwich	25 (2%)

As expected, people living in the West London boroughs registered the most complaints, but the widespread nature of the disturbance caused is indicated by there having been more complaints from Bromley in South East London where Biggin Hill is located than from Hillingdon, which is situated just to the North of Heathrow. In fact, there has been a complaint from every borough except Barking (which is in North East London). Although Noiseline was opened to receive complaints from Londoners, approximately 4% have been registered from people living outside the GLC area.

The ratio of complaints about aircraft noise to complaints about helicopter noise in the worst affected boroughs was:

<i>Borough</i>	<i>% aircraft</i>	<i>% helicopter</i>
Richmond	82	18
Hounslow	96	4
Ealing	82	18
Bromley	50	50
Hillingdon	56	44
Tower Hamlets	5	95
Hammersmith	38	62
Southwark	24	76
Croydon	60	40
Greenwich	28	72

These results show that only in three boroughs, near Heathrow, is the aircraft disturbance that much greater than helicopter noise, and that in a number of boroughs helicopter noise is the greater problem.

The pattern of complaints over the year was much as expected, there being many more in the summer (when windows are open and garden parties are

held) than in the winter, when the number reduced to a trickle but never dropped to zero. It was noticeable how special events such as the British Grand Prix held at Brands Hatch were reflected by the number of complaints received.

The results of Noiseline have shown, amongst other things, that there is considerable disturbance from helicopter noise in London; that virtually all boroughs are affected by aircraft/helicopter noise to some extent; and that aircraft noise is a particular problem at the beginning and end of the day.

The Scientific Services Branch has been monitoring the aircraft noise around Heathrow for about five years, and the Noiseline results have now directed some of the analysis towards investigating the noise-level trends in the 2 — 3 hours before the start of the NNI day; changes in that period which, of course, will not show up in the published NNI contours. Noiseline has also assisted in site-selection for monitoring, and more effort is to be concentrated in Richmond and Ealing where there is obviously considerable disturbance. Noiseline information is also likely to be used during the forthcoming planning

enquiries about proposed Heliports or Helistops in East London.

Noiseline has already had an effect on the complaints statistics published by the Department of Transport confirming that not everyone managed previously to register their complaints.

Total number of complaints about aircraft noise (DTp)

<i>Period</i>	<i>1983</i>	<i>1984</i>	<i>1985</i>
Jan-Mar	100	108	282*
Apr-Jun	185	225	
Jul-Sep	511	837*	
Oct-Dec	200	553*	

*The figures for July 1984 onwards include complaints that have been passed on to the DTp via Noiseline.

As said earlier, care must obviously be taken in the weight given to any complaints statistics. In the case of Noiseline, though, a fairly accurate picture of both extent and the type of disturbance has been obtained. The publicity for Noiseline has not been excessive, so the level of disturbance indicated is unlikely to have been exaggerated.

The telephone number for Noiseline is 01-633-3001. □

Prospect Vale Primary School, Heald Green — an Improved Aircraft Noise Insulation Scheme

John Dinsdale and Alan Baines

Housing and Environmental Health Division, Metropolitan Borough of Stockport

CONCERN has been expressed over many years starting in the days of Cheadle and Gatley Urban District Council regarding the levels of aircraft noise within this primary school and the consequent difficulties in teaching children. The school is located approximately 1.5-2 miles from the end of the runway of Manchester International Airport and:

a) on 'landing' on runway '24' the aircraft are passing directly over the school at a height of approximately 400-500 feet;

b) on 'take-off' on runway 06 the aircraft are passing directly over the school at heights between 800 and 1000 feet dependent on varying factors such as aircraft type, weight, destination and weather conditions.

The school was built by Cheshire County Council in 1962 and comprises two

distinct areas, a two-storey section constructed of brickwork but with a large window area and a single-storey section constructed mainly of light-weight modular panels.

The Environmental Health Department of Stockport Metropolitan Borough Council has monitored levels of aircraft noise over many years at the school and at a regular monitoring point, half a mile nearer to the airport. These levels can be approximated as:

Outside the school

'Landing' > 100 dB(A)
'Take-off' > 100 dB(A)

Inside classrooms

'Landing' > 70 dB(A)
'Take-off' > 80 dB(A)

In 1982, Manchester International Airport Authority agreed to offer financial assistance towards a suitable insulation

scheme and after several meetings between Stockport Metropolitan Borough Council, Manchester City Council and Manchester International Airport Authority it was decided to appoint a consultant at the expense of the Airport Authority.

Building Design Partnership of Manchester were appointed and represented by Duncan Templeton, and valuable advice was obtained from Professor Peter Lord of the Department of Applied Acoustics of the University of Salford.

A feasibility study was set up to consider the circumstances, in particular the acoustic environment and the remedial options available. Of the remedial options available three were considered in detail:

- a) Construction of a new school not exposed to high levels of aircraft noise.
- b) Protecting the teaching areas of the school as far as practicable against the

effects of aircraft noise.

- c) Construction of new teaching accommodation retaining the existing assembly hall and administration areas.

The option chosen was to protect the teaching areas of the school and the suggested methods were to build lightweight umbrella pavilions over and independent of the existing structure on steel frame work, or to build a 'conservatory-like' structure in front of the existing glazing. Ventilation, natural and artificial lighting, drainage and structural support were considered in detail and costs of the lightweight umbrella pavilion scheme were estimated at approximately £250,000, with costs of the 'conservatory-like' structure higher.

The pavilion scheme is considered to be feasible in the time periods available when funding is able to be provided and advantages and disadvantages to the education authority are accepted as follows.

Advantages include increased thermal insulation, giving a saving on heating bills, protection of the current roof structure involving less future maintenance and a reduction in general painting and pre-paint repairs.

Disadvantages include increased running costs because of the use of extract mechanical ventilation, increased lighting costs as a result of reduced natural lighting and increased costs of the cleaning and repair of extra areas of glass, steelwork maintenance and painting.

An overall cost balance of benefit to the education authority of £15,000 is accepted, and construction is anticipated during 1986.

Future technical assessment is anticipated and the contributions of Building Design Partnership, Professor Lord, Manchester International Airport Authority, Manchester City Council and Stockport Metropolitan Borough Council are acknowledged. □

Acoustics across the Atlantic

INTER-NOISE and ICA

If you are looking for an excuse to go West next Summer, American and Canadian acoustical organisations have done their best to provide one. No less than two major conferences and eight specialist events will be taking place in the space of three weeks in July/August across the (aquatic) waves, and the programming has clearly been arranged with European and other non-American delegates in mind.

INTER-NOISE 86, the fourteenth International Conference and Exhibition on Noise Control Engineering, will be held on the campus of the Massachusetts Institute of Technology in Cambridge, Massachusetts, from 21 to 23 July. Contributions in all areas of noise control engineering are invited for the technical programme, particularly on the topics of noise regulation compliance, worker protection, fundamental aspects of noise generation and measurement, machinery monitoring and diagnostics, complex acoustical mobility measurement, and computational methods for sound radiation and vibration transmission. An abstract of not more than 200 words is required for each conference paper, and should describe new work that has not previously been presented at a conference or published in a journal.

There will be an Exhibition and two technical workshops. Further details are

available from INTER-NOISE 86 Secretariat, MIT Special Events Office, Room 7-111, Cambridge, Massachusetts 02139, USA.

INTER-NOISE 86 will be preceded from 17 to 19 July, by the INCE seminar on **Advanced Techniques for Noise Control**, and the MIT Summer Course, **Machinery Noise and Diagnostics** takes place from 14 to 19 July, tuition for both events being reduced by 20% for registrants of INTER-NOISE 86.

Two hours of flying will take you on to the **12th Congress on Acoustics** in Toronto, from 24 to 31 July. The Canadian Association has arranged a comprehensive technical programme (in English, French and German but without simultaneous translation), a technical exhibition and technical visits and a stunning social programme in which you can choose between whale watching, white water rafting, fishing or just sightseeing — to name but a few options. Perhaps you shouldn't mention this to your employer when applying for his support! Further details may be obtained from: 12 ICA Secretariat, PO Box 123, Station Q, Toronto, Canada M4T 2L7.

Underwater Acoustics enthusiasts may be interested in the symposium on their subject from 16 to 18 July in Halifax; details are available from Harold M Merklinger, c/o Department of

Engineering Physics, Technical University of Nova Scotia, PO Box 1000, Halifax, Nova Scotia, Canada B3J 2X4.

Units and their Representation in Speech Recognition, 21-22 July, will focus on processes of human speech recognition, and organisation and performance of automatic speech recognition systems; details from Paul Mermelstein, Bell-Northern Research and INRS-Telecommunications, 3 Place du Commerce, Verdun, Québec, Canada H3E 1H6. This symposium will be held in Montreal.

Acoustics and Theatre Planning for the Performing Arts will attempt to tie together the acoustical design of performing arts facilities with other aspects vital to the function of an auditorium or studio as a space for performing arts production. Information on this symposium, which will take place from 4 to 6 August, may be obtained from John P Walsh, Artec/Ars Nova Research, 230 West 15th Avenue, Vancouver, British Columbia, Canada V5Y 1X9.

Three other meetings of an acoustical nature, but organised independently of ICA, are timed to coincide with the Congress. They are a conference on **Acoustical Imaging** (Halifax, 14-16 July); a **Musical Acoustics** meeting arranged by the Catgut Acoustical Society (Hartford, USA, 21-23 July) and a conference on **Non-destructive Materials Characterisation** (Montreal, 21-23 July). □

Proceedings of The Institute of Acoustics — Abstracts

Autumn Conference 1985

1 — 3 November, Windermere

Ambisonics and Similar Developments

Ambisonic Surround-sound

P B Fellgett

Department of Cybernetics, University of Reading

Now that the Ambisonic surround reproduction of sound has become a mature and tested technology, it is possible to look back and see more clearly what is its essence. The first essential requirement is to convey to the apparatus of the eventual listener a coded representation of direction. Ambisonics does this directly in terms of a smooth directional encoding free from the misleading attention given to corner-positions in so-called 'quadraphonics'. The second essential requirement is to cause the listener to hear sounds coming from the directions corresponding to the encoded information. Ambisonics does this using psychoacoustic theory (perception psychology). This rational design enables Ambisonics to make use of whatever number of audio channels are available, and thus to exploit favourably newer multi-channel analog or digital media.

Recent Developments in Periphonic Sound

J Howard Smith

Audio Design/CALREC

A description and explanation will be given of the Periphonic demonstration and a general outline given of a recent development in the use of periphony for theatre sound monitoring.

Periphonic Synthesis: A New Challenge

R Maconie

University of Surrey

Ambisonics raises the question whether ways may be found of synthesising sounds which are capable of being manoeuvred in audible space and which reproduce the characteristically asymmetric patterns of frequency propagation of natural sound sources. A radically different approach to synthesis is indicated if this goal is to be achieved.

Studio Acoustics

The Acoustic Design of BBC Studios

D J Mears

BBC Research Department

This paper will review the acoustic criteria currently used by the BBC when designing

its studios and other technical areas. The criteria encompass the universal problems of insulation, ventilation noise and internal acoustics but, particularly for concentrated studio centres, they go into more detail than is perhaps necessary for other types of building. As well as addressing the way in which the criteria were derived the paper will give some guidance as to how they can be achieved; for example high levels of sound insulation obviously require multiple leaf partitions and under these circumstances attention to the details, around windows and doors, becomes much more significant.

Design, Use and Selection of Studio Tuners

A Fry & R Burnett

Sound Attenuators Ltd

Over the years studio tuners possessing various absorption characteristics have been developed and measured under reverberant room conditions to establish their absorption coefficient as a function of frequency.

In a fairly straightforward manner, 18 tuner options have been evolved to cover the frequency range required.

The concept of modular studio tuners is that they should be interchangeable such that later adjustment of the studio's absorptive reality — established via the reverberation time — can be optimised. Nevertheless, it is necessary at the design stage to hopefully predict the exactly correct selection of studio tuners from the 18 options to obtain the desired reverberation time.

It has been found necessary to develop a desktop computer program to select in an iterative way and home in on the desired reverberation time. The computer can be used manually with quick trial selections, or best of all in its automatic mode to obtain the best mixture between the 18 types. Generally, for speed only 8 types are entered as a result of some other broad-brush pruning guidance.

Both these methods will be illustrated and comparison of predictions, manual calculations by others, and computer calculations will be presented.

Acoustic Scaling: A Re-evaluation of the Acoustic Model of Manchester Studio 7

R Walker

BBC Research Department

The design and construction of a model of a large music studio using mechanical and structural considerations rather than purely acoustic absorption criteria will be described and the results obtained will be given. The results confirm that structural elements within the studio can give rise to unexpected and unwanted low-frequency acoustic absorption. The results also show that, at least for the relatively well understood mechanisms of sound energy absorption, physical modelling of the structural and

internal components gives an acoustically accurate scale model, within the usual tolerances of acoustic design. The poor reliability of measurements of acoustic absorption coefficients, especially when the room already contains significant amounts of other acoustic absorption, is well illustrated.

Description of a Computer Based Time Delay Spectrometry Unit

P Christiansen

Crown International, Amsterdam

The subject of this paper is to discuss time delay spectrometry as one of the general class of two-part measurement methods that can simulate free-field measurements in a reflective environment, gathering information in both the time and frequency domain.

Comparison is made to other measurement techniques such as impulse testing with a single channel FFT, noise excitation with dual-channel FFT, and tone burst testing using time gating techniques, in the presence of both correlated and uncorrelated noise.

The implementation of a computer based time delay spectrometry unit is described, and examples of typical measurements such as the magnitude of the frequency response, energy time curve, and Nyquist response will be shown.

Practical Applications for the TDS10 Analyser

A Munro

Munro Associates

The use of an integrated time energy and frequency measurement system is not new but never before has the original Heyser Time Delay Spectrometry concept been developed as a practical, portable, working tool.

The writer will demonstrate, by previous in-field examples, measurement of energy with respect to time and corresponding impulse response, energy with respect to frequency within a specific time window and a 3-dimensional display of all these parameters.

The software to be presented will be third generation and has been developed by Richard Heyser himself in conjunction with the original system manufacturer.

Multi-channel Reverberation at Limehouse Studios

N F Spring

Sandy Brown Associates

The first multi-channel reverberation system in the UK was installed at Limehouse TV Production Studios in London's dockland in 1983. The system improves the acoustic conditions for singers and instrumentalists in what would otherwise be an unresponsive studio.

This paper, will discuss the reasons for choosing the system, the method of specification and the experience of users.

The Modular Construction of TV, Radio and Post-production Studios

Courtenay Nicholas
Industrial Acoustics Ltd

The design, construction and acoustic tuning of all types of studios using pre-fabricated modular acoustic panels will be discussed. Specific topics to be treated include: The acoustic performance provided by different types of construction techniques and the importance of meaningful acoustic guarantees; Differences in speed of installation problems with air conditioning, the types of system available and their suitability; The 'Turnkey' approach to studio design and construction and mobile studio facilities.

Some Practical Aspects of Vibration Isolation

C D Mathers and R Walker
BBC Research Department

In choosing antivibration mountings for mechanical isolation purposes, it is usual to consider the supported structure as a pure mass, and the AVM's as pure compliances with some added damping. System design is completely specified by resonant frequency, from which isolation can be calculated.

For broadcasting studio design, this basic model is inadequate because of three factors: modes of the structure, modes of some types of AVM, and AVM flanking by acoustic energy transfer. Some results obtained from an experimental concrete slab will be presented, and compared with predictions based on a more advanced mathematical model.

Intensity Measurement of Sound Transmission Loss

R W Guy and A DeMey
Concordia University, Canada

The sound transmission loss test suite of the Centre of Building Studies, Concordia University is being converted to measure Sound Transmission Loss by the use of the Sound Intensity Technique.

During the course of technique validation a number of novel variations on transmission loss measurement were made which hitherto have not been possible employing the traditional two chamber method.

The variations involved contour plotting of intensity across the panel and here various transmission regimes are identified; a plane to plane exposition of transmission through an absorbent lined reveal which demonstrates the loose coupling between structural and airborne modes of vibration as well as the effectiveness of reveal lining as an attenuation strategy; and finally transmission 'fault' location.

Public Address Systems

Intelligible Speech Communication in Highly Reverberant and Noisy Industrial Spaces

K Dibble
Ken Dibble Acoustic Facilities

This paper is based on a recently completed investigation carried out for the Central Electricity Generating Board in order to provide for the control of an emergency evacuation at a nuclear power station. The outcome, however, is likely to find numerous other applications. An original approach, which resulted in the development of a somewhat large and unusual loudspeaker array was adopted and the presentation will include the development of the array, the results of laboratory tests and how these related to subjective site evaluation trials. If sufficient time is available, this topic would also lend itself to practical demonstration.

Design and Implementation of P/A Systems for Difficult Conditions

Peter Mapp
Consultant

The paper will briefly review the main criteria for successful speech communication in sound reinforcement and public address systems and then goes on to discuss to what degree these design goals were achieved in three widely contrasting recent projects. Particular attention will be paid to the control of undesirable reverberant excitation, the importance of correct sound system equalisation and the maintenance of adequate signal to noise ratios. Case histories will include the design and installation of a novel public address system at Waverley Station, Edinburgh where a high level distribution system incorporating multiple signal delays and comprehensive signal processing facilities is currently being installed; the design and installation of a conference sound system in a temporary structure for over 5000 delegates and the preliminary results of two systems installed in highly reverberant areas (reverberation time greater than 6 seconds) which require the microphone and loudspeaker to be in the same sound field.

Intelligibility in Public Address and Sound Systems

P W Barnett
Acoustic Management Systems Ltd

The paper will describe and investigate the various methods of predicting intelligibility at the design stage of Sound Systems. The methods to be examined would include early work by Knudsen, % ALcons (Messrs VMA Peutz and W Klein), and work by Lochner and Burger.

Recent examples of system design will be described to validate theory.

The Design Implementation and Performance of a New Cinema Sound System for the Fairfield Halls

Richard Bussell
Sandy Brown Associates

The Fairfield Concert Hall, Croydon, designed and well-liked as a venue for classical music, must also function as a multipurpose auditorium and, as part of an upgrading of existing facilities, a new projection and cinema sound system has been installed.

The brief required that the sound system should deliver intelligible speech, high quality music and the full force of modern film sound effects to all 1950 seats at a standard comparable with the best in the West End.

This paper will review the features of an installation compatible with modern cinema requirements and describe the acoustic and

electroacoustic considerations involved in the design of a sound system for the live acoustic environment at the Fairfield Hall.

Special Conference System - Bustan, Oman

V W Dobbs
Spectrum Audio Ltd

The Special Conference System involves a careful blend of electronics and acoustics. The space is expected to be reverberant and as such the reinforcement system had to be designed to reduce the energy supplied to the reverberant field. Spectrum Audio took the unprecedented step of using constant directivity horn loudspeakers mounted in the ceiling to maintain the required acoustical control. The paper will include a resumé of the acoustical calculations and considerations in monitoring the required feedback margin and the intelligibility. Such calculation will be supported with on-site measurements.

A Public Announcement System for Glasgow Central Station

Dick Bowdler
Sandy Brown Associates

Public Announcement Systems in railway stations have to contend with particularly difficult acoustic conditions, in particular low direct to reverberant noise ratio and variations in background noise levels. These two problems have been dealt with in the new system at Glasgow Central Station. The first was dealt with by relatively conventional use of column loudspeakers, but with careful selection of loudspeakers and positioning to ensure that a sound pressure isobar was flat along a length of up to 15 m at head height. The second difficulty was assisted by assigning generally one amplifier to each loudspeaker and using the loudspeakers themselves to measure the background noise level in the 1.5 seconds prior to an announcement and thence set an output attenuator to provide the appropriate speech level.

The paper will also discuss the quality of reproduction required of the equipment in such situations, and whether or not costs can be cut by reducing the specification of the equipment itself.

Developments in Induction Loop Technology

D Edworthy
Millbank Electronics

This paper will describe some recent significant developments in the design and implementation of induction loop systems in the United Kingdom. Basic induction loop system design theory will be covered with particular emphasis placed on the requirements of audio processing and amplification circuitry for induction loop use.

Computer aided Design for Installed and Concert Sound Systems

W Mirauer and S Romeo
Bose UK

The targeted parameters will be defined. How they were integrated into the program, the prediction of effects, the dimensional capabilities and the software writing will be discussed. The application (citing examples), the hardware requirement, input data requirement and user operation will be related to the principles of acoustic and physics. The output from the system and the ways it can be interpreted. Demonstration using theoretical

model and actual case. Possible extension of this technique by integration with computer-aided product design.

Objective Measurements of Speech Intelligibility under Highly Reverberant Conditions

Klaus Højbjerg
Brøel & Kjaer, Denmark

In recent years there has been increasing interest in objective measurements of speech intelligibility. For rooms with long reverberation time (also those in which sound systems have been installed) it is very useful for control purposes to have a fast objective way of measuring speech intelligibility. RASTI (Rapid Speech Transmission Index) is a new method of measuring speech intelligibility, which provides a rating in less than 10 seconds.

The theory and principles of operation will be presented. Measurement results from the 'Grundtvigskirken', which is a Danish church having a very long reverberation time and a recently installed sound system, will be reported.

Developments in Digital Sound

Digital Stereo and its Application in Music Play Systems

W Mirauer
Bose UK Ltd

How digital techniques were adapted to provide automated, software-controlled, music play systems. The design, operational and electronic parameters of the resulting (UK Patented) system will be described, as will the interfacing with existing componentry and analogue apparatus. Operational difficulties encountered during the development, in the laboratory and in the field will be described, together with additional capacity and how it can be used. Graphics and simultaneous display capabilities, software and how it is written, coded and produced will be discussed.

Digital Sound Storage System

S Jones
Electrosonic Ltd

An interesting new development. The system can produce three different audio channels simultaneously from EPROM memory. The total message duration may be 48 or 90 seconds but there is provision for expansion up to 8 minutes at full bandwidth.

The following features will be discussed.

- A special method used to reduce the amount of storage memory required for the 10-bit data samples.
- A method of silence processing used to effect time-compression without pitch change. (This enables the speed of the sound track to adjust to the speed of an entertainment ride).
- Instant random access of the audio data; the memory may be partitioned unequally so that the three channels need not be equal length.
- The division of the messages into many short sections to build up announcements: thirty-two sections can be addressed. The system will be demonstrated.

Software Design for an Economical Real-time Digital Audio Signal Processor

Lawrence Casserley
Royal College of Music

A low-cost programmable digital signal processor board has been designed, which enables real-time audio transformations to be effected. The system interfaces to a PCM recorder and microcomputer and has a number of applications in sound recording, electro-acoustic music, etc. A brief description of the system will be given, and the main body of the paper discusses examples of practical software for the processor. The program segments discussed implement commonly used simple devices such as generators, filters, modulators, pitch transposers and reverberation. The paper will illustrate how some of these may be combined to form practical units.

Computation noise reduction for high quality digital signal processing

J A S Angus
Department of Electrical Engineering, University of York.

Practical digital filters suffer from degradations due to the finite wordlength of the arithmetic used in their implementation. These degradations result in inaccuracies in the frequency response due to finite precision coefficients and in increased noise in the output signal due to rounding during computation. A further problem is that the roundoff noise has a non-uniform frequency spectrum and may be correlated with the signal. This paper will examine the effect of different filter structures on the computation noise and will propose structures which provide the best system performance. It will also show how the speech coding technique of noise shaping can be used to alter the roundoff noise spectrum to provide improved performance. Finally the effect of using 'dither' in these structures to reduce the correlation between the computation noise and the signal will be discussed.

Limitations of Audio CODECS for High Quality Audio Applications and the Use of 'Dither' to reduce Subjective Impairments and therefore Cost

P A Conway
Department of Electronic and Electrical Engineering, University of Bradford

The addition of random noise to an analogue signal prior to digitisation breaks up the resulting contours and trades granular noise for non-amplitude dependent noise. Quantisation contours are more objectionable than additive random noise of the same mean squared value. To achieve minimum total error for a signal with added noise, a noise source identical to that added prior to quantisation may be subtracted from the signal after digital to analogue conversion.

This can be realised in practice by the use of a pseudo-random noise source. The added noise is termed 'dither' and can be used to subjectively 'cover up' CODEC impairments. This paper will discuss recent developments in the field.

A 24 bit 10 mips Digital Signal Processor - An Exercise in Nanosecond Design

D G Malham
Electronic Music Studio, University of York

A 24 bit 10 million instructions per second digital signal processor has been designed

and built at York University's Electronic Music Studio. This unit is intended as a modular component for use in a proposed all digital Music/Recording studio.

This paper will concentrate on the design process. The reasons for the various design choices, such as the word length, instruction rate and architecture, will be discussed. The problems of squeezing the limit out of (relatively) non-esoteric components will be covered and some examples of practical uses of such systems will be mentioned, with particular emphasis on electro-acoustic music applications.

The Distribution of Signal Amplitudes in Recorded Music

A R Mornington-West
IBA

The distribution of signal amplitudes within the audio band in recorded music is of broad interest to many. For acousticians the information is a pointer to necessary treatments, while for recording and broadcast engineers it affects the dynamics of the recording.

Past studies have concerned themselves with acoustic matters or have perhaps been limited by the properties of the contemporary recorded and recording media. Signals generated by current pop music are a matter of present interest; this paper will present some figures and some ideas.

A Stochastic Algorithm for the Real-Time Control of Musical Structures

Michael Greenhough
Physics Department, University College, Cardiff

The algorithm to be described and demonstrated allows the pitches, rhythms and other properties of a polyphonic sound sequence to be controlled by means of user-defined probability distributions. The particular implementation (on an IBM-PC) is sufficiently fast for users to exert control over selected distributions in real time. They may thus 'home in' on a satisfactory output without needing to be able to describe explicitly what it is that is required. By varying the form of the distributions and the degree and kind of context dependence many useful musical features (eg parallel and contrary motion, ostinato and canonical patterns) can be readily introduced and manipulated in an intuitive fashion.

The Spacio - Acoustic Processor

D G Malham
Electronic Music Studio, University of York

The Spacio - Acoustic Processor is a hybrid digital/analog unit capable of dynamically controlling the perceived location of four sound sources within a three-dimensional sound projection space.

The design involves two linked 16 bit microprocessors which massage the data from an external control computer into a form suitable for sending to the multiplying digital to analog converters used for actually controlling the sound.

Developed for Trevor Wishart, who was funded by the Ralph Vaughan Williams Trust, for use in his piece 'Vox I' it has much wider applications, especially for studio work, as it is capable of performing all the non-frequency dependent Ambisonic control functions in real time either on four independent sound sources or on a full B-format soundfield.

Control of Entertainment Noise

Noise Control Techniques and Environmental Guidelines for Open Air Pop Concerts

J E T Griffiths

GLC, Scientific Services Branch

This paper will describe the method of noise control adopted by the GLC at open air pop concerts. The initial planning and predictions of noise levels to establish the optimum stage/speaker position with regard to minimal environmental noise disturbance will be discussed. Sound attenuation tests using a shaped noise source developed from popular music will be described in conjunction with the effects of loudspeaker orientation.

Environmental guidelines to minimise noise annoyance from pop concerts are invariably based on the 'A' weighted sound pressure level. Results will be discussed to establish the basis for a guideline for assessing the low frequency aspect of noise disturbance due to entertainment sound.

Environmental Control of Entertainment Sound - Some Guidelines and Case Studies

K Dibble

Ken Dibble Acoustic Facilities

This practice is particularly well known for its involvement in the design of sound systems for the entertainment and leisure industry and for its track record in dealing with the many environmental problems that arise whenever high SPL reproduced sound is introduced in a venue in a residential area. This paper then, will discuss some of the design thinking and practical approaches — both electronic and architectural — which have been adopted to satisfy the requirements of the Environmental Health Officer in his enforcement of Part III of the 1974 Control of Pollution Act, and will take a couple of case histories to illustrate the implementation of these at a practical level.

Real Time Noise Control of Rock Concerts

S Alport & A D Wallis

Cirrus Research Limited

The paper will discuss the problems of noise pollution due to open air rock concerts in urban areas with specific reference to Reading Rock and Crystal Palace.

The use of 'short Leq' as a form of data acquisition is quantified and plots shown of automatic data gathering by this method at several sites round festivals. The resultant 'noise footprints' are plotted with atmospheric conditions shown to play a major role in the external level and its use as an on line predictive level control via a microcomputer is shown.

An 8 bit microcomputer was used to predict the 15 minute Leq and guide the sound mixer to the level required to prevent level exceedance of GLC guideline.

Room Acoustics

Sound Power Output of Loudspeakers in Small Rooms

G Adams

B & W Loudspeakers

This paper will discuss the often neglected influence of the room resonances on the sound-power output of a loudspeaker sound source placed in a small room, and compares their relative significance with those of the more usually studied near-boundary effects. Using a novel measurement technique the strong dependence of the power output of a loudspeaker system placed in a rectangular room will be demonstrated as a function of frequency and source position and the influence of room resonance on the power output at low frequencies shown to be of considerable importance under steady-state conditions. The variation of the power output of the source as a function of time as a sound builds up in the room will be examined, and the existing analysis for the near-boundary effects shown to be applicable to the concept of the 'early sound wave'.

On the Acoustics of Domestic Listening Rooms and their Effect on Sound Reproduction

Peter Mapp

Consultant

Although it is well known that the same loudspeaker can sound remarkably different in different listening rooms little research has been carried out into the underlying acoustic factors involved. This paper will look at the loudspeaker/room interface and discuss ways in which the domestic listening environment affects quality and accuracy of sound reproduction. The results of a preliminary survey into domestic listening room acoustics will be reported which question the methods and validity of standard reverberation time measurements and criteria. Methods of overcoming the generally poor acoustic environment of the domestic listening room will be discussed, including methods of electronic equalisation and digital filtering.

The Acoustics of Partially Enclosed Orchestra Pits

R K Mackenzie

Heriot Watt University

The relationship between the acoustic properties of partially enclosed orchestra pits and the subjective response of musicians will be described, together with guidelines for their geometrical and functional design.

The design of the new orchestra pit at the King's Theatre, Edinburgh, which was commissioned in August 1985, will be discussed. Details of the scale model tests to establish the optimum shape will be presented, together with a description of the electro-acoustic sound reinforcement system which was installed as an integral part of the redesign of the pit.

Equalisation of Room Acoustic Responses over Spatially Distributed Regions

K Farnsworth, P A Nelson and S J Elliot

ISVR, University of Southampton

A technique has been developed for forming the optimal unconstrained Wiener filter for inverting the impulse response of the transmission path between a source and receiver in a room. If the inversion can be accomplished of the impulse response of the transmission path between a source and a point x , then the sound field at x can be dereverberated. A study has been carried out of the effect of inversion of the response between the source and a point x on the impulse response of the transmission path bet-

ween the source and neighbouring points Y_i . In particular the sphere of influence of the impulse response inversion is established as a function of the separate distance $x - Y_i$. The use of multi-sensor arrangements is considered with the objective of creating an extended zone of dereverberation.

A Study of Sound Absorption in a Small Enclosure

E W Taylor

BBC Research Department

The effect of different absorber positioning and surface attachment on sound decay in a small enclosure excited at frequencies corresponding to each of the three lowest-order axial 'room modes' will be discussed. It will be shown that:

- 1) Sound absorption depends on the nature of the sound standing-wave pattern in the vicinity of the absorber.
- 2) Sound absorption can depend not only on sound pressure at or near an absorber, but on sound pressure-difference across it, even for a material normally regarded as 'locally reacting'.
- 3) Energy flows into an absorber from regions of the sound field not immediately adjacent to it.

Sound Sources

Loudspeakers for Sound Cancellation

A Fry and P Fryer

Contranose Ltd

A wide range of speaker cabinet types will be discussed and their advantages and disadvantages assessed for sound cancellation work. A few novel designs will be outlined and the unique features which give them particular advantages for the cancellation of sound covered in full. The most suitable speakers generally fall into the 'bandpass' and 'tube loading' categories, where all the sound emanates from a small opening of similar size to many noise sources which lend themselves to sound cancellation control, eg, diesel exhausts, compressor inlets. The two sources can now be placed very close to each other and since it depends on the distance between them, the cancellation available is therefore greatly increased.

Experimental Verification of a Low Frequency Loudspeaker Model for an Engineering Application

J W Edwards and N M J Dekker

GEC Hirst Research Centre

The ability to tailor loudspeaker performance is an important requirement in Active Noise Control applications. To this end a low frequency loudspeaker model has been developed and its transfer function relating input signal voltage to generated acoustic pressure for infinite baffle radiation has been derived. The physical parameters of the model have been determined experimentally thus enabling a theoretical amplitude/frequency response for the loudspeaker to be calculated. A comparison of the theoretical response derived from the model with direct measurements from two different loudspeakers has been made and good agreement obtained. In this paper special attention will be given to the experimental aspects of the work.

Setting up High Power Speaker Arrays for Rock Festivals**A Self
ENTEC****A D Wallis
Cirrus Research Limited**

The wall of sound once used by rock groups is now obsolete. Current systems used for open air concerts utilise multi-band amplifier horn combinations with total input power of around 36 kw. To keep down reflections, digital delay units have to be used with delay towers built into the audience. When set up, the system gives flatter sound with little phase cancellation. The resulting system

also has a very sharp cut-off outside the concert site, thus reducing the external noise limits by a significant margin. Setting up this system requires special techniques using short pulses with a spectrum analyser. The use of a computer running in real time is discussed to control the base mix level to keep it constant with weather conditions.

A Study of Sound Generation using Electro-Pneumatic Sources**A Glendinning, P A Nelson and S J Elliot
ISVR, University of Southampton**

Recent work on active control of gas turbine and diesel engines exhaust noise has

highlighted the need for a robust high intensity secondary acoustic source. An electro-pneumatic transducer is of possible use and this work describes an initial investigation of the potential power output, frequency response and linearity of such a source. An experimental source has been constructed which modulates an airstream using a reciprocating slotted plate supported by an aerostatic bearing. The effects of the degree of slot modulation, inlet plenum pressure and airflow rates on the linearity and acoustic power output of the sources will be discussed and compared with theoretical prediction.

Barriers for Noise Control

7 October 1985 at Society of Chemical Industry, London

Airport Ground Noise Control**J B Large, I H Flindell and J G Walker
ISVR, Southampton**

Abstract not available.

Scale Model Tests of Barriers in Factory Buildings**R J Orlowski
Department of Applied Acoustics, University of Salford**

Abstract not available.

The Propagation of Road Traffic Noise over Earth Mounds**D C Hothersall, S N Chandler-Wilde and B C Chapman
School of Civil and Structural Engineering, University of Bradford.**

Earth mounds provide what is probably the most acceptable method of screening environmental noise. The use of this form of screening is often limited by cost or space restrictions.

Experimental measurements of the propagation of road traffic noise from a motorway over an earth mound barrier will be presented. The site was open and represented a good approximation to standard conditions. The effects produced by the barrier and by the atmospheric conditions will be discussed in terms of statistical traffic noise measures and also in terms of the spectrum of the noise. Results will be compared with prediction methods.

Analytical methods of calculating the attenuation of sound produced by topographical features with varying surface impedance will also be discussed.

The Acoustic Protection of Perforated Screens for Buildings in Hot Climates**B M Gibbs and R N S Hammad
Muspratt Laboratory, University of Liverpool**

It is well known that conventional perforated screens offer relatively little acoustic protection either as free standing barriers or as part of a building facade. There is thus a conflict of requirements for buildings in urban areas of hot climate; the need for adequate natural

ventilation will result in a facade which offers little protection against traffic noise, particularly at the low floor levels.

In an attempt to provide a perforated screen affording some acoustic protection Wirt identified a mechanism where a saw-toothed shape can be viewed as a screen the transparency of which increases with increased height. In the right conditions an amplitude gradient device results; the sound incident is redirected away from the line of propagation. In work at Liverpool University these devices have been investigated as functions of source-barrier-receiver geometry and frequency. The work involved computer simulations and the use of scale models in anechoic conditions; field-work is also in progress. The results so far obtained are in agreement with those of Wirt in that the protection of the free standing devices compare well with that of a solid barrier of equal height. The screens, when examined as part of a building facade, yield appreciably greater acoustic protection than perforated screens which do not offer an amplitude gradient. This is true only when used in conjunction with correctly positioned ceiling absorption.

Optimal Design of Highway Noise Barriers**K R Tompsett
Atkins Research and Development, Epsom**

Recent experience shows a public demand for highway noise barriers in preference to noise insulation of dwellings, despite their relatively low acoustic performance. In many cases, such a barrier is not cost-effective compared with noise insulation, partly because of the need to extend the barrier well beyond the properties to be screened. This paper attempts to define the conditions under which a highway noise barrier may be considered to be both acoustically and cost-effective. The problem is considered analytically and formulae for calculating the cost and performance of an idealised case are presented. The question of the cost/performance trade-off between short, high barriers and long, low barriers, and combinations of these, is also considered. The results are used to derive rules whereby a

computer may be employed to select the optimum barrier configuration in any given situation.

A Study of Acrylic Enclosures for Noise Control in the Food and Drinks Industry**E A Mac Gregor
Parsons Brown**

The Food and Drinks Industry is particularly noisy due to the bottling and canning processes, but the design of noise enclosures is limited to materials which can withstand the most rigorous cleaning. Acrylic sheet is one such material. For similar reasons the bottling/canning halls are generally of hard surface finishes resulting in fairly reverberant field conditions.

Due to these non-ideal conditions current theory is inappropriate as a tool in assessing the Insertion Losses of an acrylic enclosure. Consequently an experimental rig was devised to simulate the food industry conditions as a means of predicting the benefits accruing from an acrylic enclosure.

The rig allowed for three sizes of machine to be simulated with various configurations of enclosures including: gasket seals; holes of 3 sizes; open top; enclosed top; tunnel provisions and raising the enclosure by 150 mm to simulate the ideal operating conditions within the canning halls.

The results showed that an Insertion Loss of as much as 19 dB(A) can be achieved with a completely sealed enclosure, while a typical enclosure would achieve an Insertion Loss of 3.5 dB(A). In addition, with a typical enclosure an access hole up to approximately 0.02 m² can be introduced without detriment to the overall Insertion Loss.

Acknowledgement to ICI Ltd for permission to publish research carried out within their employment.

Use of Free Belts as Barriers**Margaret Price
Department of Engineering Mechanics, The Open University, Milton Keynes**

Abstract not available.

Array Signal Processing

Loughborough, 16 — 17 December 1985

Application of Geometric Constraints to Locating Sources using DTOA Information

S Crozier

Miller Communications Systems

R Inkol

Defence Research Establishment Ottawa

In a system where the Differential Time-of-Arrival (DTOA) estimates for pairs of receivers are used to determine the location of the signal source, the source/receiver geometry implies the existence of constraints on the DTOAs. For the minimum 3 receiver system required to locate a source in two dimensional space, a single constraint exists — the DTOAs for the three receiver pairs sum to zero for any unique solution. If additional receivers are available the number of unique solutions and constraints both increase. The general problem is to make use of the available information including the geometric constraints to provide a unique and optimal or near-optimal estimate of the source location.

This paper develops a model for the covariance of DTOAs estimated for pairs of receivers when one receiver is shared. This result is important for modelling the performance of systems using DTOA information to determine source locations. An expression developed for the reduction in the variance of the DTOA estimates achieved by using constraints is dependent on the number of receivers and the signal-to-noise ratios. This expression, believed to be valid for any number of receivers, is consistent with experimental results. Finally procedures are outlined for incorporating geometric constraints into DTOA estimation.

Digital Sonar Processor

R Rawson-Harris,

Ferranti Computer Systems, Cheadle Heath

The Sonar Systems Group of Ferranti Ltd is manufacturing a single card Digital Signal Processor which is very well adapted to the needs of the present generation of Naval Sonars.

The paper describes the Processor and associated topics of interest, as follows:

- System architecture of current Naval Sonar Signal Processing equipment

- Signal Processing Algorithms of current Naval Sonars

- Data Flow and Control Mechanisms

- Ferranti Digital Signal Processor architecture

- Programming support

- Specimen Algorithms implemented in the DSP

- Performance in typical applications

We believe that our DSP has a combination of features which is unique in the field of current single-board and single-chip signal processors, even though it is not novel in any single feature. In this respect, it represents the best in engineering practice, a view which is supported by the interest being shown by ARE (Portland) in the use of the DSP for experimental equipment as well as for production systems.

Robust, High Resolution Array Beamforming

D R Farrier and D J Jeffries

Department of Electrical Engineering, Southampton University

In most practical situations it is impossible to locate sensors or calibrate their responses precisely. Unfortunately, many notionally high performance beamformers are very sensitive to such errors, and their practical performance can be disastrously degraded.

At present, the most popular high resolution techniques are eigenvector-based methods, and often rely on the orthogonality between the source directions and the noise subspace. This description is, for instance, true of both MUSIC and the 'Kumaresan and Tufts' algorithms. Both techniques have the property that they obtain a spectrum-like response, and the signal directions can then be obtained by performing multimodal maximisation. The disadvantage with both methods is that they are very sensitive to sensor errors, and (because of the orthogonality property) it is very difficult to imagine how this defect could be removed.

The method proposed in this paper is a source subspace method, based on eigenvector rotation, which has the following properties:-

- Superior resolution to noise subspace methods
- Reduced complexity
- Facilitates on-line sensor calibration (phase and amplitude simultaneously)
- Facilitates on-line sensor location (but not (c) and (d) simultaneously!)

In particular, properties (c) and (d) will be demonstrated at quite low S/N ratio, in situations where MUSIC also fails at high S/N ratio.

Location and Power Estimation of Multiple Sources by Nonlinear Regression

U Sandkühler and J F Böhme

Lehrstuhl für Signaltheorie, Ruhr-Universität, West Germany

The paper addresses the multiple source location problem which has been a research topic in radar, sonar and seismology for many years. Frequently certain parameters of sources radiating signals are unknown and have to be estimated by appropriate array processing methods. The accuracy of the estimated parameters is of most interest. Using extensive numerical simulations we shall examine the performance of the nonlinear regression method which was described in earlier work.

In the experiments we used several different signal configurations preferring closely spaced signals in the vicinity of strong sources. Most array processing methods get into trouble resolving such weak signals and give bad estimates for the parameters. We did several thousand experiments with decreasing signal to noise ratios for each signal configuration. Then we had enough results to analyse the statistical properties of the estimates. The distributions of bearing, range and power estimates were deter-

mined for every source and presented by histograms. 2-dim confidence intervals of bearing — power and bearing — range estimates were calculated for different levels of confidence. We also investigated the correlation between parameter estimates of independent sources.

Bispectral Analysis as a means to Identify the Relative Strengths of Two Sources using Data from One Receiver

D J Rothwell

Yard Ltd, Glasgow

The bispectrum is a two dimensional generalisation of the well-known power spectrum which can be used to detect the existence of phase relationships between harmonics. This paper discusses the computation and interpretation of bispectral estimates and proposes the use of a new estimator for the bicoherence, which is a normalised form of the bispectrum. The bicoherence, like the bispectrum, depends on the spectral magnitude of a signal at two frequencies and that of their sum, and it is shown to depend on how the relative phases of these frequencies change between sampling records. When two sources contribute to a noise field, the relative phases of the two fundamental frequencies vary in time and affect the relative phases of the two harmonic trains. It is demonstrated that these phase variations can be detected by the bicoherence using just one receiver and that the computed values of the bicoherence are directly related to the relative strengths of the two sources.

The Application of Eigenvector Decomposition in the Near Field

J W R Griffiths and B Sabbar

Department of Electronic and Electrical Engineering, Loughborough University of Technology

There has been considerable interest recently in the use of singular value decomposition in the processing of the signals from arrays in order to get improved resolution. Two particular techniques have received much attention, namely the MUSIC algorithm developed by Schmidt and the technique proposed by Kumaresan and Tufts. These methods have been applied to the separation of signals in the far field. When arrays become very large it is quite possible for the sources to be in the near field of the array and this paper discusses the application of these techniques to this situation. It is shown that by the use of a fairly simple process the same type of performance can be obtained in the near field as in the far field.

A Systolic Array Adaptive Antenna Processor

P J Hargrave and C R Ward

STL, Harlow

Adaptive beamforming provides a powerful means of enhancing the performance of a broad range of radar and communication systems in hostile electromagnetic environments. The technique operates by com-

binning the signals from an array of antenna elements in an adaptive weighting network, the coefficients of which are automatically adjusted to null jamming waveforms and optimise the reception of a desired signal.

The use of efficient numerical techniques to compute the weighting coefficients are desirable for many reasons. Improved antenna platform dynamics, sophisticated jamming threats and agile waveform structures are producing a requirement for adaptive systems having rapid convergence, high cancellation performance and operational flexibility. These efficient methods are exemplified by Sample Matrix Inversion in which the adaptive weight solution is computed directly from an estimate of the signal and noise covariance matrix. In practice, this technique becomes numerically unstable with ill-conditioned data, is particularly sensitive to the effects of limited arithmetic precision and is difficult to implement in real time. However, by analysing the adaptive antenna as a least squares problem, it is possible to organise the control processor around a recursive minimisation procedure operating in the data domain with no need to compute the covariance matrix estimate explicitly. Consequently, stability and numerical precision requirements are significantly relaxed.

The least squares algorithm for adaptive beamforming considered in the paper performs an orthogonal triangularisation of the data matrix using a sequence of Givens' rotations. The weight solution can be obtained either by solving the associated triangular system using back substitution or the required 'least squares' residual corresponding to the beamformed output of the array can be generated directly.

Kung and Gentleman have shown how the Givens' rotation algorithm may be implemented in an efficient pipelined architecture using a triangular systolic array. The proposed modified version of this array allows the residual to be extracted without solving the triangular linear system and in addition offers a number of significant advantages in terms of stability and circuit complexity. The recursive least squares algorithm and the distributed processing architecture also have a number of interesting features which permit different modes of operation and thus enable the system to be used over a broad range of applications.

A Parallelisable Scheme for Wide Band Beam-Forming

G Avanzi and G Musso
Ufficio RTS, Elettronica San Giorgio Eltag SPA, Italy

The Paper describes a parallel signal processing scheme for computing classically resolved acoustical beams from wide band signals, based on the computation of a Radon-like transform of the measured field. This technique can be considered as a reformation of the well-known delay and sum method in the field of DSP.

An important problem that one meets in designing a digital beam-former lies in the fact that the samples needed for summing do not correspond to the measured ones in all cases. This fact implies that a certain amount of interpolation is required.

Due to this fact the structure of the beam-former has to be split into three stages:

- 1) Analog to digital conversion of the signal taken from the transducers

- 2) Interpolation and delay
- 3) Coherent summing

The second stage works at a higher bit-rate than the first and the third ones. It is shown that a particular organisation of the operations performed by the second stage allows the parallelising of computations in such a way that each parallel channel works at the same bit-rate of the incoming data. Moreover, this processing scheme makes it unnecessary to compute a certain fraction of the interpolated samples that in a sequential scheme would have been computed even though they are never used. A general formulation of the method is outlined and a particular solution is discussed in detail.

On the Problem of Maximum Array Directivity

D E Weston
Admiralty Research Establishment, Portland, Dorset

A set of n acoustic sensors can have an ideal directivity of at least n^2 when arranged as a linear equi-spaced array shooting end-fire, with appropriate weightings and delays. The discussion covers the early studies by Uzkov, and the recent ones by the author on the Jacobi polynomial directionality patterns. The practicability of Jacobi arrays is illustrated, the status of the subject is summarised and there are two major pieces of unfinished business outstanding: a proof that the directivity of n sensors cannot exceed n^2 and, despite a good general understanding, the linked question of a simple and fundamental principle which predicts a maximum directivity law of exactly n^2 . Unfortunately there is no directly equivalent effect in the parallel field of spectral estimation.

Practical Bound for the Angular Resolving Power

J Munier and J L Lacoume
Centre d'Etude des Phénomènes Aléatoires et Géophysiques, CNRS, France

Concerns: Direction finding of remote uncorrelated point-sources by means of linear arrays of equispaced sensors.

The paper deals with the problem of resolving two sources in the presence of extra sources and background noise. Spatial prefiltering is a prerequisite so that the signals received from the two sources under examination are predominant. Moreover, the cross-spectral matrix is assumed to have been estimated without noticeable errors.

Comments:

- 1) The cross-spectral matrix eigenvalues spectrum is known to be a good tool to build detection tests for determining the number of predominant sources (eg Akaike, Rissanen). Hence a straight-forward test (2 sources versus 1 source) is proposed, using the ratio of the second eigenvalue to the next. From this one, a definition can be derived for the resolving power.
- 2) The detection threshold mainly depends on the variability of the eigenvalues. Therefore, statistical data about these latter are of great utility.
- 3) In the stationary case, the above-mentioned resolving power can be linked to the unbiased efficient estimator of the angular spacing between sources (Cramer-Rao bound).

Illustration via numerical simulations will be given.

Detection of a Plane Wave in Spatially Correlated Noise

J E Hudson
Department of Electronic and Electrical Engineering, Loughborough University of Technology

High resolution techniques often use an uncorrelated noise assumption which is not realistic for passive sonar since it is frequently reported that medium noise is non isotropic in bearing and elevation. If the medium noise correlation matrix is known it may be prewhitened but if there are plane waves present the medium noise correlation cannot be measured in isolation. In this paper an autoregressive model is used to represent the medium noise and its unknown parameters and those of a plane wave are found by both maximum likelihood and autoregressive methods and the results are compared.

The Application of Array Signal Processing to the Location of Acoustic Sources in Fast Reactors — Preliminary Experimental Results

D Firth and C Waites
Risley Nuclear Laboratories, Warrington

In the Risley Nuclear Laboratories of the United Kingdom Atomic Energy Authority acoustic surveillance techniques are being studied for application to the liquid metal cooled fast breeder reactor. An investigation is in progress to monitor the acoustic output of the reactor to obtain early warning of incipient faults such as the onset of boiling of the sodium in an overheated fuel channel. An approximate half scale model of the core of the Prototype Fast Reactor is being used to investigate array techniques. The model is monitored by an array of twelve hydrophones whose outputs are recorded in digital form by a computer based data recording and analysis system, which also offers facilities for the graphical presentation of results. The operating range is restricted to between 1 and 10 kHz by tank resonances at the lower frequency and array dimensions at the upper frequency.

Clear indications of source position were obtained for short pulses in the frequency range 1.5 kHz to 10 kHz. The predicted effect of spatial aliasing was observed when the frequency of the acoustic source was such that the wavelength was less than the spacing between the transducers. Acoustic sources of continuous white noise were located to within the diameter of the modelled fuel channel. The introduction of external acoustic interference and its effect on the ability to locate the acoustic source was investigated.

Errors of Time-Delay Beamforming with Interpolated Signals

G Bödecker, D Rathjen and M Siegel
Krupp Atlas Elektronik, Bremen, West Germany

Beamforming on a linear antenna is possible both with analog signals and with digital signals. In the case of analog signal processing, the sensor signals must be processed continuously in time. However, the data rate increases so steeply with increasing number of sensors that, in practice, digital signal processing is generally preferred. The time quantisation by the sampling frequency f_{samp} only permits the formation of a finite number of natural direction-channels, and furthermore, these channels bear a fixed relation to

Array Signal Processing

the platform. In principle, any desired directions and any desired number of direction-channels can only be obtained by means of analogue signal processing, which can be regarded as the limiting case of digital processing with $f_{\text{sample}} \rightarrow \infty$.

A compromise which allows a free choice of direction-channels and which permits digital processing with a low data rate is provided by time-interpolation of digital signals. The Shannon Theorem must be applied as a necessary and sufficient boundary condition. The lowest data rate is thus achieved.

The effect of the time-interpolation of signals manifests itself in a deformation of the beam patterns, ie in a lower directivity-gain, in deformation of the side lobes and in the occurrence of pseudo grating lobes (PGLs). From the point of view of side lobe suppression, the PGLs can be regarded as the greatest undesirable effect. Analysis of the problem shows that the PGLs for any given antenna parameters can be mathematically described simply by the ratio of the sampling frequency to the signal frequency $f_{\text{sample}}/f_{\text{sig}}$. By suitable selection of $f_{\text{sample}}/f_{\text{sig}}$ it is thus possible to regulate the deformation, and to minimise it for a given set of antenna parameters.

Adaptive Array Techniques applied to an Acoustic Line Array in Shallow Water

D Nunn

Department of Electronics, University of Southampton

We consider the problem of the optimal processing of data from a horizontal line array of acoustic sensors in shallow water. The water is assumed to be of constant depth, acoustically homogeneous, and bounded by surface of known acoustic reflectivities.

Processing is assumed to take place in octave bands. Using a time domain scheme an optimal processor is constructed, designed to accept a wanted broadband signal at a particular range/depth/bearing, and to reject all other signals. In principle it is shown that large gains may be achieved, but performance degrades as one's knowledge of the bottom and surface reflectivities becomes less accurate.

The robustness of the system is investigated and ways of increasing this are suggested.

Problems to be encountered in any practical implementation are discussed.

Suboptimal Frequency Domain Adaptive Array Processing in a Broadband Environment

D Nunn

Department of Electronics, University of Southampton

We consider the problem of the optimal processing of data from a sensor array, where the wanted signals are assumed to be in the far field, and where multipath effects are insignificant. The optimisation problem is assumed to be broadband, covering several octaves.

Classical frequency domain adaptive beamforming would result in a very large computational load, and produce a solution rapidly degraded by time variations in the noise field. In this paper we develop a new robust frequency domain algorithm which substantially reduces the computational load and also gives less sensitivity to time variations. The essence of the method is to FFT the in-

coming data and divide the spectrum into octave blocks. Within each block the complex weight vector $\underline{w}_k$ for each FFT cell k is made a quadratic function of cell no k . The optimal 'master' weight vector is that which minimises the output power for the whole band, subject to appropriate look direction constraints.

The algorithm is tested in a numerical simulation on the Cray 1. There is excellent nulling out of broadband interfering signals and discrete spectral lines. The algorithm has attractive features in that adaptive effort may be distributed at will throughout the spectrum.

Transducer Tolerance Effects on an Adaptive Beamformer

P J Mumford and A D Lawton

Plessey Marine, Templecombe, Somerset

The effects on Sonar Array performance of electrical and positional tolerances in the transducers have been treated frequently in the literature. It is well known that the lowest 'Perturbation Gain' is exhibited by the conventional beamformer and that high-resolution methods such as 'Maximum Likelihood' (ML) can be very sensitive to errors. In an adaptive beamformer the effects are less serious than some of these suggest since the mismatch between the modelled and actual hydrophone data is minimised. This fact leads to a simple analysis of tolerance effects on the ML beamformer in terms of the ensemble statistics of direction functions when tolerances are statistically specified.

By means of this analysis, and also by simulation, the feasibility of performing narrowband ML beamforming on the outputs of an array is examined, using typical tolerance values. The most noticeable effect of the tolerances is the limiting of array output power, when steered towards strong sources, to a value depending only on the tolerance values. Away from strong peaks, the direction function is only slightly affected by tolerances of the size considered.

Computer Simulation of Signal Processing Algorithms which apply a Point Model to Ill-conditioned Problems

Ira J Clarke and L Mather

Royal Signals and Radar Establishment, Malvern

Ill-conditioned problems commonly arise in many areas of signal processing due to restrictions on the physical and temporal apertures of practical sensors and also on the bandwidth and number of devices available. Within the accuracy set by knowledge of the sensor response characteristics and also by the noise floor, there are generally many valid solutions which 'fit' a given batch of the received data, just one of which is usually required. Since the data itself does not indicate uniquely the correct model of input scenario, additional criteria must be applied. Various algorithms available to the system designer apply different constraints and assumptions (such as maximum likelihood or maximum entropy) but the underlying basis for choosing a particular solution is not always obvious.

However, algorithms typified by MUSIC (Schmidt) for example, explicitly utilise a point target model, applied by steering nulls

onto certain waveforms in the data. We explore this concept in some detail and relate it to existing monopulse type processing. If the point assumption is valid in the prevailing circumstances, then the model of the input scenario chosen is clearly likely to be nearer the 'truth' than one which does not choose a point description. For this reason this type of algorithm can appear to generate results which defy the generally accepted limits of resolution. It is concluded that the performance does not contradict information theory and that this algorithm is particularly appropriate to resolving point sources on the basis of a combination of several discriminants.

The problem for the system designer is to compare the relative merits of different algorithms not only on performance but also on computational cost and on relative sensitivity to errors in co-lateral knowledge or implied basic assumptions. For this reason a computer simulation comparing directly a number of different algorithms has been set up and initial conclusions are discussed.

Sequential Processing of Multiple Data Domains using SVD

J L Mather and Ira J Clarke

Royal Signals and Radar Establishment, Malvern

A large number of modern signal processing techniques employ the singular value decomposition and subsequent rank reduction of a data matrix in order to deduce the parameters of signals of interest without excessive degradation by noise. Often applied to the case of data received at a limited number of spatially distributed sampling points, these methods require that the sources of signal are decorrelated. Such decorrelation is usually assumed to have taken place in the time domain, and is detected by the acquisition of a number of consecutive data "snapshots". Thus we see that the ability of algorithms such as MUSIC to discriminate sources which appear highly correlated in the spatial aperture (the sources are within the Rayleigh beamwidth of the receiving antenna) derives from the decorrelation occurring across the time domain aperture. Clearly we can conceive alternative types of measurement which might allow us to detect decorrelation in yet other domains, with consequent gains in our ability to discriminate sources. However, as the number of domains of data to be processed increases, so does the time taken to solve the problem exhaustively. We have therefore made use of a sequential processing strategy which uses the results of target discrimination in one domain as support for a less exhaustive search in the remaining domains. Computer simulation studies utilising this approach have suggested that, in many easily constructed examples, the accuracy with which targets may be spatially located, for example, may be improved by prior discrimination of the sources in a second domain. We conclude that, as often implemented, algorithms such as MUSIC are not extracting available information from the data in the most effective manner. As a final consideration, we suggest that many workers often ignore a useful and significant part of the solution provided by the algorithm, which may be extracted independently of any other processing strategy to enable improved discrimination in a given domain.

Optimum Array Processing Family**P Y Arques and B Lucas****Direction des Constructions et Armes Navales, Toulon, France**

The study is placed in the frame of passive array processing, using a linear equispaced-sensor antenna, performing a frequency-direction analysis.

Such an analysis corresponds to various structures known as 'classical beamforming' or 'maximum-likelihood (or optimum) method'. The improvement of the latter results from an optimisation procedure, applied to the spatial part of the processing, with a criterion of Capon's type. This idea can be generalised by extending the optimisation procedure to the temporal part of the structure. Besides, such a processing can have to deal with jammers and to cancel them. Thus various structures can be defined.

We present and study — in a static point of view — a family of optimum array processings. It is shown that the various types of processing can be represented by structures generated with a unique optimisation model and different criteria, constraints or peculiar input processes. Also, the qualifying and the comparison of the structures obtained are made possible.

Estimation of Spatial Correlations of Ambient Noise and Applications to Spatial Signal Processing**J P le Cadre****GERDSM Le Brus, France**

This paper is devoted to the estimation of the parameters defining spatial correlation of noise received by an array of sensors. One considers that noise is the part of the signal received by the array which is non coherent (ie the sum of the ambient sea noise, flow in-

duced noise, electronic noise etc).

For the use of parametric methods like Pisarenko's method the structure of cross-spectral density of noise is assumed, and it is a basic a priori knowledge. Some models of that matrix have been developed (Cron and Sherman, Arase, and Liggett) based on physical assumptions. However, there are numerous models that lead to the following question: what is best for a given situation?

On the other hand our methods need no assumption concerning the model, without the fact that the number of parameters defining the spatial correlations of noise is 'little' relative to the number of sensors. (Typically 5 parameters for an array of 30 sensors). However, this limitation is fairly acceptable in practice.

A first method is based on maximisation of a criterion called 'Maximum of relative entropy'. This criterion uses fundamentally the redundancy of information about noise received by the array. A method for iterative maximisation of that criterion is derived. The second method uses a criterion of whiteness associated to a parametric (AR or AR MA) modelisation of noise.

These two methods are studied on numerous simulations; they perform very well even for strong signal to noise ratios. Then results obtained for signals recorded at sea are presented, and the use of spatial signal processing is considered.

Array Signal Processing Application in Sonic Well Logging**S L Marple Jr and T K Booer****Schlumberger Well Services, Houston, Texas, USA****T W Parks****Department of Electrical Engineering, Rice University, Houston, Texas, USA**

In sonic well logging, an elongated tool in a well borehole periodically with depth emits a burst of sonic energy. After transmission and dispersion through the downhole rock formation, a linear array of eight sonic transducers located 10 feet away on the same tool records the time-delayed waveform response. Due to the physics of acoustic wave propagation in the earth, multiple wavelets travelling at various sonic velocities and various time delays may be encountered. The object of digital signal processing in sonic well logging is to separate the various waveform components and determine their associated wave velocities. The short spatial aperture of the tool receiver array relative to the sonic wavelength yields, at times, inadequate spatial resolution to distinguish arrivals with only slightly different velocities.

Adaptations of several high resolution one-dimensional temporal spectrum analysis methods have been adapted for application to the two-dimensional space-time data of the eight sensor sonic well logging problem. These include the maximum likelihood method (MLM), the autoregressive (maximum entropy) method, linear-prediction-based methods, and Prony's method. The proposed conference presentation will illustrate (1) the adjustment in theory to adapt to this spatial-temporal problem, and (2) the performance comparisons and tradeoffs among the various high-resolution methods and conventional beamforming (currently the actual method in use in the field). Issues of computational complexity tradeoffs among the various methods are also to be presented, because this is an important subject for real-time well logging applications. Schlumberger currently uses a small array processor in its well-logging trucks that ultimately determine the complexity of algorithms that can be implemented.

NON-INSTITUTE MEETINGS

1985

28 — 30 November. *WESTPAC II*. Hong Kong. Details in April 85 Acoustics Bulletin.

2 — 5 December. *POLMET '85*. Hong Kong. Contact: POLMET '85 Secretariat, c/o International Conference Consultants, 1st Floor, 57 Wyndham Street, Central, Hong Kong.

1986

8 — 11 April. *International Conference on Acoustics, Speech and Signal Processing*. Tokyo. Contact: Prof Hiroya Fujisaki, Dept of Electronic Engineering, Faculty of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113.

May. *3rd International Spring School on Acoustooptics and Applications*. Wiezyca, near Gdansk. Contact: Prof A Sliwinski, Uniwersytet Gdanskij, Instytut fizyki Dosw, ul. Wita Stwosza, 57, 80-952 Gdansk, Poland.

6 — 9 June. *XXX ETAN Conference*. (All branches of acoustics). Budva, Yugoslavia. Contact: Prof P Pravica, Electrotechnical Faculty, Bulevar Revoluci je 73, YOU 11000 Belgrade.

21 — 23 July. *INTERNOISE 86*. MIT, USA. See p 8.

24 — 31 July. *12th ICA*. Toronto. See p 8.

Appreciation

Willi Furrer

Members of our Institute, the older ones in particular, will learn with regret of the passing, in March of this year, of Willi Furrer in his eightieth year. From 1949 to 1976 Furrer was a professor at the Federal Technical University at Zurich where his main interests were in architecture and technical acoustics. The Swiss Society of Acoustics was formed in 1971 largely as a result of Furrer's initiative and he was its President for a number of years. He was subsequently elected an Honorary President. Internationally Willi Furrer will be remembered for his work on standards and he gave strong support to the creation of FASE of which he was elected an honorary member of council. □

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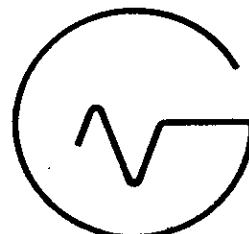
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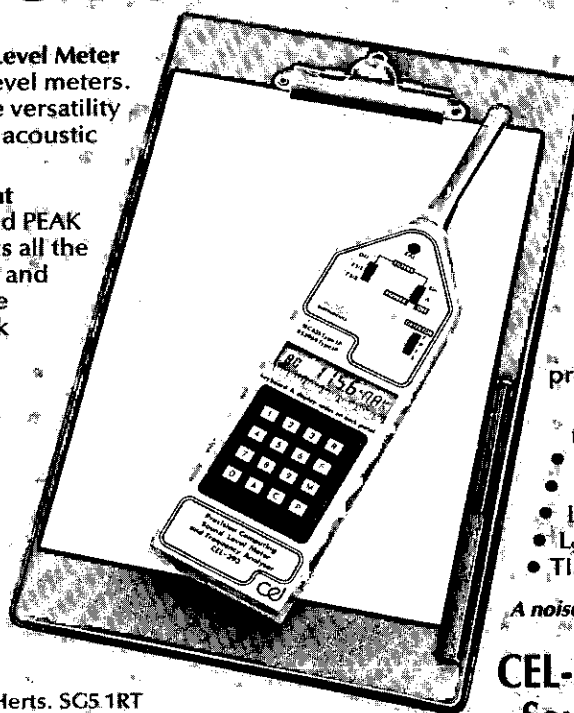
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ACOUSTICS 86

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

The 1986 Spring Conference is to be held at the University of Salford, coinciding with the official opening of the new laboratories in the Department of Applied Acoustics. As well as technical sessions of invited and contributed papers, the 1986 Rayleigh Medal Presentation and Lecture, the A B Wood Medal and Prize Presentation and Lecture and the RWB Stephens Lecture will take place. The Institute's AGM will be held on Wednesday 9 April and will be followed by the Annual Dinner. There will be a full social programme.

Technical Visits are being arranged for the afternoon of Wednesday 9 April and there will be a technical exhibition.

Offers of papers of twenty minutes duration are invited; 200-word abstracts should be submitted to the appropriate Session Organiser no later than 30 November.

Chairman of Programme Committee:

Professor P Lord FIOA
University of Salford

Sessions Co-ordinator:

Dr R J Orłowski MIOA
University of Salford

Conference Organiser:

Mr G Kerry FIOA
Dept of Applied Acoustics
University of Salford
SALFORD
M5 4WT
Tel: 061-736 5843 Ext 447/7145

Conference Secretary:

Mrs Cathy Mackenzie
Institute of Acoustics
25 Chambers Street
EDINBURGH
EH1 1HU
Tel: 031-225 2143

Session Organisers:

Industrial Noise

Mr S G Bennett MIOA
Mining Research and Development Establishment
Ashby Road
BURTON ON TRENT
DE15 0QD
Tel: 0283 216161

Environmental Noise

Mr A Corkill MIOA
ICI Acoustics
PO Box 6
Bessemer Road
Welwyn Garden City
AL7 1HD
Tel: 07073 23400

**Building Acoustics and
Open Session**

Dr R J Orłowski MIOA
University of Salford

**High Resolution Sonar, Under-
water Acoustic Imaging and
Latest Developments in Under-
water Acoustics**

Dr L W Lipscombe MIOA
DBE Technology Group
Eastern Road
ALDERSHOT
GU12 4TD
Tel: 0252 27282

**Acoustic Imaging and Inversion
Techniques**

Dr L Bond MInstP
Dept of Electrical and Electronic Engineering
University College London
Torrington Place
LONDON
WC1E 7JE
Tel: 01-387 7050 Ext 784

Hearing Damage from Leisure Noise

A review of the literature on the controversial topic of possible auditory hazards from non-occupational noise exposure (sociacusis) has been conducted by the Medical Research Council's Institute of Hearing Research. It was commissioned by the Health and Safety Executive and a report was published by HMSO in August 1985.

Despite the unsatisfactory quality or insufficient scope of most of the literature it is possible to reach some general conclusions: the sound levels of many leisure activities do contain significant risk for worst cases receiving prolonged exposures, or unprotected exposures to very high level noise (from firearms). However, given the present use of 90 dB(A) in many countries' occupational hearing conservation programmes, noisy leisure activities are unlikely to be an important factor in noise-induced hearing loss in the population. Further research should concentrate on the less

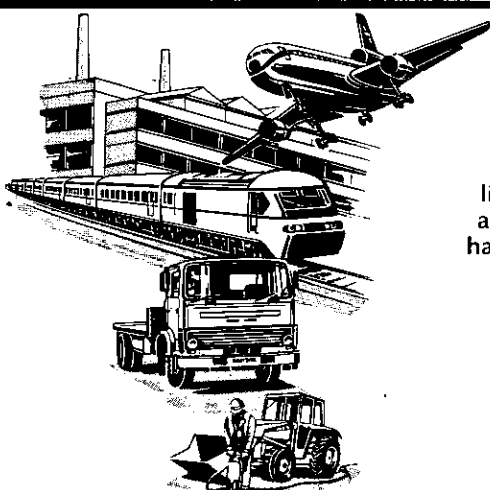
well documented parameters of leisure noise exposure, ie on the numbers exposed and the patterns and durations of their exposures. To this end improvements are necessary in both sampling and interviewing procedures. The outstanding need is for a large random-sample whole-population survey of exposure rates and patterns for leisure noise in general and amplified music in particular. Many factors need to be carefully controlled in research on potential leisure noise effects, and the review discusses the most important of these.

The review consists of a critical appraisal of the objectives, methodologies, findings and conclusions reported in the literature on sociacusis up to April 1984 and a bibliography, amounting to some 582 titles. The appraisal is divided into eight sections. An overview of the available literature is followed by a section dealing with the

noise levels of a variety of leisure activities, including those involving amplified music. Other sections evaluate the reported effects of leisure activities on hearing, particularly in young people, and discuss the relative contributions of non-occupational and occupational noise exposure to hearing loss in the population. The final section presents the conclusions and some recommendations for future research. Appendices include discussion on artefacts in mass screening audiometry and a report on an experiment on the sound levels voluntarily chosen by users of personal cassette players, including an appropriate calibration procedure.

Copies of the 200 page report, *Damage to Hearing Arising from Leisure Noise: A Review of the Literature*, by MRC Institute of Hearing Research, published 1985 by HMSO, are available from Government Bookshops, price £9.00. Orders from abroad should be directed to HMSO Bookshop, 49 High Holborn, London WC1V 6HB. □

A C Davis



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.

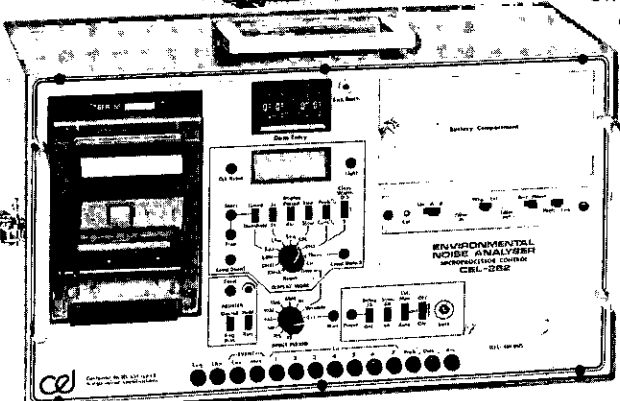
Establishment of such levels and investigation of possible infringements requires long term noise monitoring using portable versatile measurement equipment. It is for this type of measurement that the CEL-262 Environmental Noise Analyser is intended and it will find use with those organisations with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

Battery powered and easily portable, the CEL-262 will operate for up to 7 days on internal batteries.

CEL-262 Environmental Noise Analyser

For comprehensive information or free demonstration contact:
CEL Instruments Limited
35 Bury Mead Road, Hitchin, Herts. SG5 1RT
Tel: Hitchin (0462) 52731 Telex: 826615 CEL G



New Elections

At its meeting on 30 May Council approved the following elections.

Fellow

R G White J Wilson

Member

J L K Bannell K S Jraiw
V G Cole D A Logan
M Doran C Waites
J A Gillard D J Whitman
D St J James

Associate

A S Anderson R A Jones
D Appleby M G Kelso
S Avann H Latham
L G Backwell K J Lawson
M Bishop I P Lewis
J G Boulton G McCurdy
W Buckley K L Malbon
M W Bullock K Malcolm
M A Carson D Martin
G Chambers D Maynard
T C Charlesworth C P Moore
S M M Cheung R I Osborough
R I Clark R Pearce
S J Cooper P J Scott
N A Crawford R J Sergeant
L Dargan S M Sheridan
K J Doherty J N Shields
N Ellison G A Shippey
J M Fleming L Smith
R H Gaston A W M Somerville
A M Gorasia D Thomas
J E Grant H A Thomas
G S Greenhill R Thorne
H H R Gwatkin K K Wong
I P Hale P Woods
A R Hearl C J Yates
S D Hedley A L Yeung
D Hitchcock M Zakharia
R W Ip

Student

J J Capper D I Evans

Railway Noise Seminar

A one-day seminar on **Railway Noise — Prediction, Environmental Effects and Control** is to be held on Tuesday 18 March 1986 by the Institution of Mechanical Engineers at their Headquarters. The seminar aims to present the most recent information on the causes of railway noise and its effect on people, both within vehicles and at the wayside, and to bring engineers up to date on the effectiveness of the various means available to control the noise. Further details may be obtained from: The Divisional Assistant, Railway Division, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW1H 9JJ, Telephone: 01-222 7899. □

Diploma in Acoustics and Noise Control 1985

Titles of Project Reports

Bristol Polytechnic

Noise in food areas
Urban road noise
Helicopter noise at Weston Airfield
Village hall acoustics-comparison of methods of measurement with theoretical predictions
Proposed refuse transfer station
Occupational noise levels at premises operating plastic granulating machines

Cornwall College

Design of loudspeakers and enclosures
An assessment of the sound insulation to airborne noise afforded by a floor separating two self-contained flats
Motor cycle noise in St Austell
Vibration measurement and analysis for machine health monitoring and associated problems
An investigation in the sound panels and noise complaints within the city area of Rotorua District (New Zealand)
Noise and nuisance

Derbyshire College

An investigation into the impact of clay pigeon shooting
Community centre noise — a case study
Noise from the stonewashing process
Noise survey in production sheds in the concrete industry
Sound insulation between dwellings
Audible intruder noise
Evaluation of employed persons exposure to woodwork noise
The hazards to hearing of rough shooting
Clay pigeon shooting — the noise aspect
Methods of measuring reverberation time in auditoria
Fan noise in the foundry industry
Some aspects of entertainment noise
An exercise to predict road traffic noise

Leeds Polytechnic

Investigation of excessive noise levels generated by 'Bone Crusher'
Sound output reduction of a BSA Airsporter Air Rifle

Liverpool Polytechnic

The use of accepted indices for Road Traffic noise
Reverberation time as a function of absorber distribution
Barrier performance at a motor racing track and the importance of ground effect
The use of straw bales for noise control purposes
Auditory localisation in the vertical plane
Non-standard v standard motor cycle exhausts — a comparative study
The effects of road traffic noise on the residents of a small housing estate
Environmental noise problems at a boilerhouse in a semi-rural setting
The effects of Pop Group and Discotheque Noise on Hearing
The risks of vibration injuries to the hand in the Lancaster City Council's Parks Dept
The improvements that can be achieved in the airborne sound insulation properties of domestic party walls and floors
How the positioning of a loudspeaker affects transmission of sound through a party wall
The tonal variation of Road Traffic Noise from concrete and asphalt surfaces on the M63 Stockport
Reverberation time and speech intelligibility in a class room
The modification in absorption characteristics of a porous absorber when treated with a perforated metal facing
A noise nuisance arising from extract fans at a modern factory
The use of low cost curtain material to reduce the reverberation time in a community hall
Measurement of the sound radiation efficiency of a vibrating wall
The use of a direct intensity measurement system for the evaluation of the B & K reference source
Occupational noise exposure of employees in an agricultural machinery repair workshop

Colchester Institute

An assessment of the impact of a micro computer system on the acoustic environment of an open plan office
An investigation of the noise from a granary and its effects on the immediate surroundings
The control of external factory noise at the planning stage
An investigation into the requirements of a reverberation chamber
Industrial development planning and noise with particular reference to refrigeration noise from a transport depot
An investigation of the noise barriers constructed adjacent to a major trunk road

North East Surrey College of Technology

An investigation into the acoustic properties of a domestic spin drier
An acoustic assessment of the main (vestry) hall within the Chelsea Old Town Hall, King's Road, Chelsea, London SW3
A comparison of two simple prediction methods of Leq from trains in motion
A report on two investigations where the use of acoustic grade double glazing was recommended to control (i) noise breakout from a community centre (ii) intrusive train etc
An investigation into the problem of noise from a fridge freezer
Train noise. Measure or predict?
An investigation into the contribution of a school to the noise levels at a nearby site
Examination of the noise climate in a picture framing factory
Measurement and prediction of road traffic noise
An investigation of noise complaints in the L B of Croydon following the introduction of the Railair Service between Victoria Railway Station London & Gatwick Airport
To investigate the structure borne noise and vibration produced by a domestic ventilation fan
An acoustic assessment of the Council Chamber at Mole Valley District Council Offices
An investigation of a complaint of noise nuisance from a circular saw sharpening business
Some measurements and observations on a loudspeaker enclosure and its drive unit
An acoustic study of a miniature rifle range
Can you hear me? (Speech masking in open plan offices)
A study of traffic noise in an office block
An investigation into the acoustics of a teaching workshop at North East Surrey College of Technology
Magistrates Court, Cantelupe Road, Bexhill. Acoustic investigation
An investigation of two predictive methods of Leq due to railway train movements, in relation to inner urban sites
A quiet summer's Sunday in Suburbia

Tottenham College

Planning and Noise
An assessment of barrier performance in reducing the effects of motorway noise
Noise induced hearing loss
The Luis Palau Mission to London — Queens Park Rangers Football Stadium
The measurement of the acoustic impedance of an ear
An assessment of sound insulation double glazing installed in Greenhill Way, Harrow
Predictions on a bypass: Stanstead Abbots A414
An assessment of the reverberation qualities in a council chamber
'Wouldn't it be nice to get on with the neighbours' — a study on sound insulation between dwellings
Investigation of neighbourhood noise complaint
Noise levels present in central reprographic services and typing rooms
Sound insulation performance of a simple platform floating floor
The effect of the Bell Common tunnel on road traffic noise
Investigation of the noise from an extraction system
Planning and noise
An investigation into residential developments in the close proximity of the railway
An assessment of noise emitted from modern day car wash facilities
Review of Hi-fi quality assessment — Investigation of objective loudspeaker performance
A study of sound insulation properties of domestic roof construction
An assessment of the likely environmental noise impact at the proposed heliport at Milton Keynes
Acoustic problems of a modern exhibition building
An investigation of environmental noise from centralised filtration systems
The construction and performance of acoustic louvers
Building site noise — a case study
Development and use of an apparatus to test the acoustic performance of 'muff type' ear defenders
Noise levels emitted by Noel Penny engine
Powerboats and people

Heriot-Watt University

The effect of traffic noise re L_{90}
Noise associated with underground transportation
SWL of a domestic washing machine

University of Ulster

An investigation of the acoustics of the Great Hall, City Hall, Belfast
Noise from overhead projectors
A comparison of the acoustic properties of a theatre auditorium and a general purpose hall
The silencing of an air conditioning unit in Laboratory 6C45
An assessment of the risk to tractor operators' hearing
An investigation into the noise levels produced by DIY power tools
A survey of railway noise affecting housing in Belfast
Sound insulation of straight cored partition walls — field measurements
Sound insulation and privacy in timber frame housing
An investigation into the design construction and performance of a silencing unit in a ventilation system
Refrigerated container noise attenuation
An assessment of the sound insulation afforded by a triple glazed single window
Noise control in a computer room
Vehicle noise — evaluation of present controls
The acoustic properties of a multi purpose sports hall

Members having a personal interest in finding out more about any of these projects should initially contact the course tutor for the Diploma in the appropriate college. Further contact is at the discretion of the student concerned; it is not normally possible to provide copies of project reports. □

Material for the January issue of Acoustics Bulletin should reach Mrs F A Hill at 25 Elm Drive St Albans, Herts AL4 0EJ, no later than Friday 15 November.

In case you didn't hear....

An increasing number of airport operators are installing permanent noise monitoring systems, enabling them to build up a picture of noise level trends, to check compliance with international noise standards, and to identify aircraft and airlines consistently operating beyond the noise limits. Lucas CEL Instruments Ltd has been asked to supply a seven channel noise monitoring system to the West Midlands County Council, which operates Birmingham International Airport and has recently completed a lengthy investigation programme into local noise problems. The contract has been won by CEL in the face of international competition from both Europe and the United States.

Following their recent appointment as exclusive UK Agent for **vibration isolators** from Vibration Mountings and Controls, Industrial and Marine Acoustics Ltd of Stoke on Trent have announced the availability from stock of the most popular items in the VMC range. Details of the range and availability of particular types of mountings may be obtained from Industrial and Marine Acoustics Ltd, PO Box 8, Cheadle, Stoke on Trent, Staffs ST10 4LH.

The Division of Radiation Science and Acoustics of the National Physical Laboratory has published its first Annual Report for some time. The Report, intended to be the first of a regular series, details work carried out and in progress in a number of fields of acoustics, and is available to those interested from NPL, Teddington, Middlesex TW11 0LW.

The 2nd Edition of the *Handbook of the Society of Environmental Engineers* is now available, price £8. The Handbook provides listings of products and services offered by the Society's Members along with a wealth of information for workers in the environmental engineering and associated fields. It is available from the Society of Environmental Engineers, Owles Hall, Buntingford, Herts SG9 9PL. □

Book Reviews

Technical Writing & Publications Techniques

M Austin

W Heinemann Ltd, London
272pp, A4, ISBN 0-434-90354-X

This practical guide to efficient written communication has been written and illustrated by six experienced practitioners from the Institute of Scientific and Technical Communicators under the editorship of Mike Austin, a former vice-president of the ISTC. In his foreword, Monty Finniston hopes that this handbook will do for technical writers what Sir Ernest Gowers' book *Plain Words* did for communicators on everyday subjects — an ambitious claim indeed.

What relevance has this book for acousticians? Well, the results of an American survey indicate that, on average, engineers spend 24% of their time writing material and 31% of their time working with material written by other people, and doubtless similar findings would follow from a survey of the other disciplines involved in acoustics. The standards achieved at present are far from ideal, so it may be that widespread adoption of the principles advocated in this book could improve our efficiency, at least for 55% of the time. Certainly the coverage is broad, taking us through every facet of technical communication, and an appendix lists sources of information such as relevant British Standards and summarises available training opportunities.

Let me say that, as a long-time 'amateur' in the technical publications field, I found this an interesting book simply because of its breadth. I particularly appreciated the chapter by Denis Tyson on 'planning and commissioning technical translations', not on account of its main thrust but due to its fascinating introduction to the simplified language known as ILSAM. By limiting the variety of words to about 800, using standardised grammatical constructions, and ensuring that each word has a clearly-defined meaning, a very *effective* (as opposed to inspiring) style of communication can be achieved.

The authors have tried to cater for the student preparing for an examination in technical authorship or graphics, the

engineering manager who wants to improve the quality of his support documentation, the technical trainee faced with writing his first technical report, the scientist preparing a paper for publication by a learned society, a junior illustrator seeking information on the practical application and cost-effectiveness of various types of illustration, and the publications manager seeking guidance on quality assurance procedures. Yes, there is something for almost everyone here but in consequence the treatment is everywhere rather thin. In places it is also unclear who is being addressed, oscillating between information for the generalist and naive instructions to the specialist. An example of the latter occurs on page 84: 'Only water colour paints and inks recommended for the airbrush should be used. Inks and paints with coarse pigments and impurities will cause excessive wear and damage the nozzle'.

Certainly if I were asked to recommend reading material for someone wishing to

improve their technical writing, I would *not* recommend John Kirkman's chapter in the present book but rather *Effective Writing* which he jointly authored with Christopher Turk (E & F N Spon, London, 1982).

It is incumbent on those writing on communication to strive for a high standard themselves, but what of the following sentence (p14): 'In English, a pre-modifying noun, normally (not always, but normally) is equivalent in meaning to a post-modifying of-phrase'. And I wonder what my staff would say if I objected to something they had written in the words (p15): 'One reason why noun clusters cause difficulty is that pre-modifying nouns often come between a preposition and its true "complement"'. To be fair, in both cases examples are given.

Again, one might hope such a book would follow its own advice but this is not the case. Thus (p51) it recommends a text width of 165 mm for an A4 page

Telecommunications for the Hard of Hearing

At the end of 1983 the Department of Trade and Industry set up a working group to consider various problems associated with the continued provision of reliable telecommunications for the hard of hearing. Early this year the working group published its first report, which set out three main areas of action to help hearing-impaired people. It proposes a research programme to study the coupling between hearing aids and telephone handsets; a code of practice for the design of handsets capable of inductive coupling to hearing aids; and improvements in the supply of information about equipment for helping hearing-impaired people to use the telephone.

One of the main problems which may affect the hearing-impaired telephone user in the future is that some types of telephone based on micro-chip technology may not be capable of being inductively coupled with hearing aids because they cannot generate the

necessary external magnetic field. In these cases other methods of coupling must be devised. The proposed Code of Practice would identify the range of values of external magnetic field expected from existing telephones, indicate preferred values for new designs, and recommend packaging and labelling of such telephones for the guidance of suppliers and purchasers.

Vigorous action is also needed to make information available since, owing to the new status of British Telecom and the divided responsibility for the provision of subscribers' instruments, there is no clear focus for such information, says the Report.

For the future, the Group is considering the contents of a possible research programme and intends to consider other aids to the hearing-impaired such as assistance in signalling, text transmission and the scope for direct connection of auxiliary apparatus into the public telephone network. □

but throughout this book employs a text width of only 113 mm, thus leaving incredibly large areas of 'white'. The standard of layout also leaves something to be desired; one almost full-page illustration (p88) carries a lonely line and a half of text spilling over from the previous page (presumably the result of undue reliance on the word-processor). One last point, I trust that the six misspellings of 'receive' in the Figure on page 165 were left in as a deliberate mistake!

To summarise, hardly anyone could fail to learn something useful from this book. However, to claim it is the equivalent of *Plain Words* is to claim too much for this rather modest volume. So, not a book that every acoustician should go out and buy but one which you may find interesting and helpful if you are trying to improve the effectiveness of your written communication. □

Michael Delany

Letter from the Vice-President Groups and Branches

As I stated in the previous Bulletin (Vol 10 No 3) the main function of the Vice President, Groups and Branches is to act as liaison between Council and Groups and Branches and I therefore intend to disseminate such useful information that comes my way in the form of these letters in the Bulletin. (Editor please note — this may NOT happen in each and every Bulletin!).

The first piece of information is that Council recently approved some minor amendments to the Groups and Branch Constitution to cover the fact that local accounts must now be audited by the Institute's Auditors and in time for incorporation in the Institute's main accounts. Although this may be a little onerous for the hard-worked Group and Branch treasurers it is an evil necessity because of VAT etc. Full details will be sent to the treasurers in due course and the Institute Treasurer,

Ralph Harrison, will deal with any queries.

Returning to the previous Bulletin I note that the President, in his letter, pointed out that 'what you get out of the Institute depends on what you put in'. This is never truer than at Group and Branch level. By the time this letter is published the Autumn/Winter programme should be well under way and the various committees will be considering next year's programme. Can you help? Fresh ideas are always welcome.

Finally, I noted, and indeed many Council members commented on, the missing reports from several branches in the Annual Report. Such a report is useful not just as an historical record but as an aid to future planning. So please Branch Secretaries, next time! perhaps? □

G Kerry

Vice President — Groups and Branches

BRANCH AND GROUP NEWS

As usual during the summer period — and after all, according to the calendar the past few months were the summer period — Branch and Group activity has been generally in abeyance. The new joint **Physical Acoustics Group** has produced its first Newsletter for its adherents; members of the PAG committee have prepared a busy programme of activities for this autumn and for 1986. The early part of this programme appears in the Meetings List inside the back cover, and full details of the Group and its activities may be obtained from IOA Headquarters in Edinburgh.

Speech Group is arranging a meeting on coarticulation and speech instrumentation at IBM UK Scientific Centre Winchester. The meeting will cover coarticulation with special reference to speech recognition and analysis and speech instrumentation and analysis. The organisers are Bill Hardcastle (Linguistics Department, Reading University) and Geoff Kaye (IBM).

North West Branch

In July the branch enjoyed an enlightening talk and demonstration given by Tom Murphy of Vibro-meter. The company was founded in Fribourg

Switzerland in 1952 and is principally concerned with the design and manufacture of transducers and associated electronic equipment for the measurement of vibration. The main areas of application are in the aviation, power generation and petro-chemical industries.

In the mid 1960s experience in aircraft engine vibration monitoring led to the development of mono-crystal piezoelectric accelerometers with a working temperature of up to 650 deg C. Many modern airlines now monitor engine vibration with such systems and can carry out inflight recording of displacement amplitude and phase angle data to enable ground staff to apply the necessary trim balance adjustments. Experience in developing vibration monitoring systems for hostile environments has found its application in industrial gas turbines and all types of rotating machines.

The same high temperature technology is also directly applicable to the nuclear power industry. Piezoelectric transducers have been developed for monitoring the core and heat exchangers in liquid metal cooled reactors. In recent years acoustic and

vibration monitoring has been carried out on the boilers of advance gas cooled reactors.

The slide presentation continued with a discussion of accelerometer types; Tom emphasised the importance of having a reliable and robust front-end to any monitoring system. Here we had an opportunity to handle two types of accelerometer with integral armoured cable and electronics.

Tom then gave an overview of the developments made in the field of vibration measurement and analysis, from the simple velocity pick up and filter through the piezoelectric accelerometer with tracking filters, to today's sophisticated computer controlled systems.

There followed a demonstration of this latest generation system used to monitor an extensively instrumented shaft. Of particular interest was the system's ability to provide a history of the working life of the shaft in terms of vibration and engineering parameters. Such systems used on expensive industrial turbines and machinery will provide early warning of faults and make maintenance more of a science and less of an art. □

C Waites

New Products

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

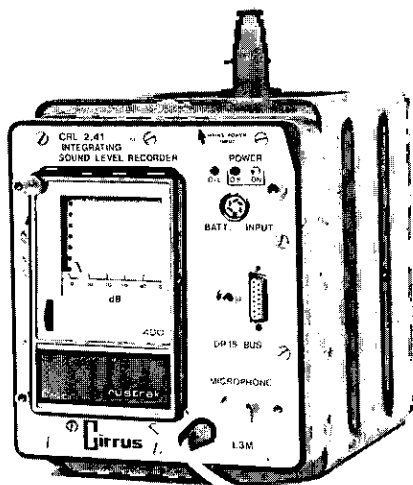
Integrating Sound Level Meter — CRL 2.22

Cirrus Research announce a new family of slim integrating sound level meters — CRL 2.22 series. A new technology analogue meter which is only 12.5 mm thick provides the display for this pocket sized sound level meter which is only 23 x 78 x 294 mm.

The CRL 2.22 measures Leq, SEL and SPL with accuracy to IEC 651 Grade 2 and the IEC 804 specification for Integrating Meters; it has a 30 dB scale and an acquisition range from 30 to 143 dB(A), or 40 to 143 dB(C), with a dynamic span of 53 dB.

With a micro-computer plugged into the 'computer' output the CRL 2.22 becomes a powerful data acquisition unit. Any Leq period from 1 second upwards can be used as a data base. With a BBC model 'B' computer the noise levels can be plotted second by second over a full working day or minute by minute for a full month, with a maximum storage of over 120,000 values on a single disc. The price of the CRL 2.22 is £350.

Integrating Sound Level Recorder — CRL 2.41



The CRL 2.41 Integrating Recorder is a waterproof hard record unit intended for long or short term monitoring where

a permanent record is required for legal purposes. It will measure Leq, SEL or SPL. When set to Leq the unit resets itself after a fixed period and repeats these short Leq measurements independently. Three fixed periods are provided: 10 seconds, 1 minute and 10 minutes. Up to 100,000 separate Leqs can be recorded on a roll of paper. The recorder has a 50 dB scale and scale zero can be set anywhere from 20 to 110 dB.

The CRL 2.41 will also interface to a microcomputer and act as a data acquisition unit.

Further details from Cirrus Research Ltd, 1-2 York Place, Scarborough, North Yorkshire. YO11 2NP. Tel: 0723 371441.

Real-Time Frequency Analyser CEL 8010

The CEL 8010 has been developed to provide a cost effective frequency analyser by using a popular and well-proven personal computer within the design. The analyser consists of parallel precision frequency measuring channels each with 80 dB dynamic span. Performance is to IEC 651 Type 1 and ANSI S1.11 Class III standards. Complete third octave band spectra in the frequency range 20 Hz to 20 kHz can update the fully annotated screen every 10 msec. Additionally the software permits three types of signal averaging to be selected before the resulting spectrum is utilised by the secondary processing software which allows mathematical manipulation of the spectrum data.

With the preferred CBM 8296 Micro-computer, analysed spectra can be stored and recalled from the integral disk drives, or using a compatible Commodore printer full printouts of the screen can be made.

Further information from Lucas CEL Instruments Ltd, 35 Bury Mead Road, Hitchin, Herts SG5 1RT, Tel: 0462 52731.

Coustone Acoustic Cladding

Discovered by ICI, Coustone is a rigid, load bearing material similar to pumice stone in appearance and texture. Moulded into panels from bonded flint particles, with pre-determined cellular air space, Coustone's acoustic absorption properties derive from its scientifically-designed air cavities. In contrast to conventional acoustic surfaces — such as urethane and mineral

fibre — Coustone has major advantages in durability, fire resistance, appearance and easy, wipe-clean surface restoration. Resilience is sufficient for both physical and acoustic integrity to withstand even quite severe knocks. Currently, Coustone is offered in 500 mm x 500 mm x 28 mm panels, weighing 9 Kg, each and fixed by hidden steel brackets. Available in a wide colour range between deep primaries and light pastel shades. Coustone's colour is sealed by organic pigmentation, while various special finishes and effects can be incorporated.

Further information is available from Sound Absorption Ltd, Healey Hall Mill, Healey Bottoms, Rochdale, Lancs OL12 6BQ; Tel: 0706 40755.

Hakuto FFT Analysers

A new range of FFT analysers are available from Hakuto with a 90 dB dynamic range and a 15-bit digital conversion giving a high resolution. Large on-board RAM stores are available from 0.25 M to 2 M bits, and either one or two floppy disc versions may be used giving long-term storage. This instrument has a very high sensitivity allowing signals as low as 0.56 micro volts rms to be analysed. The comprehensive range of functions ensures that the most complex signal analysis techniques may be carried out with 3D, Nyquist and orbit plots as standard.

Further details from Hakuto International (UK) Ltd, 33-35 Eleanor Cross Road, Waltham Cross, Herts EN7 8LF; Tel: 0992 769090. □

XVIIIth International Congress of Audiology

The XVIIIth ICA 1986 is to be held in Prague, from 24 to 28 August 1986, under the aegis of the Czechoslovak Oto-Laryngological Society. The main topics will be: Education of Professional Personnel in Audiology; Neurochemistry in Hearing; Speech Audiometry — phonological aspects and theory of information; and Hearing in Old Age. Requests for further information should be addressed to: XVIIIth International Congress of Audiology, Czechoslovak Medical Society J E Purkyne, Vítěného února 31, 120 26 Prague 2, Czechoslovakia. □

UWW-Asw

We are now recruiting for our clients, systems engineers, to work on Underwater Weapons and Anti-Submarine Weapon Systems.

The work entails assessment of effectiveness, mathematical modelling, simulation and feasibility studies and, with a choice of locations — London, Buckinghamshire, Scotland and the West Country, this is an ideal opportunity to join a progressive and truly International Organisation.

Salaries are negotiable to £15,000 but the upper limit should not deter candidates currently earning near or in excess of this.

If you have a degree and related experience please contact John Spencer or forward a detailed C.V., please quote reference AC/15.



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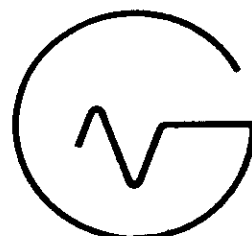
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Noise Engineer for the next generation of high-performance diesel engines

The world's largest independent manufacturers of high-performance diesel engines and the recognised industry pacesetters in this field, Perkins Engines are committing millions of pounds to the improvement of today's diesel engines and the creation of the next generation for road vehicles, agriculture, industry, military vehicles and marine applications.

With increasing international demand for our expertise - and increasingly stringent legislation on noise and emissions throughout the world - we now wish to appoint an additional specialist to take up an influential role in our Peterborough-based team responsible for noise and vibration analysis, at both base engine and installation level.

For the ambitious noise expert with at least 3 years' post-graduate research experience in this specialist field, gained either in industry or in an academic environment, this demanding brief promises exposure to a broad spectrum of projects in a company with excellent research facilities including three superbly equipped anechoic chambers. Some familiarity with finite element techniques for vibration prediction and structural optimisation would be advantageous.

The Perkins package is as attractive as the technological challenge we offer. It includes a highly competitive salary, 5 weeks' holiday and generous expenses for your relocation to the Peterborough area, including temporary accommodation arrangements if necessary. This attractive cathedral city has one of the best shopping centres in the UK, excellent communications (London 50 minutes), low-cost housing and beautiful surrounding countryside.

Please forward your full CV including current salary, to Clive Mosley, Personnel & Employee Relations Division, Perkins Engines, Eastfield, Peterborough PE15NA, quoting reference AB3, or if you want to discuss this appointment in more detail, phone him on Peterborough (0733) 67474, Ext. 3677.

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**Up to £20K
Home Counties**

Superb progressive career opportunities for graduates or equivalent in electronics, mathematics, physics, computer science or engineering who will have gained experience in the Defence, Aerospace or Electronics industry. Our client needs to attract the very best professionals to enable them to sustain their phenomenal growth record. They are in the process of moving to new highly prestigious purpose built premises and can offer you the chance to join a number of small teams working on a wide range of diverse state of the art systems projects. There are a number of varied interesting and challenging application areas which will enable you to advance your career.

Some Examples are...

Software

Generation and implementation for use in Real Time engineering applications involving both high-level languages and assemblers. Opportunities at all levels for those with Coral 66, Mascot, Pascal or Basic experience.

Simulation and Modelling

A knowledge of the design or use of simulations or mathematical models of sonar, communications or signal processing systems and their environment using analogue, digital or hybrid computers. Experience of real-time simulation would be desirable.

RF Systems

Design of RF communications systems for military applications particularly using ECCM, ESM or ASW techniques. Posts on offer include that of Team Leader.

Circuit Design

Experience of **Analogue or Digital** techniques. Applications range from VLF through to UHF using the latest signal processing and RF techniques and high speed microprocessor based TTL design to interface with 1553 Bus.

Our client is also keen to see specialists in **Ships Systems, Acoustics, Transducer Design and Oceanography.**

These important **new** positions offer excellent rewards and conditions with first class future prospects in a thriving and leading company in the High Technology and Defence industry. They represent a chance to be involved in and influence the early stages of the development of some of the most advanced systems in the world.

To find out more and to obtain an early interview please telephone **John Prodger** on Hemel Hempstead (0442) 47311 during office hours or one of our Duty Consultants on 0442 212650 evenings or weekends. Alternatively write to him at the address below.



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Institute of Acoustics

Meetings

1985

1-3 November	M	Autumn Conference: Reproduced Sound	Windermere
14 November	PAG	Remote Generation and Reception of Ultrasound	London
21 November	SB	Noise and Vibration Control in Building Services — The Real World	Southampton
4 December	SB	AGM and Buffet	Southampton
16 - 17 December	UAG	Array Signal Processing	Loughborough
16 - 17 December	SG	Coarticulation and Speech Instrumentation	Winchester
18 - 20 December	M	Acoustic Emission and Photo-acoustic Spectroscopy and Applications	London

1986

15 January	SB	Code of Practice on Sound Levels in Discotheques	Lyndhurst
19 February	SB	Current and Future Legislation for the Protection of Hearing at Work	Southampton
27 February	PAG	Ultrasonic Scattering and Attenuation in Solids	London
19 March	SB	Gearbox Condition Monitoring	Southampton
24 - 26 March	M	Speech Input/Output; Techniques and Applications. Joint with IEE, RSM, BSA, RSDR	London
25 March	M	Recent Advances in Active Control of Noise and Vibration	Southampton
April	SB(P)	Visit to Industrial Acoustics Company test facilities	Brooklands, Surrey
7 - 8 April	M	Ultrasound in Medicine (joint with The Institute of Physical Sciences in Medicine)	Bath
7 - 10 April	M	Spring Conference: Acoustics 86. Sessions on: Industrial Noise; Environmental Noise; High Resolution Sonar and Underwater Acoustic imaging; Acoustic Imaging and Inversion Techniques; Sound Insulation and Room Acoustics; Open Session	Salford
21 May	SB	Visit to Gatwick Airport	Gatwick
June	M	Noise and Vibration in the Aircraft and Spacecraft Industry (organised by ING)	
17 July	PAG	Acoustics and Ultrasonics as Probes of Emulsions and Dispersions	
September	M	Legal Aspects of Entertainment Noise	Liverpool

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

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