Institute of Acoustics

Reproduced Sound 12 Special Issue

acoustics BULLETIN

Volume 21 No 5
September -October 1996

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contents

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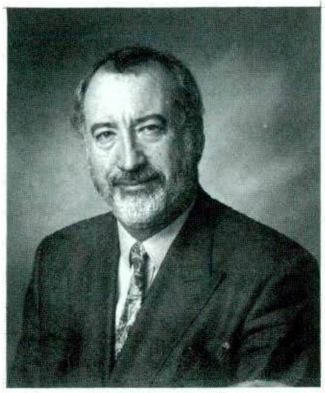

Dear Fellow Member

This issue carries a lengthy report on one of the milestones in the Institute's short history. The Internoise 96 Congress at the Britannia Adelphi Hotel in Liverpool which was hosted by the Institute proved to be a most memorable 25th Anniversary event.

As you will read, this Congress broke more or less all the numerical records and in many other ways set a standard for the future. Messages back from many of our international colleagues have emphasised the impression prevalent at the time of the congress, namely that the magnitude and organisation of the whole event considerably enhanced the reputation of the Institute. As you will read in the article, Internoise 96 stretched the secretariat's resources at St Albans to the limit. In the end we had a little luck with a number of critical factors and it all passed off well.

The November conferences at Windermere are nearly upon us as I write; indeed this issue contains three articles that make it a special one for the 12th Reproduced Sound conference which begins on 25 October (which is nearly in November!) with a strong international presence among the contributors. The Autumn Conference this year is Speech and Hearing 96 and has an extensive programme of Formal and Poster Sessions. A full house is expected for both conferences.

A large number of requests from the membership have been received at the Institute office for copies of the recent draft document from the DoE relating to the working of the new Noise Act. It seems to me there are issues there which will stir up debate for some time to come.

Sincerely yours

Bernard Berry

Bernard Berry

AUDIO APPLICATIONS OF ACTIVE ACOUSTIC ABSORBERS

Paul Darlington MIOA

Introduction

Active methods in acoustics have developed rapidly over the last two decades [1]. The term 'anti-sound' entered the public consciousness only recently and it still evokes an air of mystery, perhaps due to association with 'anti-matter' and other concepts closer to the realm of science fiction. In certain simple applications, anti-sound is now engineering fact. Despite success in these simple applications, active sound control fails to live up to the early over-inflated claims of commentators (and practitioners who should have known better). 'Anti-sound', along with other active methods in engineering dynamics, is an emerging technology, slowly finding areas of application in which it offers genuine utility.

This article describes work, conducted in the Department of Acoustics and Audio Engineering, University of Salford, in the application of active methods in audio engineering. The theme underlying the experiments, results and applications described in this article is the active control of the acoustic impedance of a surface. As the acoustic impedance defines how a surface will absorb sound power, it is not surprising that devices which offer programmable surface acoustic impedance have become known as active absorbers (although explicit power absorption is only one of their many applications). These active absorbers are constructed using conventional electrodynamic loudspeaker units, with some local inexpensive instrumentation, under the influence of a digital control system.

Before considering audio applications of this device, we shall examine the acoustics of its operation.

The Active Acoustic Absorber

In order to develop an understanding of the active absorber, we shall first consider the action of a conventional direct radiating loudspeaker, operating in a baffle, such that the radiation from the front and rear of the diaphragm does not interfere. We shall consider only the front radiation and, to simplify things, we shall assume that the pressure is uniform over the surface of the cone and that the loudspeaker behaves as a constant velocity source. These are both reasonable assumptions for low frequency radiation.

When the loudspeaker cone moves, the velocity of the cone generates pressure fluctuations, associated with the radiated pressure, p_{rad}. The volume velocity, U, and resulting radiated pressure are related by the radiation load, Z_{rad}, presented to the moving cone :

$$p_{rad} = U Z_{rad} \qquad (1)$$

When a loudspeaker is operated as an acoustic source, it radiates acoustic power, W, according to:

$$W \propto \Re e\left[\overset{*}{p}_{rad} U\right] = |U|^2 \, \Re e\left[Z_{rad}\right] \qquad (2)$$

in which the asterisk denotes conjugation. Notice that the power is radiated (denoted by a positive value of W) because physical radiation loads have positive real parts.

How Can a Loudspeaker Absorb Power?

If, in addition to the pressure generated by the motion of the cone, p_{rad}, there is some other pressure component, p_B, the story becomes more interesting. This second pressure component may be generated by a second source, or may be the sound generated by the loudspeaker previously and reflected back to the surface of the loudspeaker.

The total pressure at the cone of the loudspeaker, p_{tot}, is:

$$p_{tot} = p_{rad} + p_B = U.Z_{rad} + p_B \qquad (3)$$

and the power at the surface of the loudspeaker is:

$$W \propto \Re e\left[|U|^2.Z_{rad} + \overset{*}{p}_B.U\right] \qquad (4)$$

This expression has two components; the real part of the velocity magnitude squared times the radiation load, and the real part of the blocked pressure conjugate times the velocity. The first component is the same positive radiated power as defined in equation 2. However, the second component can be made negative, by manipulating the phase relationship between the blocked pressure (that pressure component not due to cone motion) and the cone velocity. By forcing the second component of equation 4 to be negative and larger than the first radiated power term, acoustic power can flow into the loudspeaker (denoted by a negative value for W). The loudspeaker is then absorbing power.

The phase between p_B and U can be defined by controlling the loudspeaker's velocity to be directly related to p_B, through a fixed linear control filter, H. This requires that the p_B component of the total pressure at the surface of the loudspeaker can be transduced – not a trivial task. The explicit relationship between the blocked pressure and the resulting velocity:

$$U = H.p_B \qquad (5)$$

allows the power equation (4) to be re-written as:

$$W \propto |p_B|^2 \, \Re e\left[H + |H|^2.Z_{rad}\right] \qquad (6)$$

Various configurations of the filter H will cause different surface acoustic impedances at the surface of the loudspeaker:

$$\frac{p_{tot}}{U} = \frac{UH^{-1} + UZ_{rad}}{U} = H^{-1} + Z_{rad} \quad (7)$$

Controlling for Maximum Power Absorption Of particular interest (although not for audio applications, [2]) is the controller H_{max} which causes the maximum absorption of acoustic power. H_{max} can be defined by differentiating the power expression (6) with respect to the complex controller H and solving for the negative extremum. This gives:

$$H_{max} = \frac{-1}{2\Re e[Z_{rad}]} \quad (8)$$

Given this solution for H_{max} it is possible to calculate the impedance at the surface of the loudspeaker controlled for maximum power absorption:

$$\frac{p_{tot}}{U}\bigg|_{Max.\,Power} = -Z^{*}_{rad} \quad (9)$$

Maximum power is absorbed when the speaker offers impedance equal to the negative conjugate of its radiation load. This is a well known result, both in the context of acoustic absorption in particular and load matching in general.

A Practical Active Acoustic Absorber

The explanation of the principles by which power can be absorbed by a loudspeaker presented above used a decomposition (equation 3) of the pressure at the loudspeaker cone. Such a decomposition is practically difficult to work with – transduction of the blocked pressure component is difficult and the solutions for the controller H required in practical situations are clumsy. Practical realisations of active absorbers developed at the University of Salford have avoided this difficulty by designing the cone velocity as a function of the total pressure (rather than the blocked component as in equation 5).

Figure 1 illustrates the basic practical system [3]. A long throw loudspeaker unit has a miniature microphone and accelerometer attached to the cone. These allow the direct transduction of the acoustic impedance at the surface, under the assumptions that the pressure distribution over the cone is uniform and that the cone motion is pistonic. The measured impedance is compared to the desired impedance and the cone motion adjusted to force the measured impedance towards the desired value.

The Absorber Control System Design of the appropriate cone velocity is achieved using a digital control system. The measured velocity signal is passed through a digital filter representing the desired impedance at the surface of the loudspeaker cone, z_d. This produces an output signal, p_d, which represents that pressure that would exist at the cone, given the velocity, if the desired impedance was being achieved. The difference between the actual pressure (measured by the microphone) and the desired pressure, p_d, is interpreted as a pressure error signal.

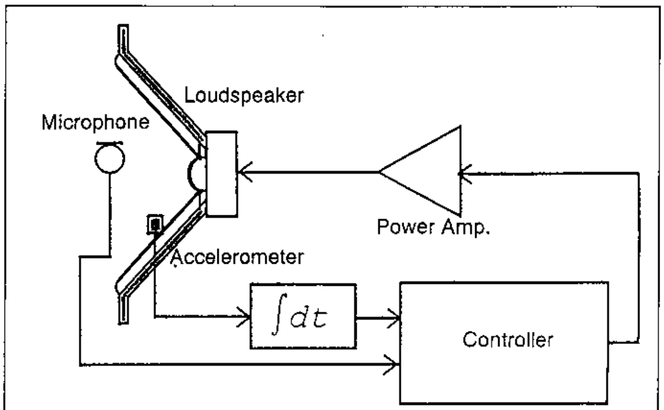

Fig. 1. Block diagram of the Salford active absorber

The loudspeaker is driven by a signal derived by filtering either (i) a signal correlated with p_B (perhaps the electrical signal driving a second loudspeaker system which is generating p_B) or; (ii) the total pressure.

The filter is designed to minimise, in a least squares sense, the pressure error. This can be achieved using an adaptive approach, such as the Widrow-Hoff LMS algorithm [4]. The LMS algorithm needs to be compensated for the plant dynamics (loudspeaker response etc.) using the Filtered-X strategy and, in the case of a loudspeaker driven by a signal derived by filtering the total pressure, the possibility of feedback needs to be addressed, perhaps using internal model control [5].

A Simple Example

As a first example of the use of an active absorber system (which will immediately suggest some real audio applications) we shall consider the suppression of acoustic resonance in a pipe. The air in a constant cross-section pipe of length L will exhibit normal modes of behaviour, which are controlled by the impedances at the ends. In the simplest case, where both ends are stopped by rigid terminations having very high acoustic impedance, the pipe system will have resonances at frequencies of:

$$f_n = \frac{nc}{2L} \quad (10)$$

Driving this system with a loudspeaker built into one end (remember the loudspeaker, as a constant velocity source, has high source impedance and so would not disrupt the boundary condition) would generate a response dominated by the normal modes. The frequency domain response would have peaks at the resonant frequencies and the pressure field inside the pipe would exhibit strong standing waves.

This modal behaviour can be seen in a time/frequency plot, (such as are popularly used in visualising transient response effects in audio systems). Such a plot shows the response to a broadband excitation (revealing the forced frequency response) which is suddenly turned off (showing the subsequent natural response). The time/ frequency response of a 4 metre long pipe is shown as Figure 2a – the modal effects are dramatically visible.

If the rigid termination of the pipe at the opposite end

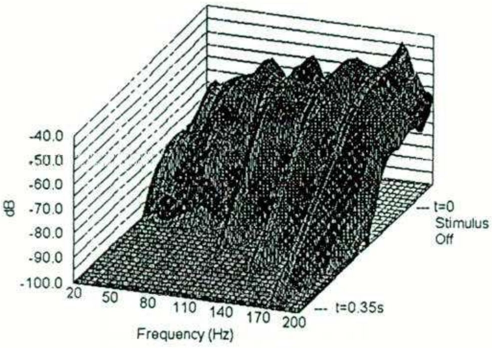

Fig. 2a. Time/frequency response of a 4 metre duct with rigid termination

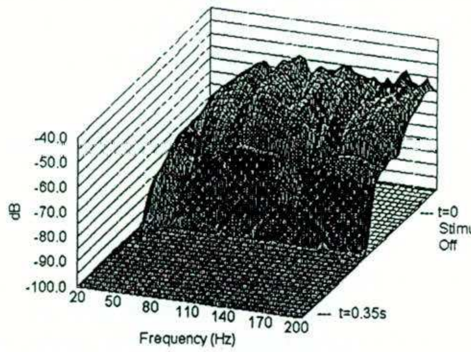

Fig. 2b. Time/frequency response of a 4 metre duct terminated with an active absorber

from the driving loudspeaker is replaced by a loudspeaker controlled as an 'active absorber', it is possible to control the impedance of the absorber such that it actively influences the acoustics in the pipe [2]. When the absorber is configured to absorb those pressure waves radiating directly away from the 'primary' source of sound [3,6], the acoustic modes are destroyed, giving a smoother forced and natural response in the frequency domain (and removing the spatial irregularity in the field caused by the standing waves). Figure 2b shows the time /frequency response of the 4 metre duct when the absorber is configured to offer an anechoic termination – a surface impedance of:

$$\frac{p_{tot}}{U} = \frac{p_o c}{S} \tag{11}$$

This 'characteristic' terminating impedance has been shown to be that which optimally flattens the response of the air in the pipe simultaneously in both frequency and space [7].

The characteristic termination of an acoustic waveguide has some interesting implications for audio, which we shall consider later – firstly we shall look at the three dimensional equivalent of the simple experiment reported above.

The Active Control of Room Modes

The rooms in which audio signals are reproduced are acoustic spaces bounded by walls with (generally) high acoustic impedance. They exhibit modes in three spatial dimensions, leading to complicated enclosed acoustic fields. The modes are so close together at mid and high audio frequencies that the effects of individual modes are seldom heard at these frequencies – rather we hear statistical effects associated with the combined action of hundreds of modes (for example, reverberation). At low audio frequencies the modes of the spaces in which we reproduce sound are widely spaced, such that we often hear frequency domain or spatial effects of individual modes. These isolated modes impose their resonant nature on reproduced sound leading to boomy, irregular perceived sound quality.

Historically it has been difficult to control the low frequency modes of small rooms as it is difficult to add enough damping material to prevent the energy accumulation in the modes (passive acoustic damping material being inefficient at low frequencies). However, as demonstrated by the one-dimensional experiment in the pipe, the active absorber is a means by which high absorption can be achieved at low frequencies.

Figure 3 shows the first mode of a small room, before and after treatment by an active absorber. The room has volume of approximately 27 m^3 and its first mode is at 43 Hz. The absorber was implemented using a single 200mm loudspeaker, positioned on an end wall. Figure 3a shows a contour plot of the pressure distribution when the room is excited at the first mode frequency by a loudspeaker on the opposite wall to the 'absorber'. Figure 3b shows the pressure distribution with the absorber on. To achieve this level of control the absorber implements a complex surface acoustic impedance, designed to take account of the radiation load it experiences within the room [2,8].

Active technology in low frequency room acoustics is a practical solution to both the temporal and spatial irreg-

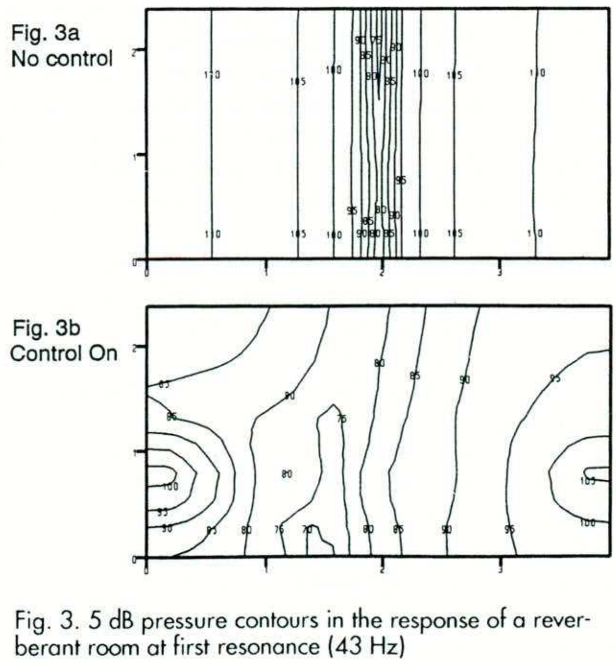

Fig. 3. 5 dB pressure contours in the response of a reverberant room at first resonance (43 Hz)

ularities caused by room modes [7]. In addressing the spatial aspects of room modes it goes much further than attempts to smooth out frequency domain irregularities using equalization [9].

Active Acoustic Loads in Loudspeaker System Design

The active absorber described above is more properly a device with programmable acoustic impedance; it does not have to be configured to explicitly absorb acoustic power. Viewed as a component with a programmable acoustic impedance, several alternative applications in audio suggest themselves, including some novel ideas for loudspeaker enclosures and systems.

The Active Transmission line Enclosure The transmission line loudspeaker enclosure [10] directs back radiation from the main low frequency driver into a waveguide. As the back radiation propagates down the waveguide it is subject to phase change, due to the speed of propagation. After some distance, L, the waveguide is opened, such that the back and front radiation components are joined. The phase change experienced by the back radiation during propagation down the waveguide allows the front and back radiation to add constructively over a frequency range of a musical twelfth. Unfortunately, sound propagating down the waveguide experiences a sudden impedance change at the opening. This causes 'reflex' action at the port, increasing the rate of phase change experienced by the backradiation, and reflections which give the main driver a resonant back-load.

Both these problems have been addressed by constructing a transmission line enclosure with an actively controlled loudspeaker at the end of the waveguide, in place of the port [11]. The device offers characteristic termination to the waveguide (see the simple example above). This guarantees that the back radiation from the main driver is never reflected back to colour the response. At the same time as absorbing sound coming down the waveguide, the back of the controlled loudspeaker cone (which is exposed to the air outside the enclosure) ensures that sound which comes down the waveguide is radiated perfectly – the device couples the waveguide and the frontspace. This principle has been verified on both experimental and commercial transmission line enclosures.

A Bass Reflex Loudspeaker with an Active Port The bass reflex enclosure achieves phase inversion of the main driver back radiation by passing it through a resonant acoustic network. The network is formed of two lumped acoustic parameters; the compliance of the air in the enclosure and the mass of a slug of air in a port built into the side of the enclosure. The physical properties of air and the overall dimensions of the enclosure place limits on the tuning of the phase inverter network.

Figure 4 shows a sectional view of a loudspeaker system with a port implemented by a loudspeaker controlled to offer programmable impedance inside the enclosure. The controlled loudspeaker acts as the port, but can be programmed to offer the impedance of any mass of air and, consequently, it is not limited by the enclosure size. The port can further be programmed to have specified damping. Figure 5 shows a typical far field frequency response of the system, constructed in a 17 litre enclosure with 110mm units as both main and active port drivers. The figure compares the differences in measured far field response between driving both units in parallel and in the active bass reflex configuration [12].

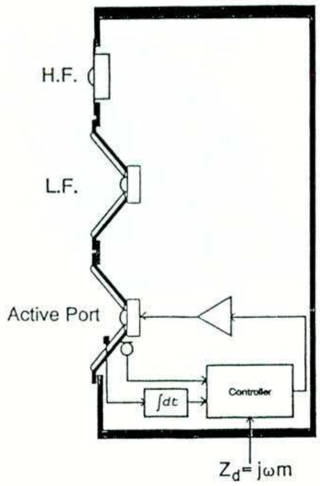

Fig. 4. A bass reflex loudspeaker enclosure with an active port

The control technologies used to realise the active bass reflex enclosure are capable of adapting the tuning of the enclosure in real time. This would allow a very small enclosure to be tuned to be highly efficient at producing a single bass frequency, tracking the program content to decide which that frequency should be at any instant.

Other Applications

In addition to controlling the acoustics of enclosed spaces and forming active components for the design of loudspeaker enclosures, a number of other areas of application of the absorber technologies are being pursued.

Low Frequency Noise Control The active absorber can be configured to achieve a number of active control tasks [13], including noise control. The active absorber systems described above have been used to control noise inside the cabins of passenger vehicles, where the low frequency modes of those cabins can cause high pressure levels [14].

Absorbing and Diffusing Surfaces The implementation of active absorption has been discussed in one- and three-dimensional contexts. Current research interest is focused upon incorporating the absorber technology into a cellular diffusing structure. Such diffusers [15] have a bandwidth which is high pass limited by the depth of the system; the surface does not work effectively when the maximum cell depth is less than a quarter wavelength. The incorporation of a number of 'active cells' into the surface, in which the cell is terminated with a surface of programmable impedance, would allow this frequency

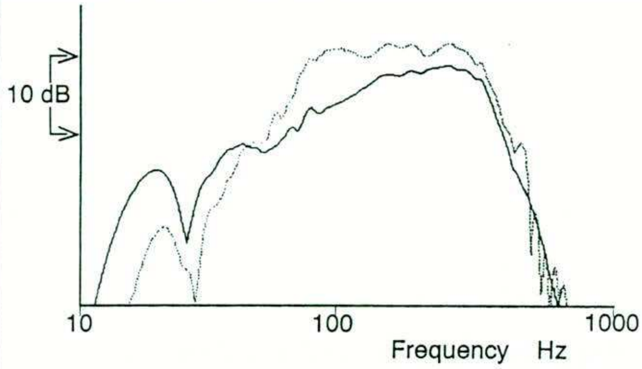

Fig. 5. Typical far-field response of the Active Bass Reflex System. (heavy – both lf units driven in parallel; light – second unit operated as 'active port')

limit to be avoided. Each active cell could be programmed to offer the impedance of (a number of) cells of different virtual depths, exceeding the physical depth of the overall diffuser.

The Future

Controlling the motion of a loudspeaker cone such that it offers a pre-specified impedance to incident sound generates an active component which can be built into an acoustic or electroacoustic system. These components have performance advantages over conventional passive devices.

Example: The control of the low frequency room mode described in this article was achieved by a single 200 mm loudspeaker in a small enclosure – to achieve an equivalent degree of damping using passive means at such low frequency would require the addition of so much absorbent that the useable volume of the room would be drastically reduced!

Active acoustic components also allow concepts to be investigated which are simply not feasible in passive terms.

Example: Who knows what developments will be possible when components such as negative acoustic masses are used in innovative new loudspeaker enclosures?

It is seen that active techniques broaden horizons in acoustic and electroacoustic design – this article has attempted to show that such developments will have direct benefits in audio and reproduced sound.

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The author has been privileged to work with many fine students and researchers on active methods in audio over the last eight years - much of the labour behind the ideas discussed in this article is theirs. Special thanks are due to Gowei Xu, Guy Nicholson, Andrew Dixon, Christophe Anet, Susan Mercy, Pernille Roungkvist, Jesper Kragh, Mark Avis and Christos Koutsodimakis.

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ACOUSTIC MODELLING OF ENCLOSED SPACES

Julian R Wright MIOA

This article aims to review briefly the past, present and future of modelling acoustic radiation in enclosures. Whilst the illustrations and examples focus on domestic listening rooms the principles are general to other partly or wholly enclosed spaces.

Methods

There are four main methods:

Scale modelling Historically scale models (typically 1:10) were an essential adjunct to numerical techniques, which were limited by pre-computer (ie human) processing capabilities. Barron [1] reviews the subject. Scale models are costly and time-consuming to implement and quite inflexible, although potentially very accurate. Likely to die out as computer methods become more prevalent.

Ray tracing A mature and powerful technique, based upon tracing the paths of wavefront normals around the enclosure. Inherently limited by the assumption of specular reflections, although some improved algorithms have been developed [2,3]. Likely to remain popular.

Image model The oldest [4] and most accessible method, both conceptually and mathematically. Treats enclosure boundaries as 'acoustic mirrors', generating image sources behind the boundaries. Similar in many ways to ray-tracing. Suffers from the need to generate an infinite number of image sources [5,6]. This is only ameliorated when boundaries have significant absorption. The author demonstrated the technique in 1986 [7] (as have many others before and since [8,9]) but this model used only 33 sources. It has been shown since that even 729 sources will not produce a convergent model without unrealistic amounts of (low-frequency) absorption [10].

Finite Element Analysis (FEA) The author must admit to a preference for this method as the future of acoustic modelling. However, it is not without problems and limitations. At present FEA is very demanding of processing power and computer hardware in general. Accurate models of large and complex systems are therefore not always possible. Nevertheless, the technique is most accurate at low frequencies where the other numerical methods are weakest.

The principles of FEA are well documented [8,11,12]. To summarise, it is a numerical method whereby a macroscopic (in this case, mechano-acoustical) system is subdivided into many discrete (finite) elements. These elements are assigned degrees of freedom which are influenced by the other elements. The result is effectively a very large set of simultaneous equations which can be solved by a computer program. Although the FEA technique grew out of the need to model expensive life-supporting mechanical structures such as aircraft, dams and bridges, in recent years acoustics has been included and we can now model problems in acoustics which had previously been effectively insoluble.

Aspects of Enclosure Modelling

Three boundaries v. Six boundaries Because of the complexity of modelling a fully enclosed space a common approach has been only to model the three boundaries 'closest to the source' [13, 14, 15]. Whilst this provides valuable insight into source/boundary interaction, it is also potentially very misleading. Figure 1 shows the

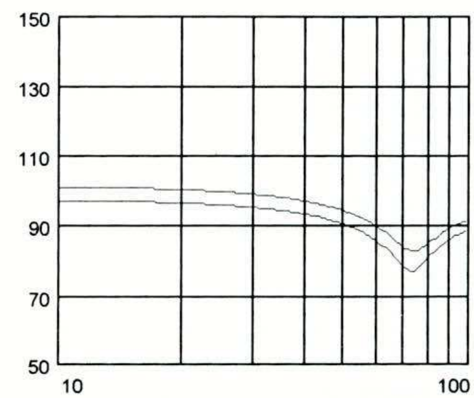

Fig.1. SPL (dB) v. frequency (Hz) at two points in a 'room' ignoring the 3 boundaries furthest from the source

predicted Sound Pressure Level (SPL) at two points (microphones) in an IEC standard room due to a point source radiator near one corner, assuming only the three boundaries nearest the source are present. The other three boundaries are 'anechoic' terminations, or total

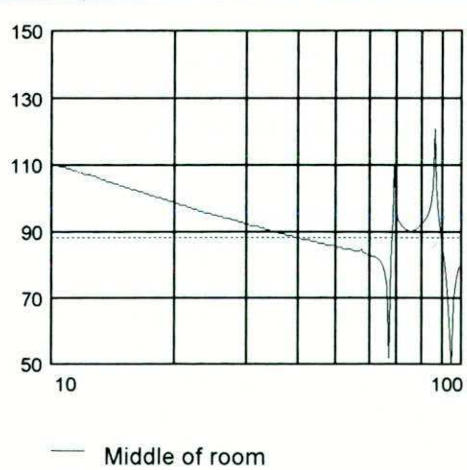

Fig. 2. SPL (dB) v. frequency (Hz) in the middle of the room considering the effects of all 6 boundaries

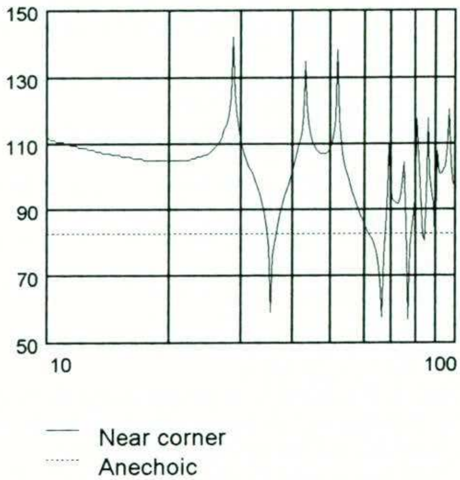

Fig. 3. SPL (dB) v. frequency (Hz) near a corner of the room considering the effects of all 6 boundaries

absorbers. One microphone is near the centre of the room, the other near the corner diagonally opposite the source. Figures 2 and 3 show the FEA prediction allowing for the presence of all six boundaries.

Some significant differences are apparent :-

a) the 'dip' around 75Hz predicted by the 3-boundary model becomes a general 'rise' in the 6-boundary case!

b) the asymptotic 'room gain' is 36dB for 6 boundaries, but only 18dB for 3 boundaries.

c) Modal behaviour is not supported at all by the 3-boundary model.

d) The 3-boundary model is in error by up to 50dB!

b) and c) are intuitively to be anticipated and d) is alarming but perhaps not surprising. a) is the most insidious, showing that the dip which the simpler model anticipates will not really exist!

'Truncating' the impulse response Many applications of the image source method try to circumvent the requirement for an infinite number of images by

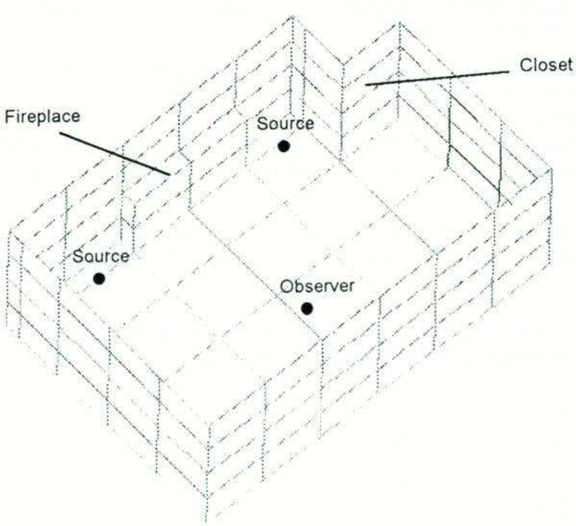

Fig. 4. 'Real' room with fireplace, closet, two sources and a listening position (ceiling omitted for clarity)

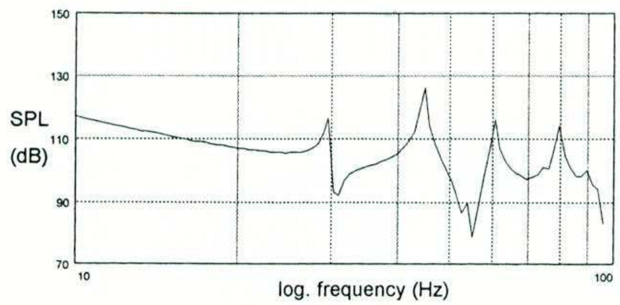

Fig. 5. SPL v. frequency at the listening position

requirement for an infinite number of images by considering only the reflections arriving within a predetermined time. This raises the question of what that time should be. We would effectively be producing a 'truncated' impulse response of the room. Some of these methods then 'add on' an estimate of the reverberation tail, particularly those which are aiming to provide auralisation. Such approximations become more valid with increasing absorption (i.e. usually at higher frequencies).

We still do not fully understand the way the brain interfaces with sources in rooms. Is a steady-state model appropriate? How important are late reflections?

Complex structures One of the primary practical requirements of acoustic modelling of enclosures must be the ability to study complex structures. Simple analytical techniques such as the image method are not at all suitable. The FEA approach is attractive to the practical acoustician, as the mathematical route to the solution allows for edge diffraction, reflection, mechanical motion (i.e. nonrigid surfaces), and absorption. Figure 4 shows a room with a mantelpiece and fireplace, and a closet in one corner. Two point sources are located either side of the fireplace, and the observation point set between the sources and near the back wall. Figure 5 shows the SPL v. frequency response at the observer when both sources are operating in-phase.

Conclusions

The FEA technique is a potentially exact method for modelling acoustic radiation in enclosures, limited only (at present) by computer hardware, and there is little doubt that this method will become commonplace during the next decade as software runs faster and becomes easier to use. However, there is still a place for the established techniques, particularly ray-tracing which to some extent complements FEA. The image method should be used with extreme caution.

There is no longer any good reason to ignore boundaries when modelling enclosures. Such an approach may lead to flawed designs.

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LOUDSPEAKER DESIGN IN THE PRESENCE OF WALLS

James A S Angus FIOA

Introduction

The effect the presence of boundaries have on the low frequency output of loudspeakers is well known [1-4]. Many methods of ameliorating these effects have been proposed, ranging from careful positioning to special speaker designs which try to remove the effect of the boundaries.

However, in most practical applications the loudspeaker designer is faced with the fact that the speakers will be used in an unspecified room, with six boundaries, and a limited space in which to position them.

The purpose of this article is to present a method of designing loudspeakers in which the presence of the nearest three boundaries is taken into account in the design of the low frequency speaker. The article will first review the effects of the three boundaries. It will then discuss how these effects might be compensated for. The article will then examine the low frequency behaviour of loudspeaker drive units, and make suggestions for new alignments which take account of the boundaries. It will conclude with some simulation examples.

How Boundaries Affect Loudspeaker Output

When a speaker is placed near a reflecting boundary an image source is formed due to that reflecting boundary. Thus when a speaker is placed near three reflecting boundaries seven image sources are formed, as shown in Figure 1. The effect of these image sources, which represent reflections from the boundary, is to modify the local acoustic impedance seen by the loudspeaker. Because a dynamic speaker is mass controlled in its normal working region it forms a high impedance source and therefore the radiated power is affected by the local impedance variations.

Waterhouse [2] extended work by Rayleigh [3] and confirmed experimentally that the power output of a source in the presence of three, mutually perpendicular, boundaries is given by:

$$\frac{W}{W_f} = 1 + \frac{\sin\left(4\pi \frac{x}{\lambda}\right)}{4\pi \frac{x}{\lambda}} + \frac{\sin\left(4\pi \frac{y}{\lambda}\right)}{4\pi \frac{y}{\lambda}} + \frac{\sin\left(4\pi \frac{z}{\lambda}\right)}{4\pi \frac{y}{\lambda}} +$$
$$\frac{\sin\left(4\pi \frac{(x^2+y^2)^{1/2}}{\lambda}\right)}{4\pi \frac{(x^2+y^2)^{1/2}}{\lambda}} + \frac{\sin\left(4\pi \frac{(y^2+z^2)^{1/2}}{\lambda}\right)}{4\pi \frac{(y^2+z^2)^{1/2}}{\lambda}} + \frac{\sin\left(4\pi \frac{(z^2+x^2)^{1/2}}{\lambda}\right)}{4\pi \frac{(z^2+x^2)^{1/2}}{\lambda}} +$$
$$\frac{\sin\left(4\pi \frac{(x^2+y^2+z^2)^{1/2}}{\lambda}\right)}{4\pi \frac{(x^2+y^2+z^2)^{1/2}}{\lambda}} \qquad (1)$$

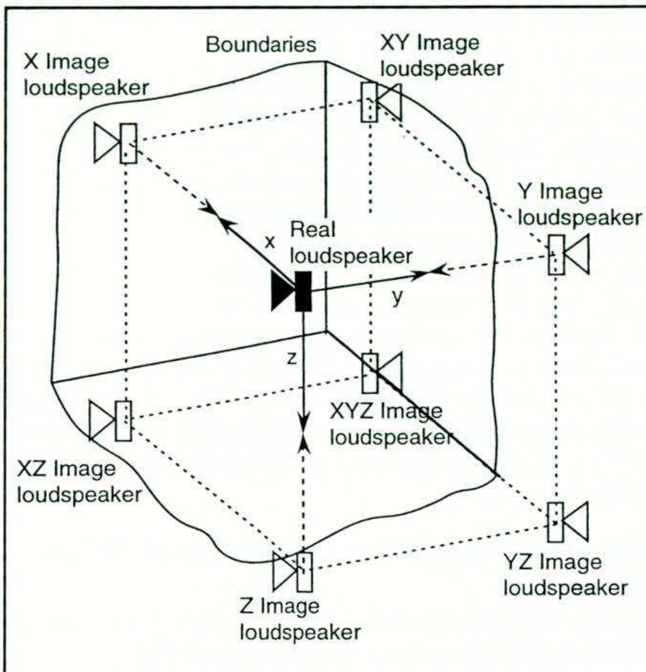

Fig. 1. Images formed at the nearest three reflecting boundaries to a loudspeaker

where: $\frac{x}{\lambda}, \frac{y}{\lambda}, \frac{z}{\lambda}$ are the distances to the boundaries and $\frac{W}{W_f}$ is the power output relative to the free field output.

Equation 1 gives the output for three boundaries and each term in it represents the contribution of one of the image sources. For one or two boundaries the output power can be obtained by setting the distances from the unwanted boundaries boundaries to infinity. The effect of this is plotted in Figures 2 and 3 for two different boundary conditions.

In one case all the dimensions are the same (Figure 2), in the other they are different so as to minimise the effects (Figure 3). From these graphs we can see two main things:

1. If the dimensions are the same then one has a low frequency response which rises to 9dB above the mid-band response and which has significant variation over the frequency range.
2. By placing the speaker carefully with respect to the boundaries one can eliminate some of the variation in the response but one still has a 9dB rise in response at low frequencies.

The above is well known and the 9dB rise at low frequencies is inherent in operating in an environment with three boundaries.

Given that the problem is inherent can one design the low frequency output of the loudspeaker to allow for this

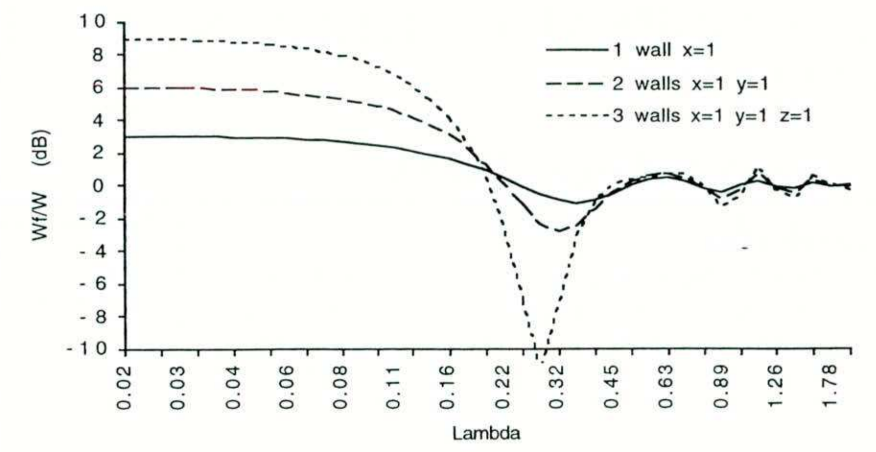

Fig. 2. Loudspeaker boundary interaction 'non-optimum' placement

effect? In order to answer this we need to consider whether the curves shown can be compensated by any known equalisation network. Figure 4 shows the 'optimum' three boundary case overlaid with a simple 6dB per octave shelf. From this graph we can see that a simple 6dB per octave shelving type equaliser can do a creditable job of equalising the gross response at low frequencies providing one accepts that there will be some variation from flatness. However, the ideal would be to build the equalisation into the loudspeaker alignment so that extra equalisation components are not required. Such alignments may also offer advantages in the size of loudspeaker enclosure. Unfortunately loudspeakers have frequency responses which have slopes in excess of 6 dB per octave. Therefore, to see if see if such alignments might be possible, we need to look in more detail at the response of the moving coil loudspeaker drive unit at low frequencies.

The Low Frequency Response of Drive Units

The low frequency output of a moving coil drive unit in an infinite baffle can be given by (from Small [5]):

$$G(s) = \frac{s^2T^2}{s^2T_c^2 + s\frac{sT_c}{Q_{TC}} + 1} \qquad (2)$$

where T_c is the drive unit time constant given by:

$$T_c = \frac{1}{2\pi f_o}$$ where f_o is the unit's resonance frequency

and Q_{TC} is the total system Q

This gives us the familiar second order response in which the shape of the curve is controlled by the Q to give responses which vary from peaked to heavily damped as shown in Figure 5.

The curve for Q=0.2 seems to have a slope which is less than 12dB per octave and could provide what we require. Therefore let us consider the frequency response of a drive unit whose Q is less than 0.5, that is, heavily damped.

Equation 2 can be re written as:

$$G(s) = \frac{\frac{s^2}{\omega_o^2}}{s^2 + s\frac{\omega_o}{Q_{TC}} + \omega_o^2} \qquad (3)$$

The denominator of (3) can be rewritten in the form of: $D(s)=(s+\alpha+\beta)(s+\alpha-\beta)$

where $\alpha = \frac{\omega_o}{2Q}$ and $\beta = \omega_o\sqrt{\frac{1}{4Q^2} - 1}$ (4)

Equation 4 clearly shows the two roots of the second order equation. If Q is greater than 0.5 then b is imaginary and we have the familiar conjugate root of a second order system. However if Q is less than 0.5 then b is real and we have two real roots in the system, one at a break frequency which is greater than the drive units resonance and one which is below. In fact the resonance will be at the geometric mean of these two break points.

Because each break point is real the frequency response will only change by 6 dB per octave at each one. This means that the frequency response will contain a section between the breakpoints, around the resonance, which has a slope of 6 dB per octave.

This behaviour pattern is shown in Figure 6.

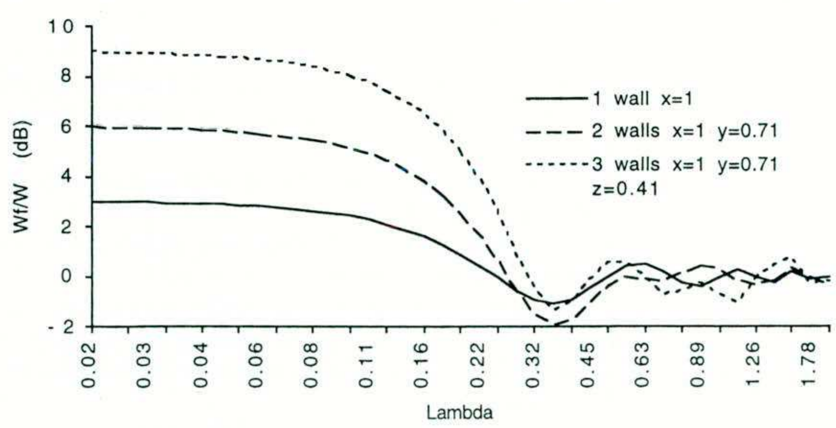

Fig. 3. Loudspeaker boundary interaction 'optimum' placement

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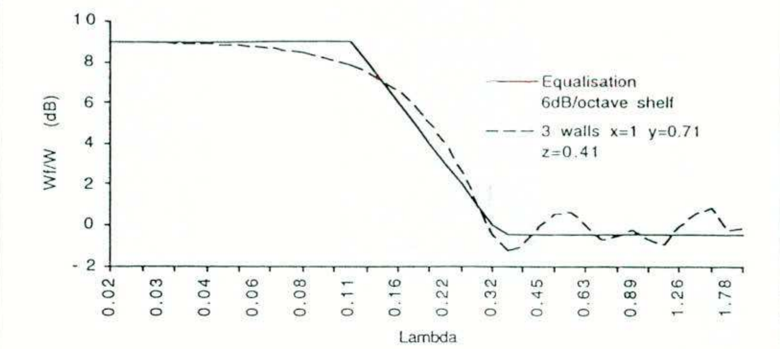

Fig. 4. Loudspeaker boundary interaction 'optimum' placement plus equalisation curve

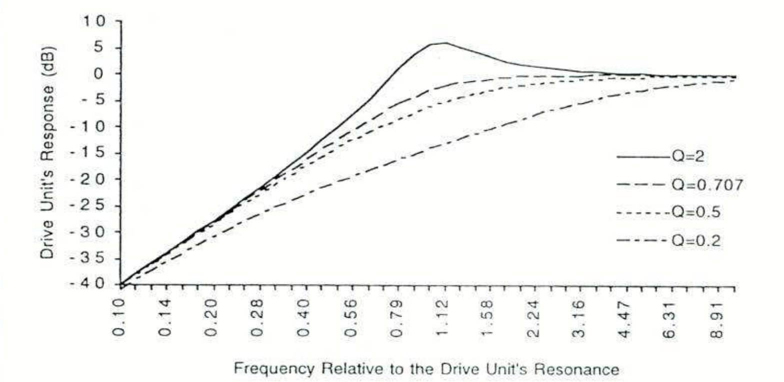

Fig. 5. Drive unit response for varying Qt

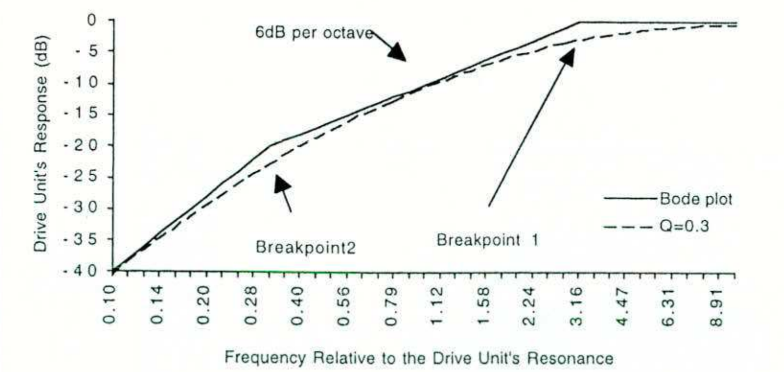

Fig. 6. Drive unit response for small Qt

Equation 3 can therefore be written as below

$$G(s) = \frac{\dfrac{s^2}{\omega_o^2}}{\left(s + \dfrac{\omega_0}{2Q} + \omega_0\sqrt{\dfrac{1}{4Q^2} - 1}\right)\left(s + \dfrac{\omega_0}{2Q} - \omega_0\sqrt{\dfrac{1}{4Q^2} - 1}\right)} \quad (5)$$

Both Figure 6 and equation 5 show that one can achieve a 6dB per octave slope in a drive unit around its resonance frequency by choosing an appropriately low Q for the drive unit.

Application

For closed box loudspeakers one can apply the above equation without modification. One just has to adjust the drive unit's Qt and resonance in the box such that when it is placed in the room the bass lift due to the boundaries is compensated by the 6dB per octave section in the loudspeaker's response. This section needs to extend over about one and a half octaves to compensate for the 9dB lift introduced by the boundaries. This could be achieved by a total system Qt of about 0.4 to 0.5.

For vented box loudspeakers the problem is a little harder. However if one looks at Small's [6] results for mis-tuned enclosures one finds that enclosures, which have low Q drivers and are mis-tuned such that the port resonance is lower than the drive unit's, can also exhibit a region of slope which is 6dB per octave. Therefore they can also be designed to compensate for the room boundaries.

Results and Further Work

Figures 7 and 8 show these ideas applied to a sealed and vented box loudspeaker. They are based on the parameters of a real drive unit with a Qt of 0.31 and a resonant frequency of 65 Hz.

The results clearly show that it is possible to compensate for the bass lift due to the boundaries. However the ripples could probably be optimised further and more work needs to be done in this area.

The results are also dependent on the position of the loudspeaker in the room. In these calculations the loudspeaker was placed in such a position that its back would be near the wall, a typical bookshelf mounting. However, although the results get poorer as the speaker is moved away from the wall, the results vary smoothly towards the free-field result as one moves away from the boundaries.

Figure 9 shows the effect of moving two of the boundaries further away by 50% and one can see the effect is a slight reduction of low frequency output.

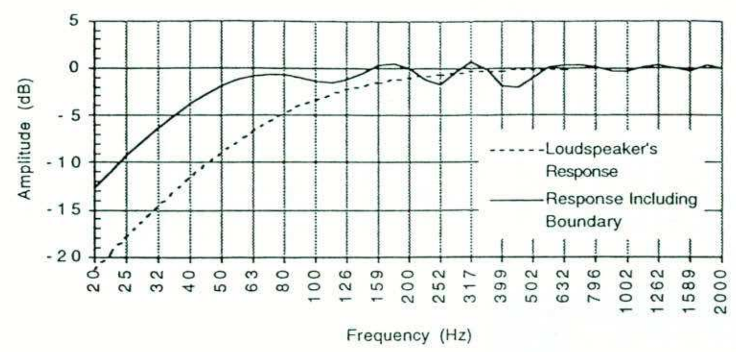

Fig. 7. Frequency response of a closed box loudspeaker design including the boundaries

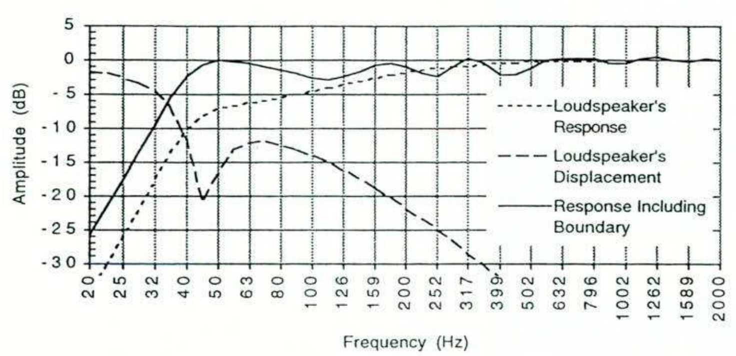

Fig. 8. Frequency response of a vented box loudspeaker design including the boundaries

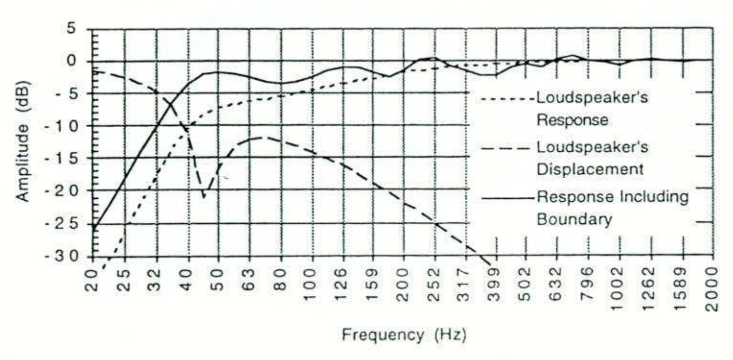

Fig. 9. Frequency response of a vented box loudspeaker design with the boundaries further away

Conclusion

The effect of the three nearest boundaries on a loudspeaker can be broadly compensated for with a 6dB per octave shelf. Loudspeaker drive units with a low Q exhibit a region of 6dB per octave roll off in their frequency responses which can be used to provide this compensation. Thus by designing with such units in conjunction with the effect of the room boundaries it should be possible to achieve better low frequency performance in real domestic environments. However there are still three other boundaries to be considered in a real room, but that is a different story.

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NOISE MONITORING IN THE SULTANATE OF OMAN

Robert F Whiteman MIOA & Neil G Anderson MIOA

An Oast House deep in the heart of the Ashdown Forest is the headquarters of a UK based environmental consultancy. 'Your mission', said the Controller, 'should you choose to accept it, is to carry out the monitoring of noise pollution in the Sultanate of Oman.' We of course thought long and hard about spending six weeks in the Middle East, in the summer, in the sun, and finally, after almost 30 seconds of continuous deliberation, agreed that we should make such a sacrifice 'for the good of the firm'.

The Sultanate of Oman, formerly Muscat and Oman, is as you will probably know, an Arab kingdom whose northern coast guards the eastern approaches to the Strait of Hormuz, to the Persian Gulf. It has a 1000 mile long sea coast on the Indian Ocean and it is, of course, a Moslem country.

The rapid infrastructure development of the last 25 years using oil revenues has transformed the country. The Sultan of Oman, His Majesty Sultan Qaboos bin Said, is an absolute ruler. He is advised by a 55 member Consultative Assembly and an elected 50 member Consultative Council but retains legislative power. The (1990) population of 1.5 million includes 0.25 million expatriates. Law is thus made by royal decree and regulations by Ministerial Decision.

Our task was to examine the existing noise levels in the Sultanate and report to our client, the Ministry of Regional Municipalities and Environment (MRME), with a picture of the noise problems which exist in the populated areas.

There are two main centres of population in the Sultanate, the most significant of which, and where most of the urban and suburban population live and work, is the Capital Area. This encompasses the old capital of Muscat, the Mutrah business district and the various residential, diplomatic and commercial areas, along the main road to the international airport at Seeb and westward along the Batinah Coast.

The second area of population which the survey was to examine was the environs of Salalah, 800 kilometres south west of the Capital Area on the southern Indian Ocean coast near to the border with the Republic of Yemen.

Salalah is a principal town of Southern Oman, situated in the middle of a predominantly agricultural area on the coastal plain. Connected to the capital by a tarmac road, travel to and fro is most conveniently accomplished by air. Salalah has the benefit of the monsoon and produces many tropical and sub-tropical fruits and vegetables. There is a modern and expanding sea port at Rusayl, to the west of Salalah. The area is popular with tourists from many of the surrounding countries in the monsoon season which brings a welcome and contrasting coolness to the air, temperatures here rarely rising above 35°C even during the summer.

The Noise Regulations

It is evident from the way in which the Ministerial Decisions are worded, in the English translation at any rate, that they have been heavily influenced by the long history of association with the UK. Unlike the UK, however, noise levels are given actual acceptable limits, generally in terms of the $L_{Aeq,T}$.

Two of the Ministerial Decisions were relevant to the tasks we were to perform on our contract in the Sultanate. The first dealt with Noise in the Public Environment and the second with Noise in the Working Environment. The Regulations for Noise in the Public Environment give noise level criteria for various categories of land use for noise from different sources at different times of the day. The sources described are:

- industrial plants;
- road traffic;
- airports; and aircraft.

The time periods are day, evening and night and there are five land use categories ranging from rural residential to industrial commercial.

Inception – Preparation

The project was, for us, largely a leap into the unknown. Our company had recently worked in the Sultanate in other disciplines but the requirements of this project were different and appeared less precise, requiring careful interpretation on our part to ensure our client's needs were satisfied.

A major, underlying requirement of the project was technology transfer, both in terms of equipment supplied and training to be given to environmental noise measurement.

Advance arrangements had been made for our arrival, with a luxury hotel to provide the basic needs of the survey party. In due course the innocents arrived abroad.

It was about seven o'clock in the morning with the air temperature reported by the pilot as thirty five degrees Celsius and rising. Fortunately the airline provided an air conditioned bus to carry us and the other the passengers the twenty five yards from the aircraft steps to the terminal building.

Despite our worst fears customs evinced only a mild interest in our sound level meters and the associated equipment and we emerged shortly after to meet our reception committee, a helpful representative of Penspen's local agent who was to give us generous administrative support during our stay.

This was Thursday; the start of the Omani weekend. Friday is the day of rest and thus no meetings with the client until Saturday and so our helpful rep, PK, most kindly offered to show us around to enable us to get some idea of the sorts of industrial plants and roads and traffic conditions we were likely to be encountering during our work. We were able to see a few of the places of interest in the capital as we toured: the harbour at Al Mina where the Sultan's yacht was moored and the local souq is located, and the old town of Muscat where one of the Sultan's palaces is to be found. Then back to our hotel with its magnificent views along the Batinah coast for a swim, lunch and ice cold beer!

Fig. 1. Environmental noise monitoring in the town of Nizwa

Meeting the People

Omani Coffee Our work began with a meeting with the people of the Ministry including those who were to guide us and we were to offer training to during the course of the contract. This was our first encounter with 'Omani Coffee'. It was a source of some merriment on the part of our Omani hosts for there is a ritual associated with the serving of coffee to visitors. The initial glee with which our unfamiliarity with the customs was greeted and the subsequent instruction in the correct procedure, later enabled us to cope adequately with the same situation arising in other circumstances.

Apparently it is traditional for the host to ply the guest with the coffee, which is served from a traditionally designed jug (today's are often Thermos manufactured). The coffee is black, quite strong and poured into a small handleless cup. The crucial point is, however, that the host shall continue to refill the cup until the appropriate signal is given by the guest. Politeness dictates that the guest finishes any left in the cup. The 'joke' is that we were not told the appropriate signal until we were about to burst.

All the people with whom we were to work were keen and enthusiastic which made our work much easier and more enjoyable. We held a number of seminars to supplement the practical hands-on experience obtained in assisting us with the monitoring. The seminars were stimulating for all.

Workplace Noise

The first aspect of the survey to be tackled was the occupational noise in factories. The team proceeded to take us on a tour of various industrial plants ranging in size from a major power station and desalination plant to a back street lock-up type wrought iron workshop with a whole gamut of intermediate sized works between. In every instance our arrival at a premises was greeted with, in the case of Omani run businesses, the offer of the ubiquitous coffee, generally followed by cold drinks (Pepsi) and accompanied by a wide ranging discussion between our colleagues from the ministry and the operators of the plant on almost any topic except noise levels.

It was plain that the Ministry officials were regarded as being of some considerable status by the people running the factories, perhaps in part due to the somewhat draconian powers conferred upon them by the Regulations which they administer.

The regulations basically state that if the regulatory criteria are exceeded then the employer must carry out whatever work the Ministry decides is necessary in order to mitigate the problem. Consequently, it was never even mooted that access to any plant would be denied and the management were always willing to cooperate in any way with the requirements of the team including shutting down machinery, starting up machinery and carrying out any and all operations that the plant was capable of in any desired combination. This rendered our task so much easier than many equivalent UK situations, HMG please note.

Generally the small industries, often with only two or three employees, did not have large scale mechanical processes going on and noise levels were consequently well within the requirements of the regulations. This was due to the patterns of working and the limited use of machinery. Larger industries tended to have some noise problems as there was a lack of understanding by the workforce about the need to protect hearing. Usually the management had provided some form of ear defenders but persuading the workers to wear them in hot, humid conditions was a difficult problem.

We visited industrial estates in various parts of the Capital Area, extending our range as far as Sohar northward and Nizwa in the west. Included were various sorts of industrial plant, cement manufacturers, copper extraction and refining, aluminium products (extrusion processes), concrete block manufacturing, textile mills, furniture manufacturing, a flour mill and a fashion factory making jeans.

There were a number of instances where a breach of the Regulations were identified and discussions with our Ministry colleagues ranged widely over options for noise reduction.

Road Traffic Noise

In the UK we are used to assessing traffic noise for proposed road schemes by calculation based on the much revered CRTN but Oman has no equivalent document to guide the assessment. The contract required us to establish on the basis of monitoring results whether the noise levels in the Sultanate generated by automobiles exceed the standard limits as stipulated in the Regulations for Noise Control in the Public Environment.

One of the first aspects that strikes the observer is that the traffic composition is not like that in the UK. There is a very large percentage of four-wheel drive vehicles, mostly of the 4-litre petrol engined variety. The HGVs tend towards the US style with large, long bonnet tractor units. There are very few old vehicles on the roads, largely as a result of very strict annual checks on older vehicles carried out by the police.

The second characteristic that is evident is that, in the urban and suburban areas, the roads are, generally, either six lane dual carriageways or single lane back roads with little gradations between.

Traffic flow figures were not available since such information is considered classified. There is a general reticence about releasing information which we were not used to. Whilst carrying out some noise level monitoring outside of the built up area one afternoon we set up our meters, with our colleagues from the ministry in attendance, alongside the television receiver station. Whilst taking photographs of the monitoring as was our habit, we were challenged by a passing police patrol and constrained to promise not to include the satellite dishes in our photography.

Fig. 2. Traffic noise monitoring in the Capital Area

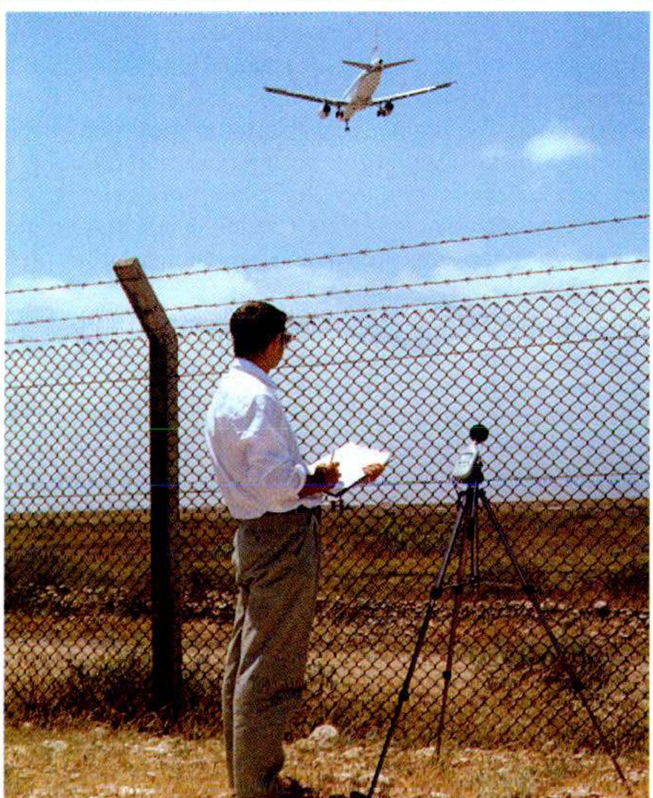

Fig. 3. Aircraft noise measurements at Salalah

It was with some amusement that we later discovered picture postcards for sale in a stationers which depicted the self same installation.

The results of this study were expressed in terms of the likelihood of dwellings within certain distances of certain major highways being subject to noise levels in excess of the criteria stated in the Regulations. The need to take account of the traffic flow was emphasised to the client but without a validated model, accurate prediction of traffic noise levels was difficult.

Aircraft Noise Monitoring

Our task was to monitor aircraft noise levels and develop a set of noise level contours which would enable the local authority to determine compliance with the criteria stated in the Regulations. It would possibly have been better to apply one of the available models but in this instance the client was insistent that measurements were what was required and that the contours should be demonstrably based on the information thus acquired.

The international airport at Seeb shares a runway with the military, the police force air wing and the Royal Flight. Information on the comings and going of commercial flights is obtainable but none for the other operations. In addition, whilst the airport perimeter is fenced, this is not

CONFERENCE NOTICE

NUMERICAL/ANALYTICAL METHODS FOR FLUID-STRUCTURE INTERACTION PROBLEMS

Underwater Acoustics Group Conference

16 – 17 December 1996

PAFEC Ltd, Strelley Hall, Nottingham, NG8 6PE

Provisional Programme

Monday 16 December 1996

09.00 Registration and coffee

11.00 Welcome

11.15 A B Wood Medal Lecture
A foundation for logarithmic measures of fluctuating intensity in ocean acoustics • *N Makris, Naval Research Laboratory, Washington, USA*

12.30 Lunch

Sonar Applications

14.00 Numerical methods for active sonar performance • *D J W Hardie, DRA, Winfrith*

14.30 Performance prediction of a volumetric array of free flooding ring projectors • *A B Callaher, DRA, Winfrith*

15.00 Comparing FE/BE models with measurement: Flextensional transducers • *J R Oswin (1), J Dey (1), D T I Francis (2) & P C Macey (3), (1) BAe-SEMA, Bristol (2) University of Birmingham (3) PAFEC Ltd Nottingham*

15.30 Tea

16.00 Substructuring in finite element analysis of sonar transducer arrays • *C Chen, J R Dunn & B V Smith, University of Birmingham*

Tuesday 17 December 1996

Acoustic Boundary elements

09.00 Mesh coarsening: an essential tool for effective fluid-structure interaction analyses • *C McCulloch, LMS*

09.30 The influence of structural mesh on the coupled fluid-structure interaction problem • *S J Newhouse & I C Matthews, Imperial College*

10.00 Vibroacoustic analysis using hybrid Fourier/3D modelling methods • *P C Macey, PAFEC Ltd*

10.30 Coffee

Submerged vehicles/periodic systems

11.00 A simple method for modelling the interaction of a bubble with a rigid structure • *P Harris, University of Brighton*

11.30 Statistical power flow method for submarine self noise • *M Blakemore (1) & J Woodhouse (2), (1) SAIC Ltd, Cambridge (2) Cambridge University*

12.00 A combined-finite element and boundary element analysis of the vibration response of a fluid - loaded plate with periodical stiffeners • *J Zhang (1), V F Humphrey (1) & M Petyt (2), (1) University of Bath (2) ISVR, University of Southampton*

13.00 Lunch

Scattering/propagation

14.00 Acoustic scattering by cubes: Combined finite element/boundary element modelling and experimental measurements • *V F Humphrey (1), J Zhang (1), P D Thorne (2), P A Chinnery (1) & S Sun (3), (1) University of Bath (2) Proudman Oceanographic Laboratory, Liverpool (3) Technical University of Denmark*

14.30 Propagation, scattering and moving objects modelled using transmission line matrix (TLM) • *S C Pomeroy & R Jaycocks, Loughborough University*

15.00 Simulation of pulses propagation and scattering in layered periodically inhomogeneous media • *O E Gulin & V V Temchenko, Russian Academy of Sciences, Vladivostok*

15.30 Tea

16.00 Analytic-numerical solution of direct and inverse problems of a pulse's propagation in layered media • *O E Gulin & V V Temchenko, Russian Academy of Sciences, Vladivostock*

16.30 Viscous and elastic swimbladder models for acoustical scattering from fish • *C Feuillade & R W Nero, Stennis Space Center, USA*

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MEMBERSHIP

The following were elected to the grades shown at the Council meeting on 3 October 1996

Fellow
Barker, P R
Cowley, A
Dryden, S M
Townend, D J

Member
Banks, P J
Clark, P
Clarke, E H
Collins, P
Figgins, W
Fisher, M P
Gibbs, M M
Grieves, J R
Haines, G J
Harris, D J
Ient, S J
Jones, C J C
McCann, D D
McWillie, A C
Milne, A D
Nicholls, D J
Thomas, A L
Thompson, H B
Wells, R H
Wiseman, T S

Associate Member
Anderson, G
Chiles, S G
Cojeen, C J
Geaves, G P
Hall, A R
Kellett, S V
Laws, R M
Lewis, R J
Lyddon, S G

Associate
Bartlett, G
Daniels, D
Din, M A
Fynn, L C
Richards, S D
Scaife, M P
Sharma, S K

INSTITUTE DIARY 1996/7

1996

1 NOV
IOA CofC in Env Noise M'ment exam
Accredited Centres

8 NOV
IOA CofC in W'place Noise Ass't Advisory Committee
St Albans

14 NOV
IOA Publications, Meetings Committee
St Albans

15 NOV
IOA CPD Committee and Branch Representatives
St Albans

18 NOV
Environmental Noise Group Committee
St Albans

21 – 24 NOV
1996 Autumn Conference – Speech & Hearing
Windermere

28 NOV
IOA Membership, Education Committee
St Albans

4 DEC
IOA CofC in Environmental Noise M'ment Advisory Committee
St Albans

5DEC
IOA Medals & Awards, Council
St Albans

16/18 DEC
Underwater Group Conference - Numerical/ Analytical Methods for Fluid-Structure Interaction Problems
Nottingham

1997

6 FEB
IOA Publications, Meetings Committee
St Albans

7 FEB
IOA CofC in W'place Noise Exam
Accredited Centres

12 FEB
One-day meeting - The Noise Act 1996
London

13 FEB
IOA Membership, Education Committee
St Albans

27 FEB
IOA Medals & Awards, Council
St Albans

7 MAR
IOA CofC in W'place Noise Ass't Advisory Committee
St Albans

24 APR
IOA Publications, Meetings Committee
St Albans

1 MAY
IOA Membership, Education Committee
St Albans

15 MAY
IOA Medals & Awards, Council
St Albans

16 MAY
IOA CofC in W'place Noise Exam
Accredited Centres

6 JUN
IOA CofC in Env Noise M'ment exam
Accredited Centres

13 JUN
IOA CofC in W'place Noise Ass't Advisory Committee
St Albans

19/20 JUN
IOA Diploma Exams
Accredited Centres

8 JUL
IOA CofC in Environmental Noise M'ment Advisory Committee
St Albans

19/22 AUG
ISMA '97 International Symposium on Musical Acoustics
Edinburgh

18 SEP
IOA Publications, Meetings Committee
St Albans

25 SEP
IOA Membership, Education Committee
St Albans

2 OCT
IOA Medals & Awards, Council
St Albans

10 OCT
IOA CofC in W'place Noise Exam
Accredited Centres

31 OCT
IOA CofC in Env Noise M'ment exam
Accredited Centres

7 NOV
IOA CofC in W'place Noise Ass't Advisory Committee
St Albans

13 NOV
IOA Publications, Meetings Committee
St Albans

2 DEC
IOA CofC in Environmental Noise M'ment Advisory Committee
St Albans

4 DEC
IOA Membership, Education Committee
St Albans

FIRST ANNOUNCEMENT

One-Day Meeting

The Noise Act 1996

(Organised by the Environmental Noise Group and the Measurement and Instrumentation Group)

The Royal Society, London SW1

12 February 1997

The Noise Act 1996 introduces a new night noise offence and a new procedure for the confiscation of noise-making equipment. The Act aims to complement the way in which problems of neighbour noise are tackled in England, Wales and Northern Ireland. Clarified powers of confiscation of noise-making equipment for statutory nuisance offences have already been brought into force, and the new night noise offence will be available for local authorities to adopt in April 1997.

The noise complained of must be measured using an approved device in a specified manner. In contrast to statutory nuisance, the night noise offence is based on the exceedance of an objective standard, the "permitted level". The permitted level is established by reference to the "underlying level of noise".

The meeting will include invited presentations from the Department of the Environment, the Building Research Establishment (who were asked to develop the measurement protocol), and local authority representatives who hold different views about the topic. The afternoon session will comprise demonstration exercises, run by instrument manufacturers, of the measuring techniques required by the Act. There will be ample opportunity for discussion of the issues raised by the Act, and the meeting will be valuable for all those involved in the Act's adoption and enforcement.

Certificates of attendance for CPD purposes will be available to delegates.

Numbers will be limited. Early application is advised.

Please register me as a delegate to the one-day meeting on the Noise Act 96 on 12 February 1997

Name:

Address:

Tel: Fax:

☐ I enclose a cheque for the delegate fee

☐ Invoice me

☐ Members £80.00 + £14.00 VAT = £94.00 ☐ Others £110.00 + £19.25 VAT = £129.25

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CALL FOR PAPERS

ISMA '97

INTERNATIONAL SYMPOSIUM ON MUSICAL ACOUSTICS

(in association with the Catgut Acoustical Society, the Institute of Acoustics (UK) and the European Acoustics Association)

UNIVERSITY OF EDINBURGH

19–22 August 1997

Following previous international symposia on musical acoustics held in Hartford (1986) Mittenwald (1989), Tokyo (1992), and Dourdan (1995), the next meeting in the series will take place in Edinburgh in 1997. Edinburgh, capital of Scotland, is one of the most spectacularly beautiful cities of Europe. The Symposium takes places during the Edinburgh International Festival which runs from 10th - 30th August 1997. The technical sessions will be held in premises of the Faculty of Music in the centre of Edinburgh. Accommodation will be available at very reasonable rates in Pollock Halls, picturesquely set at the foot of Arthur's Seat and Salisbury Crags yet only a fifteen-minute walk from the City Centre.

There will be a Symposium Dinner in the evening of 21 August. On the other evenings there will be concerts of acoustical interest, possibly as part of the Edinburgh International Festival. On 22-23 August there will be a meeting of the Galpin Society in Edinburgh at which papers on the technology of historical musical instruments and the history of musical acoustics will be presented.

Papers are invited on any topic on the acoustics of music. It is expected that themes of the meeting will include the modelling of musical instruments and the acoustics of historical instruments. An abstract (150-200 words) should be submitted as ASCII test (plain ASCII or HTML, not as an encoded attachment) by email or on diskette by 2 December 1996 to ***Arnold Myers, University of Edinburgh, Reid Hall, Bristo Square, Edinburgh EH8 9AG, Scotland Tel: +44 (0)131 650 2423 Fax: +44 (0)131 650 2425 Email: A.Myers@ed.ac.uk***

It is envisaged that the abstracts will be published on the Symposium's World Wide Web site. Abstracts should be delivered electronically wherever possible rather than on paper or by fax. Papers should be delivered in person at the Symposium by one of the named authors. A time of 20 minutes will be allowed for each presentation, to include 5 minutes for discussion. The language of abstracts, papers and presentations will be English. It is intended that there will be no parallel sessions. The full text of all papers must be received by the organisers by 31 May. The text with black and white illustrative material must be sent as camera ready copy; six pages will be allowed per paper. Format specifications will be issued with the acceptance of abstracts in January 1997. Papers will be published as a part of Volume 19 of the Proceedings of the Institute of Acoustics and distributed to participants on registering at the meeting. Details of Symposium fees and registration procedure will be published in January 1997.

2 December 1996 – deadline for submission of abstracts • **31 January 1996** – notification of acceptance of abstracts • **31 May 1996** – deadline for receipt of camera ready copy • **30 June 1997** – notification of acceptance of papers

ISMA Organising Committee: D Murray Campbell (University of Edinburgh) Peter Dobbins (BAeSEMA) Clive Greated (University of Edinburgh) Arnold Myers (University of Edinburgh) Peter Nelson (University of Edinburgh) Bernard E Richardson (University of Cardiff) James Woodhouse (University of Cambridge)

ISMA 97 Scientific Committee: Xavier Boutillon (France) Neville Fletcher (Australia) Avraham Hirschberg (Netherlands) Carleen Hutchins (USA) Jurgen Meyer (Germany) Isao Nakamura (Japan) Thomas Rossing (USA) Julius O Smith (USA)

Please notify the organisers as soon as possible (preferably by email) if you expect to attend the Symposium – whether or not you intend to give a paper - to help with planning and so that you will receive further information about ISMA '97 and the subsequent Galpin Society meeting.

Further information from the Chairman of the Organising Committee, Dr D M Campbell, Department of Physics and Astronomy, University of Edinburgh, James Clerk Maxwell Building, Mayfield Road, Edinburgh EH9 3JZ, Scotland Tel +44 (0)131 650 5262 Fax +44 (0)131 650 5902 Web URL: http://www.music.ed.ac.uk/research/conferences/isma/ Email communications to isma.97@ed.ac.uk

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considered by the authorities as a permissible approach point without some form of official approval which occupied a precious whole day of our six week stay. Naturally enough whilst the arrival and departure times were scheduled for the commercial flights, the direction of take off or landing was variable according to criteria to which we were not party. An added difficulty was the relatively low number of flights per day, about eighty in total.

The next problem was locating the measurement sites with respect to the airport in the near featureless, semi-desert terrain around the airport. Maps other than tourist maps, were not available. Somewhat hampered, we proceeded by producing our own base map using a GPS (Global Positioning System) device which was part of our equipment.

The instrument we used was the size of a pocket calculator and contains within its memory 102 national and international mapping grids. It draws its information from up to 9 navigation satellites which may be above the horizon at the time giving a location accuracy of down to 15 metres, entirely adequate for our purposes.

We first mapped out the airport perimeter fence by taking readings at every change of direction. We then located the axis of the runway. After this we proceeded with the monitoring of aircraft movements by setting up at various locations in the area around the airport, determining our location by the GPS and thus providing sufficient information to enable an interpolation of noise level contours on our map.

However, as at most tropical airports, many of the flights were at night or early morning, most between midnight and 8:00 a.m. 'Dune bashing', even in a Landcruiser, at night was not recommended and the authorities were not keen on having people wandering around the airport perimeter in the dark. Our work was thus necessarily carried out during the daylight hours and even then the opportunity for monitoring was limited because the flights were clustered in the morning with little activity during the afternoon and even in the mornings there were long periods of inactivity followed by short busy periods. Long days on the beach you say? Never, we remained 'the professionals' blistered by the hot sun and seared by hot desert winds.

The basic approach was to establish control stations on the runway axis to monitor all movements using event trigger mode. We then ranged through the desert collecting the spatial variation data, identifying the aircraft by observation, reference to the schedule provided by the aviation authorities and by synchronous timing. We collected, collated and analysed what data we were able. Fortunately the number of aircraft types using the airport was limited and so the data collected included a number of instances of each and so gave a useable basis for our work.

The remainder of the process consisted of producing the appropriate LDEN values to enable us to prepare the required contour map.

The work at the airport at Salalah proved even more difficult. There were only four scheduled flights each day, two in and two out. The location was rather more remote than Seeb and therefore the GPS was even more crucial to our investigations. The client did not require a contour plan for this airport and so was pleased to receive a descriptive account of our (somewhat limited) monitoring at this airport.

The main conclusion was that the Regulatory criteria are unlikely to be breached in the foreseeable future at Salalah. At the international airport, care would need to be exercised as to what type and where development may be allowed in the future, particularly bearing in mind the continuing future development.

Lasting Impressions

This was a great opportunity to work in a very different environment in close cooperation with local people. The staff at the Ministry were pleased to have our help in assessing environmental noise which is beginning to be a problem in their country but may yet be addressed in time to prevent future difficulties.

In passing over a goodly portion of the country on our journey to Salalah it was very evident that whilst most of the interior is desert it was far from trackless, being criss-crossed by innumerable tracks left by vehicles. The south is somewhat greener than the north and it is from there that the country is supplied with fruit and vegetables and from where the world in biblical times got its supplies of frankincense.

It was quite warm! Temperatures were generally 35°C and above rising to as high as 49.9°C (never higher because work must stop at 50°C). The humidity, in the Capital Area, ranged between 15 and 64% and near to the coast frequently exceeded 80%. Wind speeds were rarely above 1 to 2 metres per second and usually zero. The sun being high overhead most of the day one can stand in the shadow of one's hat.

The Omani people we were fortunate to meet were very friendly and possessed of a great sense of humour. Universally, if we parked at the margins of a rural road passing motorists would stop to make sure we were not in difficulties, reassuring 100 kilometres from anywhere. We were once stopped by a policeman for a random check of our vehicle particulars. He spoke no English; we spoke precious little Arabic and after some gesticulating and our failure to produce any of the documentation which was supposed to have been supplied by the car hire company and wasn't, his gestures plainly indicated, with a suspicion of good humour, that we should 'go away'.

Technically the project was not particularly demanding but the scope was potentially enormous and our minds were frequently exercised in overcoming practical difficulties which arose in unexpected places.

We would conclude with the thought that if ever the opportunity arises to spend some time in or even just visit the Sultanate of Oman we would unhesitatingly recommend that the chance be grasped with both hands.

Rob Whiteman MIOA and Neil Anderson MIOA are with Ashdown Environmental, The Oast House, Hodore, Upper Hartfield, East Sussex. Ashdown Environmental is a member of the Association of Noise Consultants

INTER-NOISE 96

30 July – 2 August 1996, Liverpool

The scene – one large Liverpool hotel, the Britannia Adelphi; over 1200 people from 40 countries milling through lounges, session rooms, bars, restaurants, and exhibition areas; dedicated delegates anxious to present their work and absorb that of their peers; potential clients and customers examining and discussing with company representatives the impressive array of instrumentation and services on show; accompanying persons eager to sample the delights of the excursions planned for them and, possibly, overawed by the technology on display. This was the atmosphere of the most ambitious INTER-NOISE to date – INTER-NOISE 96, the 25th in the series overseen by International INCE, and organised by the UK Institute of Acoustics.

The Scale of INTER-NOISE 96 – Creating It and Coping With It

It all started in 1993 at INTER-NOISE 93 in Leuven, Belgium when it was announced that the 25th INTER-NOISE would be held in Liverpool in the UK and organised by the UK Institute of Acoustics. The realisation of what was involved did not bear in on the people concerned until well after the champagne celebrations!

INTER-NOISE 96 was designed and set up by the Institute of Acoustics Congress Organising Committee consisting of the General Chairman, Bernard Berry; Technical Programme Manager, Nicole Porter; Congress Manager, Roy Lawrence; Technical Facilities, Ken Dibble; Treasurer, Geoff Kerry; Local Coordination, Ian Critchley; Committee Members, Peter Barnett, Ian Campbell, Robert J M Craik, Geoff Leventhall, David J Oldham, Chris Rice, Andy Watson and Ralph Weston; Proceedings Editors, F Alison Hill and Roy Lawrence; Summaries Document Editor, Robert C Hill; Conference Secretariat, Cathy Mackenzie Management Services. The above were assisted by an International Advisory Committee consisting of individuals from most of the countries, in addition to the UK and USA, participating in the Congress.

The venue was selected more or less by default. It had been suggested that for a UK bid to be successful, it would help if the location was outside the capital on the grounds that most of the potential delegates already had some acquaintance with London. The simple fact is that, according to the directory consulted, only one hotel could offer the scale and mixture of facilities needed for a Congress likely to have eight parallel sessions (eventually there were ten), both plenary and technical. The unique possibilities offered by the venue for the traditional exhibition and victualling facilities together with reasonable international access and an interesting hinterland suggested that the choice was likely to be a successful one. The alternative possibility, that of using a purpose built convention centre, was ruled out on a point by point comparison.

A question that was uppermost in the minds of the Organising Committee was whether international delegates would consider Liverpool an attractive proposition, for without an adequate response, initially in terms of the number of technical contributions offered, the event would be less of a success than was hoped.

With this in mind, and with views taken on how other international conferences had fared, a very extensive advertising campaign was initiated. The Internet, a worldwide distribution of leaflets, an 18 page article in Noise News International, posters at INTER-NOISE 94 (Yokohama), and Forum Acusticum (Antwerp), stands at INTER-NOISE 95 (Newport Beach) and the International Congress on Acoustics (Trondheim) seemed to ensure that few in the international noise control community were unfamiliar with a colour photograph of a Mersey ferry boat against a backdrop of the Liverpool waterfront. There was also something stirring in the world of Beatles memorabilia at just about the critical time. All this was most energetically supported by the team of Special Session Organisers, selected for their competence in their subject area and their ability to twist arms.

The result was an initial response to the call for papers of more than 900 abstracts with offers from as far away as Thailand, Malaysia and Mexico. In the manner of previous congresses this number of papers was eventually reduced by withdrawals (and the fact that a delegate's fee had to accompany every paper submitted for publication in the Proceedings for both the formal and poster parts of the programme) to something over 650, but still a record for the INTER-NOISE series. Organisationally, this response was to prove a mixed blessing. Clearly it guaranteed that the Congress would not fail for shortage of support. Yet there was little in the experience of organising INTER-NOISE 83 in Edinburgh that prepared the organising staff for the magnitude and complexity of the tasks that lay ahead.

There was, for example, an immediate impact on the design and organisation of the Congress Proceedings. The large number of papers to be accommodated, together with observations taken of the way delegates had used their copies at previous congresses, suggested that there was some logic in making the Proceedings into a boxed set (ultimately of six volumes weighing about 6 kg) that delegates could leave in their hotel rooms, whilst providing a Summaries Book in A4 format that could be carried around the congress. This book comprised 100-word abstracts provided by the individual authors, arranged so that all the papers being presented at a certain time were grouped together. In practice composing this book from text provided on something like seven hundred computer disks of every conceivable source (including a few with viruses in residence) was a task that would have been eased with the benefit of prior experience.

There is a view that the Congress Manager probably

The delegates' first sight of the congress

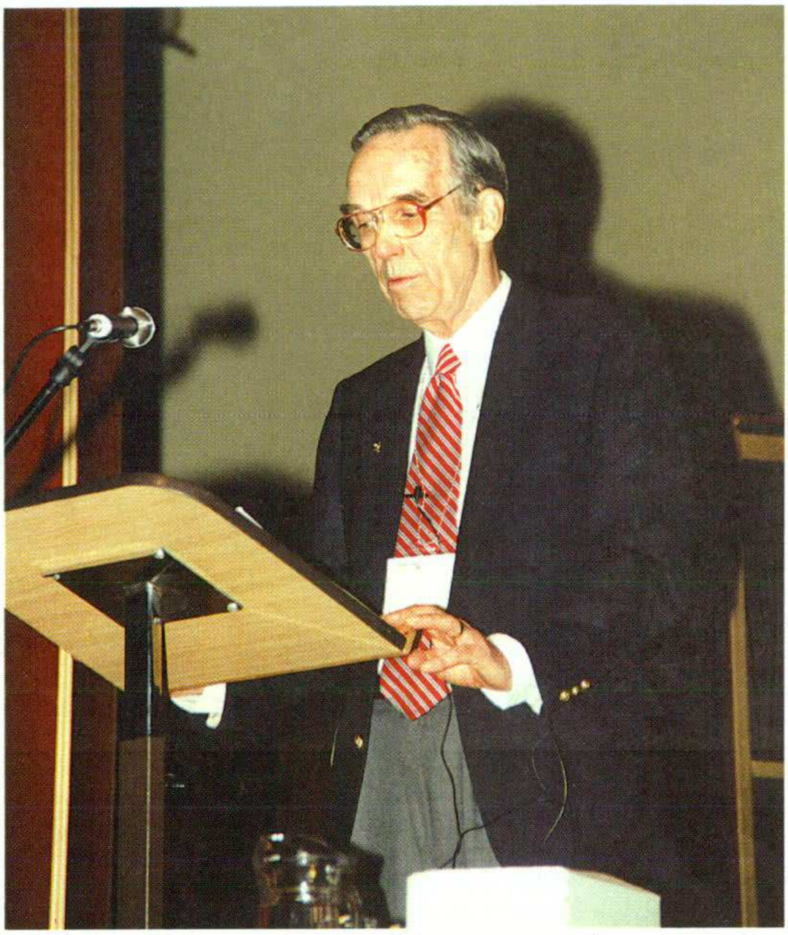
made a mistake in electing to have the Institute office cover the hotel bookings rather than pass it to an agency and he is known privately to concur with this view. The reasoning at the time the decision was made is, perhaps, understandable. The large number of papers offered, he opined, may be too good to be true and that a significant proportion of authors may well be intending to pay the delegate's fee in order to have a paper in the Proceedings, but not show at the Congress leaving a programme in disarray. Could it really be true that this number of noise control engineers were intending to cross the world to this re-emerging former sea port? Any tendency for this to be happening would then, he argued, be seen at the earliest stage in the numbers not requesting hotel reservations. In the event this did not happen but first-hand experience was gained of the facility with which delegates could change their rooming requirements (up to four times in some cases) by using today's instant communications technology; future Congress organisers should be warned!

Eventually one thousand bedrooms – all that were available within the city – were taken up leaving some overflow space at the Halls of Residence of the city's two universities. The city's hotel managers arranged private meetings to discuss how to make welcome the delegates to one of the largest congresses the city had ever seen.

The management of all aspects of a delegate's registration, which included the receipt of the initial offer of a paper, the approval of the abstract, outward correspondence with authors and delegates, all aspects of the handling of the proceedings manuscript and the summary text and the accommodation requirements, was superbly covered by the database management system the Institute has used for many years. It also covered all the actions necessary to convert into a printed reality the programme constructed by the Congress General Chairman and the Technical Programme Manager, with the valuable assistance of the many Special Session Chairmen.

A lot of work went into the visual appearance of the Proceedings; in most cases there was sufficient time to request an author to provide a correctly formatted version where cutting and pasting in the office was not sufficient. The title pages were computer generated and these steps produced a pleasing uniformity of appearance. Alison Hill undertook all the painstaking work. The printing was carried out using, in printer's parlance, 'sixteen to view' that is to say sixteen pages on the same bromide using a fixed exposure. This method was given an initial trial, but severe problems arose on the production run as some

The mêlee at registration



Bill Lang, President of International INCE, opening the congress

manuscripts arrived with a low density of type or on paper that was not particularly white. A considerable amount of manual improvement had to be undertaken.

The main problem with the assembly of the Proceedings lay further up in the chain. It has already been noted that International INCE rules require the prepayment of a delegate fee before a paper is placed in the programme and therefore in the Proceedings. In practice for those paying by credit card or by cheque there were no major problems. For those paying by some form of bank transfer, the picture was quite different. It was often some time after the transfer had been initiated that the complete information was received. This meant that contributions that had been ruled out had to be accommodated and, because the Proceedings were organised in INCE category order, critical repagination had to be undertaken well after the time the raw material should have been with the printers. In the event an articulated lorry left the printers at St Albans to arrive near the venue eight hours before registration was due to commence!

The development of a timing mechanism that would ensure the ten session rooms kept strictly to timetable was given a lot of thought. Examples used at previous conferences were generally ruled out as unsuitable for the venue. Many innovations reached a mock-up stage utilising wired and wireless links to a central computer but all these were discarded. The system eventually used involved a PC standing outside each room (no, not a member of the private company of ex-Liverpool policemen who provided discreet 24-hour security, but the other type!) which took information from the central timetable programme to indicate which paper was presently being given in that room and what was due next. The VDU screen also showed the progress of the twenty minute session. By means of a board in each PC carrying low power relays, the colour signals were echoed by wire to the speaker's lectern, the overhead projector table, (which were specially designed and constructed for the comfort of nervous presenters) and the chairman's desk. There were no audible signals but the system was reported as having worked well. The suggestion has been heard that the speakers felt they were somehow wired to a central intelligence that would know if they overran! Rob Hill of Acoustical Investigation and Research Organisation and Dr Alfred Vella, head of computing at Luton University produced the entire working system.

Another innovation was the provision of a pocket-sized programme card which assisted delegates to steer

A view of the exhibition in the main lounge

Technical Programme Sections and Chairmen

1 Active sound control
J Tichy & N Doelman
2 Algorithms and signal processing
H Hamada, P Darlington & C Boucher
3 Deriving greater value from noise annoyance surveys through international collaboration
R G de Jong & J Fields
4 Measurement and subjective effects of community noise
B Schulte-Fortkamp & B Berglund
5 Subjective evaluation of environmental noise (Part I)
H Fastl & S Kuwano
6 Barriers for noise control (Part I)
D C Hothersall, C Menge & S Chandler-Wilde
7 Methods for predicting noise outdoors (Part 1)
K Attenborough & G Daigle
8 Structure-borne noise and its sources (Part I)
B Gibbs & A Nilsson
9 Education in acoustics
T Kihlman & S Kurra
10 Sound intensity
G Rasmussen
11 Applications of sound intensity in building acoustics
H Tachibana & R Guy
12 Waves and vibration in beams, plates & structures
V Krylov & U Orrenius
13 Statistical energy analysis
J Cuschieri, R Craik, E Gerretsen & C Hopkins
14 Acoustics imaging of noise sources
P Wagstaff & M Kleiner
15 Analytical methods (Part I)
R Heng
16 Duct acoustics
D J Oldham
17 Industrial noise control (Part I)
R J Peters, J Cowling & B Shield
18 Vehicle interior noise
L Vasudevan
19 Aircraft noise
A Marsh & D Stephens
20 Military aircraft noise and NATO CCMS
R Weston & C Svane
21 Sound insulation (Part I)
T Vigran, A Warnock & F Reis
22 Building acoustics
R Walker & E Arato-Borsi
23 Applications of active control
H G Leventhall, P Darlington & C C Boucher
24 Airport noise
G Bekebrede, I Yamada & C Day
25 Developments in standards and regulations for environmental noise
P Dickinson & P Schomer
26 Methods for predicting noise outdoors (Part 2)
L C Sutherland & T Embleton
27 Barriers for noise control (Part 2)
B H Sharp & J Kragh
28 Structure-borne noise and its sources (Part 2)
B A T Petersson & A Moorhouse
29 Structural intensity
G Pavic
30 Industrial noise control (Part 2)
J Tourret & D G Bull
31 Non-auditory health effects
S Bly, L Finegold & S Stansfeld
32 Subjective evaluation of environmental noise (Part 2)
T Gjestland & I Flindell
33 Windfarm noise
M Legerton & A Bullmore
34 Assessment of tonal noise
A McKenzie
35 New techniques in instrumentation
G Wong & P Brüel
36 Standards for machinery noise
R Higginson & H Jonasson
37 Road traffic noise
G Watts, M Burgess, B Buna & J Seller
38 Human response to vibration
M J Griffin, S Maeda, J Edwards & E J Brueck
39 Vibroacoustics: the limits of predictability
F J Fahy, R Bernhard & J Cuschieri
40 Active vibration control
M J Brennan & R J Pinnington
41 Railway noise
J G Walker, C Hanson & B Hemsworth
42 Low frequency measurements
R Peppin
43 Motor vehicle noise
U Sandberg, G Brambilla & F Pedrielli
44 Blast noise propagation and assessment
G Kerry, P Schomer, J Vos & G Luz
45 Entertainment and leisure noise
J Griffiths & S Turner
46 Urban noise
K Collins & J Slama
47 Analytical methods (Part 2)
J Blomqvist, T Tomilina & S Gerges
48 Changes in annoyance and noise levels around airports
M Vallet, S Fidell & J Kastka
49 Sound insulation (Part 2)
A Kotschy & A Cops
50 Active control of structurally radiated sound
M Brennan & J Nicolas
51 Porous materials
J S Bolton
52 Miscellaneous noise control
D Trevor-Jones & C Gordon
53 Sound quality
R Bisping, P Davies & K Genuit
54 European issues
C Grimwood & D Gottlob
55 Construction site noise
D Towers & N Antonio
56 Noise and sleep
K Pearsons & B Griefahn
57 Occupational noise
H Lester & K Broughton

It took three buses to get all the session chairmen to their pre-congress briefing. This is one bus load

their way through the extensive technical programme.

For delegates' convenience a black shoulder bag was provided along with a clip board. The thought occurred during the planning stage, however, that the lack of external identification of the shoulder bags belonging to individual owners could lead to an international incident, so the idea of providing clip-on luggage labels emerged. Unfortunately when these labels were being individually printed from the data base, the Congress Manager had not allowed, in determining the field lengths, for a delegate with a double-barrelled surname, each barrel of which was incredibly long. Accordingly the labels went awry and had to be redone throughout the night and morning before Congress registration opened.

Another innovation concerned the delegates' badges. The Congress Manager took the view that the part of a badge to be recognised at the greatest distance was the delegate's nationality and duly made arrangements to print badges carrying the delegate's flag printed in colour directly from the information held on the data base. Experience showed that, with the exception of one machine, no bureau colour printer could produce the flag part with an unquestioning fidelity. Unfortunately that machine would have had to run continuously for several days which, by the time this was discovered, were no longer available. The same machine was used as a compromise measure to produce flags that were stuck on the badges on the morning of registration.

A final comment on how in-depth planning can come unstuck. On the afternoon of Monday immediately prior to the first day of registration, a three and a half ton truck arrived to pick up the accumulation of material that had to be taken the two hundred miles from St Albans to Liverpool. It duly collected from the Institute office but was not big enough to take on a lot more material held at another store. A seven and a half ton truck was available at the depot but had to be reserved immediately. The most junior member of the Institute's staff who was at the store, on being unable to contact the office, personally gave the order to order the larger truck. So another problem was averted!

The Congress Environment

There can be no doubt that having Liverpool as the venue proved a considerable attraction to potential visitors with the promise of architectural interest, the two cathedrals, its history as a major port with the redeveloped dockland and not least its musical heritage. The surrounding country offered many opportunities for visits to places of natural beauty and technical interest. The ones organised by the IOA in cooperation with the Merseyside Tourism and Conference Bureau included four visits to Chester, technical visits to the Manchester Concert Hall (see article in July/Aug Acoustics Bulletin) and Manchester Airport, several 'Beatles' tours, a trip to Port Sunlight on a Mersey ferry and a visit to Martin Mere, a


St George's Hall before the arrival of the horde

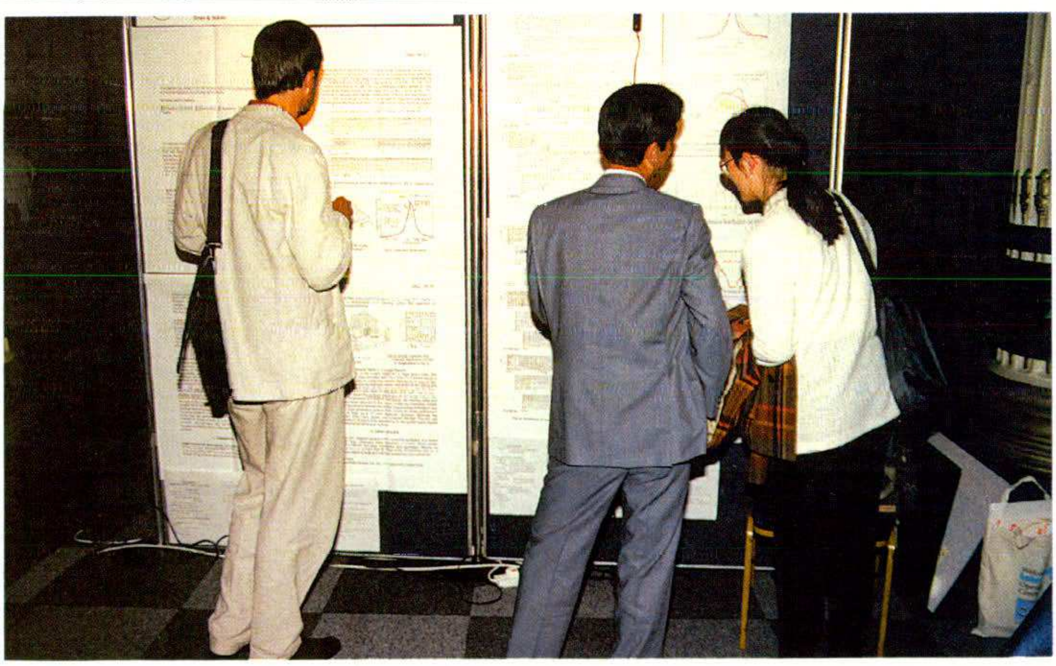
wildfowl and wetlands centre. All these factors ensured that a large number of family and friends accompanied delegates to Liverpool and this added to the atmosphere of warmth and enthusiasm which was such a notable feature of INTER-NOISE 96. The countries from which delegates came are listed below and it can be seen that INTER-NOISE 96 was a truly world event:
Argentina, Australia, Austria, Belgium, Brazil, Canada , China, Croatia, Czech Republic, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong, Hungary, Ireland, Israel, Italy, Japan, Korea, Malaysia, Malta, The Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Saudi Arabia, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, UK, USA.

Registration Day

The start of registration was delayed due to the late arrival of critical material from St Albans and this resulted in a large assembly of rather bemused delegates in the Adelphi foyer whilst frantic work went on behind the scenes to restore the situation. However things were sorted out and registration progressed smoothly. Inevitably the usual problems arose, concerning hotel bookings, names missing from the list of registrants, registration fees not paid, and so forth that afflict all conference organisers. The efficiency and good humour of the IOA staff kept the queue moving at the information desk and by the time the city tour was due to leave the hotel everybody was well and truly part of INTER-NOISE 96.

An important part of the arrangements for delegates was the delivery to their Adelphi Hotel bedrooms and to the various other hotels of their copy of the Congress Proceedings, a heavy box containing six volumes; a very dedicated team of helpers have to be thanked for this effort and a service whereby overseas delegates could arrange to have their boxes sent home.

On registration the more manageable document containing the congress programme and summaries of all the papers was made available to delegates together with a single folded programme card giving the location and authors of each paper, thus enabling delegates to plan which papers they wished to attend. These were given out, together with other useful documentation in a smart black, briefcase-style, holdall with shoulder strap and showing the INTER-NOISE 96 logo; these bags were much appreciated and rapidly became part of the INTER-NOISE 96 scene.


Delegates inspecting a poster presentation

The Opening Ceremony

A city orientation trip was arranged for the Registration day. Ten coaches left the Adelphi Hotel after lunch and gave the visitors a whistle stop tour of the main centres of interest in Liverpool including both the Metropolitan and Anglican cathedrals where short organ recitals demonstrated the superb instruments installed there. Then the delegates and accompanying non-delegates crocodiled the short distance from the Anglican cathedral to the Liverpool Philharmonic Hall for the official Congress Opening Ceremony, sponsored by CEL, at 17.00hrs.

While the congregation assembled in the superbly refurbished Philharmonic Hall they were treated to some fine music-making by a string octet from the Liverpool Youth Orchestra. Their programme included works by classical composers and finished with Scott Joplin. Such was the spell their music making cast upon the audience that when somebody greeted an acquaintance in a loud voice he was firmly shushed into silence!

Bernard Berry, as President of the IOA and General Chairman of the Congress, welcomed the visitors and wished them a successful week. He then introduced the Lord Mayor of Liverpool, Cllr Frank Doran, who gave the expected welcome to Liverpool and its delights and bestowed his blessings on the Congress.

Then followed the more technical welcomes in the persons of Professor John Tarn, Pro-Vice Chancellor of the University of Liverpool, Professor Dr-Ing Jens Blauert, Chairman of the Board of the European Acoustics Association (EAA), Dr Volker Irmer of DG XI, European Commission and Professor Bill Lang, President of International INCE. There followed the presentation to Bill Lang of the Honorary Fellowship of the UK Institute of Acoustics after which he gave the first of three Distinguished Visitors Lectures, 'A quarter century of noise control'. The text of this address was included in the July/August 1996 edition of Acoustics Bulletin.

Buses then transported the delegates and accompanying non-delegates to the Merseyside Maritime Museum, the Museum of Liverpool Life for the Welcome Reception and then to the various excursions which included a Mersey River cruise with buffet supper and a chinese banquet. After group photographs the Session Chairpersons and their families went on to the Merseyside Maritime Museum for pre-prandial refreshments, dinner in the presence of the Lord Mayor and briefing on their duties as chairpersons.

During this delegates' assembly day the manufacturers assembled their exhibitions. They must be congratulated on their considerable efforts in preparing an impressive, useful and entertaining display of instrumentation and services. The individual exhibitors are listed overleaf.

The Technical Programme

The main papers were presented in ten parallel sessions on Wednesday, Thursday and Friday and divided into fifty-seven separate programme sections; the titles of these are listed on page 28 and can be seen to cover the subject areas of noise control and environmental effects traditionally the focus of the INTER-NOISE series.

In addition to the formally presented papers there were over fifty informal poster presentations given in three sessions on each of the three days. With these, the presenter had half an hour to assemble the figures and texts on a board, two hours 'on-show' time and half an hour to remove the material to make way for the next poster session.

On Monday and Tuesday the mechanics of the technical sessions were set up. In addition to the usual audio/visual equipment and the sound reinforcement systems, at the entrance to each of the ten session rooms was the PC controlling the timing and an entrance lobby constructed with sound absorbing surfaces by Ian Critchley, an Institute member. These reduced the level of disturbing external conversation noise transmitted to the lecture spaces; particularly necessary for rooms near the exhibition and refreshment areas.

Coffee and tea were available at all times and at several places during the congress. As there were few breaks in the very intensive technical programme there was no set lunch time but instead a continuous buffet service provided by the hotel staff during the period 11.40 to 14.00, in various rooms not taken up by the presentations. It is perhaps an appropriate place to record that the hotel staff were peerless in their dedication to the comfort and needs of the visitors and deserve the grateful thanks of all concerned.

Wednesday 31 July This was the first day of the technical programme of papers and poster sessions and it was prefaced by the second of the Distinguished Visitor Addresses, this time given by Professor Philip Nelson, ISVR, on the subject, Acoustic Prediction. His theme was that whereas the future is unpredictable, sound is, being governed by well established classical theories, predictable with quantifiable accuracy. He reviewed recent research into active techniques for controlling sound and made an effort to predict their impact on the future of noise control. Both feedforward and feedback techniques were discussed within a control engineering framework and he attempted to relate this point of view to the adaptive signal processing methods currently in use.

Thursday 1 August The third Distinguished Visitors Address was given by Professor Keith Attenborough of The Open University; his subject was Natural Noise Control. At this time Professor Attenborough was presented with the Institute's Rayleigh Medal for 1996.

His paper dealt with the fact that the natural environment influences noise in several ways; atmospheric processes themselves create noise and also affect the generation of noise by road vehicle and aircraft engines. His theme was concerned with ways in which the natural environment reduces sound or can be encouraged to attenuate sound during its propagation. The coverage included the properties of porous materials, ground effects and propagation through trees and foliage.

The technical sessions then followed the pattern of the previous day with the manufacturers exhibition closing at six o'clock. Those booked for the Congress Banquet then retired to prepare for this prestigious event in the magnificent St George's Hall.

Obviously it is not possible to summarise the content of all the technical sessions and it would be invidious to highlight any one paper from all the hundreds delivered. Those who would like more details of the papers can of course purchase the Proceedings or view them in the Library at St Albans. However a chairman who sent in a brief resume of his Programme Section deserves, I think, to have it used as an example of those 57 varieties comprising the Congress technical programme. It illustrates the international nature of the treatment of the various subjects. It was the Section on Construction Noise and was co-chaired by Nick Antonio of the UK Building Research Establishment and Dave Towers of Harris, Miller, Miller and Hanson, USA. The session went as follows:-

'Nick Antonio (UK) started the session with a whistle stop tour of the new British Standard 5228 detailing noise and vibration control on construction and open sites. Professor Stelamaris Rolla (Brazil) detailed measurements of noise from medium size civil construction works on sites in Brazil, for operator, other worker and neighbour exposure to noise. Dr K K Lau (Hong Kong) of the Hong Kong Environmental Protection Department described the existing control of construction noise and recent developments. He examined legislative control, practical guidelines and a new 'pending limit' system.

Richard Clough (UK) of Wimtec (formerly Wimpey Environmental) detailed the prediction, assessment and control of construction noise in the UK, focussing on the origin of the noise standards and a case history in depth. He emphasised the practical controls and limitations that construction sites can work to. Steven Wolf (USA) gave a comprehensive talk on the noise from the construction of a tunnel project explaining rationale and the details of a sound insulation package offered to local residents.

Otto Martner (Germany) of Muller-BBM presented measured data on the noise levels of bridge to road crossings under various conditions for a number of bridges. He examined the effect of profile section and flexible seal details, showing some systems that can achieve substantial improvements. Richard Carman of Wilson, Ihrig and Associates (USA) shared his experiences with community response to ground-borne vibration from construc-

List of INTER-NOISE 96 Exhibitors

Academic Press
ACO Pacific
Analog/Causal/Technofirst
Automated Analysis
BRE Acoustics
Bruel & Kjaer
BSW Vibration Technology
CEL Instruments
Cirrus Research
DataKustik GmbH
Digisonix, Inc
Environmental Noise Barrier Association
European Process Management
Ferguson & Timpson
HEAD acoustics
Health & Safety Executive
HSE Books
Industrial Acoustics Company
Index Data Systems
INTER-NOISE 97/ OPAKFI
ISVR
Lambda Photometrics
Larson-Davis
LMS
MBI Products Company
Meyvis en Co
National Physical Laboratory
Neutrik (UK)
Nitto Boseki Co
Noise & Vibration Worldwide
Norsonic
Norwegian Public Roads adm
Ono Sokki
PAFEC
Quest/P.C. Werth
Sampson Modul Windows
Sony Magnescale Deutschland
Sound Absorption
SoundPLAN
Stapelfeldt Ingenieurges.
The Modal Shop
The Salex Group
Walesch Electronic
Wolfel
01dB

Acknowledgements

The Institute of Acoustics wishes to record its gratitude for the various forms of assistance generously provided by the following:-

George Maling of International INCE for pertinent and accurate advice together with valuable encouragement.

Dr Alfred Vella, Head of Computing at the University of Luton for the software design, with Robert C Hill, of the timing system.

Robin Cross of British Telecom for assistance with the audio-visual arrangements.

Staff and students at North Warwickshire College of Arts and Technology acting as audio-visual assistants.

Harman Audio (UK) Ltd, British Telecom Research and Ken Dibble Acoustics for the provision of items of audio-visual hardware.

South Bank University and Institute Distance Learning students helping as Congress Assistants.

Alistair Sommerville in connection with the poster sessions.

AMS Acoustics for providing registration staff

Mel Kenyon for assistance with setting up the city orientation arrangements.

Jason Haynes of BRE for on-site supervision of the timing system

Dr Tony Jones of the Acoustical Investigation and Research Organisation for general advice.

Staples Colour Printers, St Albans for the efforts of the printing staff at all levels.

Eileen Downey and her staff at the Britannia Adelphi Hotel.

Alison Kelly and staff at the Merseyside Tourist and Conference Bureau.

tion activity looking at building damage criteria. He highlighted the need for annoyance based vibration criteria and tabled some suggested targets.

The session was concluded by Dr Glenn Frommer (Hong Kong) of the Hong Kong MTRC, describing the extensive works and controls over the construction of a new rail system to serve the new Hong Kong airport. The size and complexity of the project with the high numbers of people potentially affected, provides huge challenges in construction noise and vibration control and the speaker provided an overview of the contractual controls, training and practical control, the scale of the project and experiences to date.'

Friday 2 August There being no Plenary Session, formal and poster sessions recommenced at 8.40 and continued until 16.00

The Exhibitors Reception

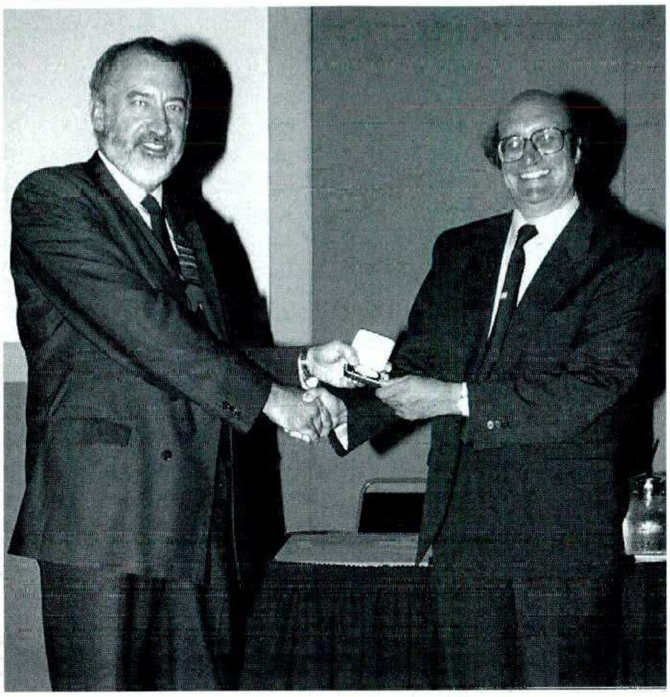
At the end of the first technical day the Exhibitors hosted a Reception in the exhibition area for delegates and accompanying non-delegates during which wine and soft drinks were served whilst the visitors toured the various stands. After this delegates were free to enjoy the evening as they wished but there were two organised events. One was a Mediaeval Banquet at Ruthin Castle in North Wales and the other a Mersey River cruise and buffet supper.

The Congress Banquet

St George's Hall, built in 1850, is one of the greatest 19th century buildings in the world. It cost £300,000 to build and would now be beyond the means of any city to contemplate. Liverpool is lucky to have such a masterpiece at its heart. In the 1850's Queen Victoria called the building 'worthy of ancient Athens'; in 1990 her great great great grandson Prince Charles called it 'one of the greatest public buildings of the last 200 years which sits in the centre of one of Europe's finest cities'.

The banquet was an event to remain in the memory for many years. The six hundred delegates and families were received in the Court Room and then entered the banqueting hall to the accompaniment of St George's Hall's grand Henry Willis organ. A truly magnificent start to a matchless occasion. When the guests were seated they were served a superb six course meal by waiters with a Liverpool accent and renowned sense of humour; they were happy to take photographs of table groups, with cameras trustingly handed to them by diners of all nationalities enjoying themselves immensely.

Following the dinner were the various addresses, the first given by the IOA President, Bernard Berry, then followed Professor Bill Lang, USA, Anita Lawrence, Australia, Per Bruel, Denmark and George Maling, USA. Bill Lang was presented with a silver cup by Bernard Berry in recognition of his services to the INTER-NOISE series and to mark the occasion of the 25th Congress. All would agree that the highlight of the speeches was that given by



The President presents the 1996 Rayleigh Medal to Professor Attenborough

the invited speaker Mr Peter Maloney. As a Liverpudlian born and bred his task was to initiate the guests into the mysteries of the Liverpudlian accent and the debt it owes to Irish, Scottish and Welsh origins. The manner in which he performed this task kept the guests in fits of laughter and applause. However there were several Liverpool/ Irish/Welsh in-jokes which resulted in some blank faces from overseas but in general the joyful humour was appreciated by all present.

The Closing Ceremony

After the finish of the technical sessions, people prepared themselves for the Closing Ceremony which took place at 17.00 in the Britannia Adelphi's main banqueting hall. This ceremony, sponsored by Brüel and Kjær, was hosted by the Hungarian Acoustics Society as an invitation to Budapest for INTER-NOISE 97. There were speeches by the President of the Hungarian Acoustic Society and other representatives, which included a video of the attractions of Budapest and its surroundings and a warm invitation to all present to plan to attend the 1997 Congress.

Anonymous adjudicators had chosen the two posters which, together with their presenters, most clearly and attractively transmitted their messages. Although there were many excellent entries the winners were – a French entry by P Boineau, Y Gervais & V Morice with their poster 'An aerothermoacoustic model for computation of sound radiated by turbulent flames' and a Hungarian entry by A Pota & F Kvojka, 'Investigation of community complaints in Budapest'. Bernard Berry presented the winners with engraved shields.

Bill Lang spoke of the many innovations that marked what he described as 'the most fantastic INTER-NOISE congress ever' and predicted that many of them would find their way into future events.

Then came final farewells by the IOA President who gave thanks to all those who contributed to the success of INTER-NOISE 96. Bouquets were presented to Nicole Porter, the Technical Programme Manager and to Eileen Downey General Manager of the Britannia Adelphi Hotel, whose wholehearted cooperation together with that of her staff had ensured the smooth running of the domestic arrangements of the congress. Bernard then thanked his wife Penny for her practical help and loyal support; her reward was a surprise holiday in Turkey, with Bernard of course! Bernard himself was then handed a gift in recognition of his work as Congress Chairman; he opened it to reveal a framed print of a well known Liverpudlian scene.

The visitors were then invited to be guests of the Hungarian delegation at a supper of Hungarian food complemented with generous quantities of Hungarian champagne.

Thus ended the Silver Jubilee of the INTER-NOISE series, widely acclaimed among delegates during and after the Congress as the most successful ever. World research into the understanding and control of noise is in good hands as evidenced by the obvious enthusiasm and dedication of the speakers when presenting their progress at the Liverpool Congress, thus amply supporting the optimistic Logo of INTER-NOISE 96, Noise Control – the Next 25 Years. This surely augers well for the achievement of the quieter world we are all striving for. The Hungarians take over the mantle for 1997 and, with the birth pangs of the Liverpool Congress still fresh in our minds, we wish them good luck and every success in Budapest next year. Waiting in the wings for 1998 is New Zealand.

John W Tyler FIOA ❖

Personal note by the author.
I, and others, feel that not sufficient public acknowledgement has been given to the IOA St Albans staff for their work on the mammoth task of organising the infrastructure of INTER-NOISE 96. Linda, Ann, Joanne, Gill and Luk of the permanent staff not only worked for the Congress and helped run it in Liverpool but also kept the rest of the IOA organisation going. The many part time staff supported them fully. David and Richard, partners of Joanne and Linda respectively deserve special thanks for the generous way they helped with the organisation in Liverpool. However, two people merit special mention for their efforts beyond the call of duty. Cathy Mackenzie and Roy Lawrence showed complete disregard for their own interests as they wrestled with the neverending tasks and problems which arose. In the weeks leading up to the Congress, they worked 18, 24 and, on two occasions, 48 hours without stopping. I know this because I spent some time at St Albans helping to produce the special Congress edition of Acoustics Bulletin. Their supreme efforts ensured that INTER-NOISE 96 was the great success that it undoubtedly was and it would be most unfair if these efforts were not fully and warmly acknowledged in print. All the people at St Albans deserve our thanks and gratitude.
A final piece of information. The Congress Manager's grandfather (also a man of enterprise) ran a horse and cart to take emigrants' luggage from the Adelphi to ships on the Mersey. Could he have been the last Englishman the ancestors of some of our USA delegates spoke to before sailing? He later lost a hand in a bar room brawl in Boston, Mass.

PARTNERSHIP IN ACTION

Mike Heath CB CBE CEng

The engineering profession has reached a stage where we are now seeing the fruits of many years of discussion and negotiation aimed at establishing a single, clear voice, delivering messages which are not only heard but are respected and acted upon by Government, industry and other agencies with whom we work.

Between us, the Engineering Council and the professional Institutions have at last safely negotiated a unity within the profession. The tangible result was the launch earlier this year of a restructured Engineering Council, signalling a new relationship between our respective bodies.

It would be easy to dismiss 'unification' and the 'new relationship' as just so many ambitious words. However, in the few months since the establishment of the new Council we are already seeing positive evidence of the relationship developing into a true partnership, able to address and resolve many of the diverse issues facing the profession.

This is as it should be: if the correct image of a dynamic, wealth-creating profession is to contribute to a change in the perception of the role of engineers and technicians, then the emerging partnership is essential. It is essential not only to address the high profile issues, but also how our mutual resources are harnessed most effectively.

The new Engineering Council has many roles, from that of a facilitator to being the voice of the profession. These are roles it obviously must not and cannot carry out unilaterally. The Council and the Institutions have to work together to develop the profession in ways that will achieve the respect and status we seek. We are looking for a degree of acceptance by government, industry, academe and the public that, despite recent progress, is not yet there.

It is heartening, therefore, that we are seeing the partnership in action in many forms. By its very constitution, the Senate of the Council is itself an example of the relationship working, as are the many pan-Institutional groups set up to define direction and policy for the profession on key issues.

There are now solid examples of collaborative working and achievement at many levels to show how productive our partnership can be. For example, the grass-roots of the profession lie in regional structures and networks. Partnership at this level is particularly important and that is why the Regional Affairs Institution Working Group was an early initiative. The Group, under the chairmanship of Dr John Williams, has worked well together to come up with proposals to rationalise the regional network. Vital to the future of the profession and its standing in society is the mapping of education, training and competence standards for engineers and technicians, not just for today's generation, but also for those succeeding it. Although the setting of such standards is the Council's responsibility, it was immediately obvious in the New Relationship that arrangements could only be agreed in partnership with the broader church of Institutions, industry and the world of education. The Institution Working Group on the revision of SARTOR has wrestled with this difficult issue and the important debate has perhaps taken a little longer than some expected. What matters is that we ultimately have a satisfactory conclusion that best serves all interested parties - in partnership we all have a stake in getting it right. It is hard to envisage any other way in which such a thorny issue could be handled.

Other groups are dealing with important issues concerning the quality assurance of nominated bodies and our relationships with industry. We will also need to address in more detail S/NVQs, CPD and the particular contribution our Young Engineers can make.

But those who put together the New Relationship saw that we should not only be looking inward at the internal arrangements for the profession, but should look outwards at some explicit contribution to the affairs of the nation. They developed the idea of the 20/20 Vision Programme with four themes: Transport, Energy, Communications and the Environment. Under a lead Institution in each case, all Institutions have had the opportunity to join together to produce a significant contribution to the national debate. I have been delighted to see the way in which Institutions have been prepared to collaborate in such a fruitful way.

A key activity for the profession is to be able to respond to government initiatives and proposals. We have taken a new approach to the sharing of responsibility here by inviting an Institution to pull together a profession-wide response. One example was the British Computer Society which co-ordinated the response to the government's Information Society Initiative and another is the Institution of Civil Engineers who are co-ordinating a response to the Government White Paper on Competitiveness.

We are also accepting offers of Institution resource in other ways. For example, the public relations for the Council's Environment Award has been taken on by the Institution of Electrical Engineers. We are also looking at the possibility of seconded personnel from Institutions working in the Council.

There are of course a host of other issues being addressed and important projects in hand. In particular, the profession is deeply involved in the Year of Engineering Success, now building up for 1997. We

have also made a major contribution to the government inspired Action for Engineering initiative, now drawing to a close but with much implementation work left in the profession's hands. Regular meetings between Council staff and Institution Secretaries help to ensure that work is being taken forward in agreed and co-ordinated ways. I suppose that the most burdensome part of the partnership is the need to communicate. That is always hard work but absolutely vital, even if it seems sometimes at the cost of a rainforest or two! I am only too aware that it is a big effort to receive and assimilate communications as well as to send them and we need to do more work to avoid unnecessary bureaucracy and sharpen our systems.

Our relationship is still at a formative stage and I don't suppose there are many who will disagree with my view that the challenge for us all is in sustaining long-term what has started so well. But succeed we must if the engineer is to take a proper place in the public mind and in national decision making.

Of course, the philosophy of partnership should extend beyond the engineering profession itself. If we are really to have a meaningful dialogue with government, then we need to form links with the other members of the engineering community nationwide. That includes the representatives of industry and academia.

I am glad to be able to report that there seems to be general support from other bodies for the proposition that some sort of forum, based perhaps on the groupings formed for Action for Engineering, is needed. We can be sure that the engineering profession would be asked to play a leading role in any such forum.

Finally, I have already mentioned the Year of Engineering Success. Next year has every prospect of being the most exciting for engineers in living memory as the YES team develop their plans to celebrate the successes of our engineering efforts. I hope that as many of you as possible will feel able to do something personally to help make it go with a swing.

Mike Heath is Director General of the Engineering Council

Institute Fellow's Achievement Applauded

The election of three women engineers as Fellows by the Royal Academy of Engineering has been applauded by campaigners for more women to enter the profession.

Among 45 eminent engineers elected this year is Ann Dowling, Professor of Mechanical Engineering at the University of Cambridge and a Fellow of the Institute of Acoustics. The others were Dr Sue Ion, Director of Technology Development, British Nuclear Fuels; and Dr Rachel Spooncer, Operations Manager, ICI Engineering Technology.

Citations

Rayleigh Medal - 1996

Professor Keith Attenborough

Keith Attenborough studied physics at University College London, graduating in 1965. Although his final year research project was on the subject of astrophysics and a career in physics teaching was on the cards, a change in plans found Keith at Leeds University researching into engineering acoustics. This led to the award of his PhD in 1969, for his thesis entitled 'Sound Dissipation in Porous Media', since when the acoustical properties of porous materials have remained one of Keith's particular research interests.

After brief periods as a Research Assistant at the Bartlett School of Architecture and a Research Fellow at the Department of Building Engineering, University of Liverpool, Keith joined the Open University in 1970 as a Lecturer in the Engineering Mechanics Discipline of the Faculty of Technology. Rising through the ranks of Senior Lecturer and Reader he was promoted to a personal chair as Professor of Acoustics in 1992.

Early in his Open University career, Keith's energies were largely absorbed by the process of contributing to the first Technology Foundation Course. Whilst preparing this, he developed his interest in outdoor noise as a suitable subject for his future using Home Experiment Kit Sound Level Meters specifically produced for the project. Over a period of several years, the accumulated student noise survey data have helped to examine trends in noise levels in the United Kingdom.

For his principal research subject of outdoor noise, Keith had become intrigued by naturally occurring porous material and the prospect of energy efficient exploitation of these materials for acoustical purposes. Much of his research has focused on the ground effect which is sensitive to the acoustical properties of the surface, and he has been involved in numerous measurements in the United Kingdom and the United States of America to study the various parameters involved.

Keith's work has contributed significantly to the prospect of designing the outdoor environment for noise control. His studies have also encompassed the asphalt which is used to control tyre/road noise, and latterly investigating the use of porous materials to clad vertical surfaces of buildings and barriers.

Keith has been awarded numerous Visiting Professorships at Universities throughout the United States of America, Europe and India. He has authored or co-authored over sixty refereed papers in Academic Journals and is Associate Editor of Applied Acoustics and of Acoustica/Acta Acustica.

He is a Fellow of the Institute of Acoustics and a Fellow of the Acoustical Society of America.

The Institute of Acoustics is pleased to award the Rayleigh Medal in 1996 to Professor Keith Attenborough for distinguished academic and professional contributions to the discipline of acoustics.

Honorary Fellowship - 1996

Professor William W Lang

After majoring in physics at the Massachusetts Institute of Technology, Bill Lang joined the US Navy. He received his B.S. in physics from Iowa State University in 1946 while still serving in the Navy, from which he was released to the Reserve in 1947. Returning to MIT, he gained his M.S. in 1949 while working at the MIT Acoustics Laboratory. This was followed by periods of employment as a consultant at Bolt Beranek & Newman, as an Instructor of Physics at the US Naval Postgraduate School and as a consulting engineer in acoustics at the DuPont Company. During this period, Bill continued with his studies and in 1958 was awarded his PhD in physics from Iowa State University.

Bill Lang commenced his long association with IBM in 1958 when he was appointed to head the Corporation's programme to design low noise computers and business machines, this project being based at the IBM Acoustics Laboratory in Poughkeepsie. Bill also made substantial contributions to technical advances in digital processing of acoustic signals and in audio engineering. He has had a major influence on the development of international standards for the determination of noise emissions from computers and business equipment, having served on and chaired many national and international technical committees and working groups. In 1989, Bill was instrumental in establishing the IBM Academy of Technology, and after 34 years with IBM he retired from his post as Program Manager - Acoustics Technology in 1992.

Through his leadership and contributions to acoustics, Bill Lang has shaped the development of the field. He has long advocated noise control engineering as a discipline requiring formal education, professional qualifications and continuing professional development. In 1971, he was a founder member of the Institute of Noise Control Engineering in the USA. In 1974, he co-founded the International Institute of Noise Control Engineering (I-INCE), of which he is President. With the late Fritz Ingerslev, Bill Lang has ensured that I-INCE is the leading international organisation dedicated to applying physical and engineering principles to the control of environmental noise. He has also been President of the Noise Control Foundation since 1975, has served as a Member of the Executive Council of the Acoustical Society of America and is now the Society's Treasurer.

Bill is a member of the (US) National Academy of Sciences and a Fellow of several Professional Societies, including the Institute of Electrical and Electronic Engineers, the Acoustical Society of America, the America Association for the Advancement of Science, the Audio Engineering Society and the Institute of Acoustics. Over the years, he has won many awards including the Silver Medal of the Acoustical Society of America. He has been the editor of two books, has authored or co-authored more than 50 technical publications, and is Features Editor of Noise/News International.

In parallel with his busy professional career, Bill Lang remained active in the Naval Reserve, specialising in submarine acoustics. Over his 35 years of naval service he commanded three Naval Reserve units, and now remains on the Navy's roster as Captain US Navy (Retired).

The Institute of Acoustics is pleased to award an Honorary Fellowship to Professor Bill Lang in recognition of his outstanding contributions and international leadership in the field of noise of control engineering. ❖

Hansard

24 July 1996
Noise Barriers

Mrs Dunwoody: To ask the Secretary of State for Transport what plans his Department has to extend the use of acoustically absorbent noise barriers alongside roads.

Mr Watts: I have asked the Chief Executive of the Highways Agency to write to the hon Member.

Letter from Lawrie Haynes to Mrs Gwyneth Dunwoody, dated 24 July 1996:

The Secretary of State for Transport has asked me to reply to your Parliamentary Question concerning any plans for extending the use of acoustically absorbent noise barriers alongside roads.

Noise mitigation barriers are prescribed in principle by location, length and height; various other characteristics may be provided for in particular contracts to prescribe quality and type of materials, structural form and acoustic properties.

Decisions on the use of absorbent materials in noise barriers are made on a case by case basis on the grounds of technical merit and cost effectiveness. They do provide a measure of relief from reverberation of traffic noise which reduces the effectiveness of conventional barriers in some circumstances.

There are no forward plans to specifically extend the use of absorbent materials, except to the extent that circumstances may justify it.

Extract provided by Rupert Taylor FIOA

Book Reviews

Sound Intensity, 2nd edition
F J Fahy
E & F N Spon, 1995
ISBN 0-419-19810 5 £29.99

Edition 2 of 'Sound Intensity' is a paperback book for anyone who is working in the field or even has any interest in it. Edition 1, a hardback published in 1989, was a true compilation of the then present knowledge. The author stated in the preface 'My principal purpose in writing this book has been to compile information about Sound Intensity' and the subject was covered as well as any such volume could. Edition 1 organisation was not as logical as many readers would have liked and this has been addressed in edition 2. New chapters now appear, one of which, 'Chapter 7: Errors in sound intensity measurement', pulls together data which were spread more widely in edition 1 and is thus more easily understood. However, many error sources still need reference back to other chapters and while these are given, perhaps even more error data could have been regrouped to give an easier understanding of potential measurement errors. It is now however one of the better references works in this area.

The content of edition 2 is little different in concept to edition 1, but the passage of time has given more formality to some measurement methods and allows new instrumentation techniques to be discussed. The history of sound intensity is briefly discussed with over 30 references to historical work for those with such an interest. The two following chapters 'Sound and sound fields' and 'Sound energy and sound intensity' are very similar to the original and, apart from some tidying up of symbols and the addition of a section on reactive intensity, add little new information. Sound intensity is described in both mathematical and descriptive form, but a similar criticism applies as to edition 1, in that a small addition of more simplistic description would have helped the casual 'browser' without taking anything away from the more serious reader. Those who have attended Frank Fahy's lectures are usually treated to such a description and such an addition would have made the book a good 'bedtime' read as well as being an authoritative work. This being said, these two chapters are probably the best source available to answer the question 'What is sound intensity?'

The chapters on measurement principles have been extended by adding measurement of transient sound fields. Many of the changes are reserved for chapter six, now titled 'Instruments and calibration' where multi-microphone probes are covered. The 1993 IEC standard 1043 is explained and useful information is provided for those undertaking sound intensity measurements, both debutantes and experienced users. A composite section on 'System performance evaluation and field calibration' covers similar ground to the previous edition, but now it is laid out more logically and has additional data which many will consider essential. Sound power is separated out in Chapter 9 and as a result is easier to follow. In particular, four ISO 9614-1 indicators are defined and explained as well as two scanning indicators. The chapter then goes on to practical examples of sound power determination; a vital matter for those undertaking it for the first time.

A total of 186 references give a most comprehensive source list of both practical and theoretical issues and there is little doubt that for everyone interested in sound intensity, this book is invaluable, it may be that only those who are using the technique outside the laboratory may find it worthwhile to buy if they already own edition 1, despite the lower price; perhaps calling it edition 1.9 may well sum up the changes. It is however, truly a classic book.

Alan D Wallis

Numerical Ocean Acoustic Propagation in Three Dimensions
Ding Lee & Martin H Schultz
World Scientific Publishing Co Ltd
ISBN: 981-02-2303X £39

In recent years in the UK, long range underwater propagation modelling of all descriptions, let alone 3D, has fallen by the wayside. This is a pity because there are some interesting effects due to horizontal refraction and cross-slope propagation which could influence tomography experiments. In addition, of course, the mathematics is equally applicable to a physically scaled down version of the environment with correspondingly reduced wavelength. Whilst orders of magnitude can be estimated on cigarette packets, hard number crunching (on super-computers) is the only way for the details.

In the USA propagation work continues. This timely book for researchers consolidates the authors' well known development of 3D parabolic equations to calculate propagation loss.

It starts with the Helmholtz equation (for a sine wave source) and ends with their brainchild, the computer model FOR3D, for which a 50 page listing is given in Chapter 8. Terminology is clear and derivations of differential equations are explicit and straightforward. The authors take some trouble to justify approximations, and there are a number of tests against analytical solutions throughout. Even operator formalism is used painlessly to derive and manipulate the two basic numerical schemes that form the backbone of the approach. Although each chapter has its own references, puzzlingly there is no overall index.

Chapter 4 goes to town on the Lee-Saad-Schultz approach on which FOR3D is based. It includes flow charts and discussion of the main subroutines.

I was surprised in Chapter 7 (Three-Dimensional Effects) that the author didn't do a harder sell of the subject. Where do you see the greatest effect? What is the maximum horizontal bend? Would the calculated phase differences alter tomography results or active sonar time smearing, etc? In fact they simply compared the FOR3D optional solutions for decoupled azimuth dependence 'Nx2D' and for coupled azimuth dependence '3D' in two cases: a gulf stream eddy environment, and a continental slope. Presentation of these differences could perhaps have been enhanced by using contour plots or standard graphics packages.

Chris Harrison ❖

Editor's Note

Jon Silverman, the author of the article 'Aspects of Research on Acoustics in the UK' published in the July/August 1996 issue of Acoustics Bulletin, has written to point out that his brother Andrew Silverman, but not he, is a member of the Institute. Jon was therefore accredited with the title MIOA in error.

A J Asbury AMIOA has written to point out that he was the author of the Consultancy Spotlight 'Noise in a Hydro-Electric Power Station', published in the July/August 1996 issue of Acoustics Bulletin and not his colleague, Philip Dunbavin MIOA.

New Products

LARSON•DAVIS LTD

Accurate Environmental Noise Modelling Windows Software

Larson•Davis, Inc is pleased to announce that Australia-based RTA Technologies has appointed Larson•Davis as its international Distributor of ENM Software for North and South America and the United Kingdom. ENM, 'Environmental Noise Model', is Windows 3.1 and Windows 95 software used to predict noise levels from sources at a distance. The noise level attenuation is calculated for the effects of distance, barriers, ground effects, wind, and temperature gradients.

ENM comes with four modules. SOURCE helps characterize the sound producer. SECTION describes the two-dimension elevation and height of the ground from the source to the receiver. MAP permits 3D topography to be defined using ground contours. The ENM SCENARIO module does the work of calculating sound contours. All modules can be opened at once to assure fast and understandable data entry and immediate visualization of results.

Some features include:

- Up to 100 sources and multiple receivers.
- Source directivities at any selected point (not just the 20 ISO points)
- Finite width and barriers calculations
- Auto hatching to do what-if scenarios over a range of meterological conditions
- Full hardware support for Windows 3.1 and Windows95 with digitalizer input
- Optional programs meet exact requirements of special algorithms; BBN/EEI, CONCAWE, NORDFORSK
- Modules available for ISO 9714 and VDI 2714

Advanced Sound Level Meter: System 814

The Larson•Davis System 814 is a totally modern implementation of the classic SLM with switched analog octave filters, adding a number of state-of-the-art features such as dual peak detectors and the versatile data logging capabilities unique to the Larson•Davis line of handheld sound level meters.

Highlights of this ergonomic Type 1 SLM include an exceptionally large dynamic range (> 100 dB) with automatic scanning through the analog bandpass filters. The icon-driven user interface includes scrolling pull-down menus and a pick & choose setup mode. A large backlit true bit-mapped graphics display provides an optimal presentation of spectra and time history/ statistics graphs. Flash memory will permit easy field upgrades of the system firmware as new features become available. The battery life of approximately 40 hours using 3 AA cells.

Integrating Sound Level Meter DSP-80

This lightweight integrating sound level meter uses digital signal processing (DSP) electronics for outstanding dynamic range and flexible filtering, while maintaining full type 1 accuracy.

The microphone is a robust 3/8" electret type providing a dynamic range of more than 100dB in a single (primary indicator) range.

Measuring parameters include:

- A, B and C frequency weightings
- FAST and SLOW exponential-time-averaging
- C-weighted PEAK detector time weighting (or averaging)
- Leq integrated level (A and C weighted)
- Maximum rms (root mean square) level since last reset
- Quartz controlled elapsed time display
- Calibration from front panel
- Addressable RS-232 communication port

Further information on these products may be obtained from Larson•Davis Ltd , Redcar Station Business Centre, Station Road, Redcar, Cleveland, TS10 2RD Tel: 01642 491565 Fax: 01642 490809

01 dB

SONATA: user-friendly acoustic and vibration measuring system

French company 01 dB, specialists in top-end (class-1) computer-assisted acoustic measurement instruments, has developed Sonata - a new easy-to-use acoustic and vibration measuring system.

The Sonata system is based on a low-cost acquisition board, with control software offering the same advanced features as the top-end 01 dB models.

The Sonata system takes the form of a precision microphone that connects directly to a PC with multimedia capabilities running any of the 01 dB acquisition or processing packages for Windows.

Users can choose between the dBENV package for environmental noise analysis, the dBBATI package for building acoustics and reverberation time analysis, and, above all, the dBFA package for post-processing and real-time frequency analysis.

Sonata is stated to be ideal for industrial applications (such as quality control testing) that do not require high precision or involve a large number of test points (and thus a large number of measuring systems). It also provides an affordable solution for design offices with occasional acoustic or vibration test requirements. Sonata offers high-performance capabilities for solving highly complex problems, such as FFT analysis covering up to 3,700 points (in post processing or with transient module).

For consultant engineers working with sound level meters, Sonata is said to provide a fully complementary solution for analysing building acoustic problems: acoustics technicians can record the signal from the sound meter onto a tape recorder for subsequent analysis using Sonata.

Multiple-user licences are available at special terms.

The Sonata system takes the form of a full kit including a high-quality multimedia board, 01 dB software modules as required, and a class-2 microphone with preamplifier and power supply.

For further information on Sonata or other 01 dB products please contact either M. Fabrice Parodi, 01dB, 111, rue du 1er Mars, 69100 VILLEUEBAINE, FRANCE. Tel: (00 33) 78 53 96 96 Fax: (00 33) 72 33 02 12 or John Shelton MIOA, 6 Church Lane, Cheddington, Leighton Buzzard, Beds LU7 0RU. Tel: 01296 662852 Fax: 01296 661400

NIT (NUMERICAL INTEGRATION TECHNOLOGIES)

SYSNOISE Revision 5.3

NIT have released SYSNOISE Rev 5.3 which offers complete analysis capabilities, with acoustic FEA and BEA calculation modules and the possibility to model the interaction between a vibrating structure and any acoustic medium, such as air or water.

SYSNOISE Rev 5.3 is available to work on all major UNIX workstations and parallel computers. Additional versions on PC (Windows NT and 95), CRAY, CONVEX and Inter Paragon will be available.

SYSNOISE Rev 5.3 adds more new features than every previous upgrade and has a completely reworked Graphical User Interface, with on-line hypertext-based documentation. A customizable button window will allow users to assign each step of the analysis process to different buttons. New dedicated postprocessing tools include visual and audio animation of predicted sounds.

This new revision is based on a multi-model concept. In earlier revisions users were limited to working on only one Finite Element (FE) or Boundary Element (BE) model at a time, but now they can analyze super-models which comprise multiple FE and BE models. Three additional calculation methods (infinite-FEM, generalized Indirect BE and the Raleigh method) allow computational efficient treatment of complex acoustic problems.

Other major new features allow the study of the effect of mean flow on acoustic propagation in ducts, and to simulate the vibro-acoustic response of a structure subjected to random loads, e.g. in a reverberation chamber, or to find out which parts of the structure are really most responsible for the radiated sound.

One of the most significant enhancements to SYSNOISE Rev 5.3 is the NetSolver which allows to split large jobs over different CPUs in a network, practically dividing calculation times by the number of CPUs involved.

MOSART

Numerical Integration Technologies (NIT) have also announced the release of MOSART. MOSART is a Computer-Aided Engineering (CAE) software tool to predict acoustic comfort levels inside passenger compartments (cars, trucks, buses, trains, ships and airplanes). Other applications include the analysis of vehicle pass-by noise and noise emission simulations.

MOSART uses Advanced Ray Tracing (ART) technology to predict high-frequency acoustic characteristics of complex enclosures. MOSART complements the Boundary Element (BE) and Finite Element (FE) technology already available from NIT through its well-known SYSNOISE software. SYSNOISE, with its BE and FE methods is more suited for low to medium frequency acoustics.

MOSART will be used to optimize the placement of speaker systems and to position sound trim packages. Phenomena such as acoustic diffusion and sound transmission through walls are easily accounted for. Phase ray-tracing enables modelling acoustic interference effects.

MOSART has its own graphical user interface which is fully integrated in the SYSNOISE environment, sharing its new database structure. Easy-to-use menus and graphical buttons will guide the user through the solution sequence. Model geometries are imported through embedded interface routines to most common FE and mesh generator packages, such as MSC/NASTRAN, MSC/PATRAN, Hypermesh, ANSYS, SDRC/I-DEAS and others.

NIT specializes in developing software for predicting and optimizing the sound radiated by vibrating structures. NIT is a wholly owned subsidiary of LMS International, Leuven, Belgium.

For more information, please contact Mr Peter van Vooren, NIT, LMS Numerical Technologies, Interleuvenlaan 70, B-3001 Leuven, Belgium. Tel: (+32) 16 384500 Fax : (+32) 16 384550.

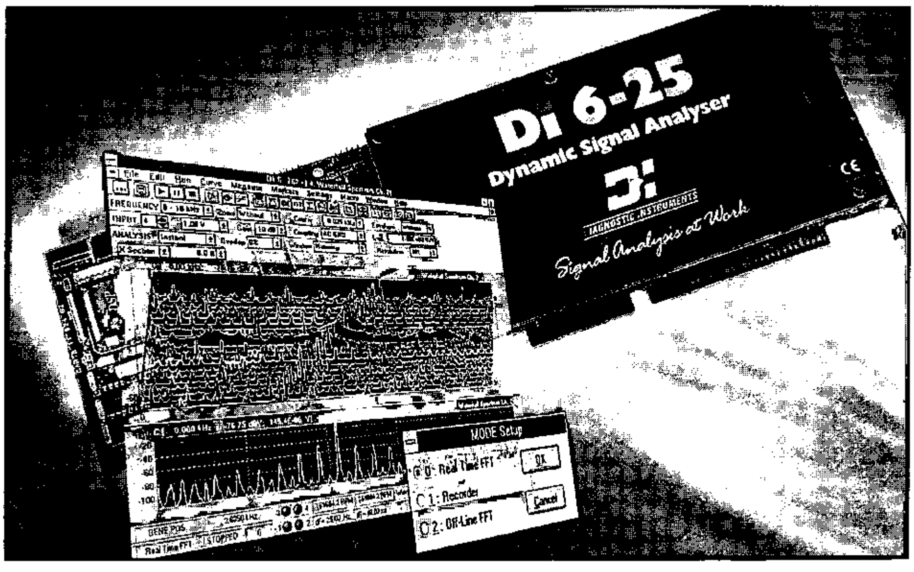
DIAGNOSTIC INSTRUMENTS

Real-time Noise and Vibration analysers - DI 6-25

The DI 6-25 range has a modular design which allows users to select the combination of hardware and software that best suits their requirements. Should those requirements change, additional hardware and software modules can be added to expand and enhance the system's capabilities as required.

At the heart of each DI 6-25 is an autonomous measurement and signal processing system that plugs directly into the ISA bus of a host PC. This system performs all measurement and computationally-intensive signal processing tasks, thus guaranteeing both performance and measurement quality, regardless of the specification of the host computer.

DI 6-25 system can be con-



figured with between 2 and 14 inputs for multi-channel FFT analysis or up to 26 channels for data recording. All inputs are fully-parallel providing synchronous sampling over all channels at up to 51.2 kHz (20 kHz analysis bandwidth) using multiple high-precision 16 bit A/D converters. An integral signal generator is used for internal calibration as well as providing a wide range of signal types for vibration or acoustic test purposes. A dedicated 50 Mz floating point Digital Signal Processor delivers a real-time FFT bandwidth of 20 kHz on up four channels while computing a 3200 line spectrum.

Application software for the DI 6-25 allows the instrument to be configured simply as a high-speed data recorder, as a multi-channel real-time FFT analyser or as a multi-channel recorder with off-line FFT analysis capability.

All of the DI 6-25 application software is written for Windows 3.1 and Windows'95, providing not only a familiar and consistent user-environment but also transparent data exchange with other Windows applications through 'Cut and Paste' or export of text and graphics to standard text, bitmap or meta files.

Particular care has been taken with the design of the DI 6-25 hardware and software to ensure that the system is both easy to install and easy-to-use. Since no hardware configuration adjustments are required, installation of both hardwarte and software can typically be achieved in a matter of minutes. Furthermore the graphical user interface provides 'virtual instrument' control over all aspects of measurement setup, processing and data acquisition control that one would expect in a stand-alone instrument.

The DI 6-25 provides a full range of time and frequency domain functions with integration to convert between different forms of measurement and display units. Both 2-D and 3-D displays are available with a comprehensive cursor functions including extraction of spectrum and order information from 3-D maps.

Once acquired, data can be exported from the DI 6-25 in a variety of industry-standard file formats allowing it to be read-in to spread-sheets and word-processors, as well as the majority of third-party post-processing applications.

An optional software tool-kit is available for each DI 6-25 application program which allows control of all major functions and data exchange through DDE links as well as customisation of the Widows user-interface using Visual Basic.

The DI 6-25 range fully complements DI's range of hand-portable single and dual-channel analysers, whilst DI's QuickStartTM training programs help users to be productive from day one.

For additional information please contact Steve McMahon or Peter Rogers, Diagnostic Instruments Ltd., 2 Michaelson Square, Kirkton Campus, Livingston, EH54 7DP. Tel: 01506 470011 Fax: 01506 470012

CEL INSTRUMENTS Ltd

Gsi-65 Hearing Conservation System

CEL Instruments, a Welch Allyn company, with a long track record for providing training and risk assessment products, have now expanded this coverage with health surveillance products from Welch Allyn's Medical division.

The first product to be introduced is the GSI-65 Industrial Audiometry system, a PC controlled product with extensive database capabilities for an employee-centred Hearing Conservation Programme. It comprises the GSI-17 Audiometer, which meets both IEC and ANSI specifications, together with PC communications and database software.

This combination allows the system to be configured for three different levels of complexity to satisfy the requirements of small, medium and large organisations.

Using only the GSI-17's manual screening facility an audiometric test can be easily completed by an Occupational Nurse. Adding the GSI-65 Automatic PC communications software provides fully automated hearing testing, requiring a minimum of supervision, for a highly cost-effective audiometric screening programme.

With the further addition of the GSI-65 Enhanced Database software it is possible to store employee demographic data, job function information, noise exposure and hearing records in an integrated database which can sort and group data through the use of a query language.

There are two models in the range: the Automatic Industrial Audiometer is suitable for organisations seeking cost-effective Health Surveillance while the Enhanced Industrial Audiometer will appeal to multinational or multi-site operators.

For further information contact: CEL Instruments Ltd, 35-37 Bury Mead Road, Hitchin, Herts. SG5 1 RT Tel: 01462 422411 Fax: 01462 422511

CEL Instruments is a Key Sponsor of the Institute

LORIENT

Acoustic Door Seals

Lorient Polyproducts has produced a comprehensive guide to the acoustic performance of its range of fire, smoke and environmental seals.

For all products, comparative figures are provided for acoustic performance relating to an unsealed door, to a fully caulked door (representing theoretical maximum performance) and to the improvement achieved using the relevant Lorient seal. The tests were carried out at Sound Research Laboratories Ltd. in accordance with BS EN ISO 140/3 - 1995 'Laboratory measurements of airborne sound insulation of building elements.' The test data is for a range of commonly used door leaf constructions, including extruded chipboard, solid chipboard, non-combustible vermiculite and other mineral cores. None of the tested constructions were specifically designed for acoustic performance so that the contribution of the various seals tested was not enhanced in any way.

Comprehensive details of the test findings are incorporated within 'Acoustic Sealing Systems for Door Assemblies' available from : Lorient Polyproducts, Fairfax Road, Heathfield Industrial Estate, Newton Abbot, Devon TQ12 6UD. Tel: 01626 834252.

Items for this section should be sent to Mr J Sargent MIOA, Oak Tree House, 26 Stratford Way, Watford WD1 3DJ

Letters to the Editor

The Editor
Acoustics Bulletin

Sir,
I enjoyed reading the article on 'Aspects of Research on Acoustics in the UK' in the July/August 1996 issue of the Bulletin, but would just like to correct one minor detail regarding the status of the National Physical Laboratory. NPL remains a government laboratory but is now operated under contract by NPL Management Ltd, the management model being known as 'Government-Owned, Contractor-Operated' or GO-CO.
Yours sincerely,
Dr Graham Torr MIOA
Head, Acoustics Branch, Centre for Ionising Radiation and Acoustics, National Physical Laboratory

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The Editor
Acoustics Bulletin

Sir,
I write with regard to 'Aspects of Research on Acoustics in the UK' by Mr Jon Silverman, published in the July-August Bulletin.

Mr Silverman volunteers the suggestion that the achievements of 'accurate sound measurement' and 'active noise control' might 'epitomise 20th century acoustics'.

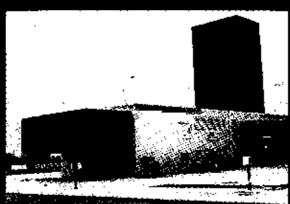
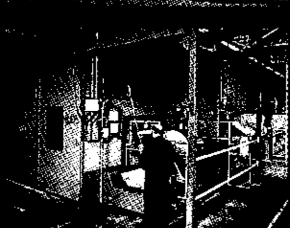
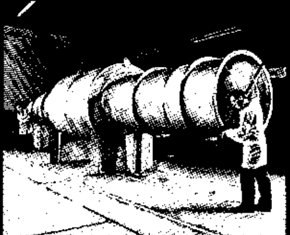
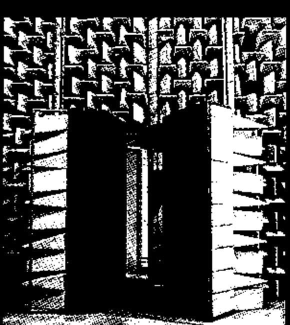
Whilst he is of course entitled to his opinion, I feel that, despite his caveat, he does undermine other acoustics disciplines. I suspect each member of the Institute has their own (different) opinion of such a major accolade. I shall not venture my own view save to suggest that, surely, the saving/protection of life must rank higher than improving the quality of life? Perhaps we should leave the judgement of our achievements to the 21st century acoustics historians!

Notwithstanding the above, I would like to thank Mr. Silverman for an interesting and informative summary.

Finally, he and other members might find further historical interest in the writings of Stokes [1], who was one of the earliest (perhaps the first?) to derive the equation for radiation from a spherical source, and Hunt [2] who provides a comprehensive historical summary of transducer development including many British references.
Yours sincerely,
J R Wright MIOA

[1] G G Stokes, On the Communication of Vibration from a Vibrating Body to a Surrounding Gas, Phil Trans Roy Soc, 158, pp 447–463, 1868.
[2] F V Hunt, Electroacoustics - the Analysis of Transduction, and Its Historical Background, Amer Inst Physics, 1982 (first edition 1954). ❖

The Salex Group Limited
Noise Control Engineers

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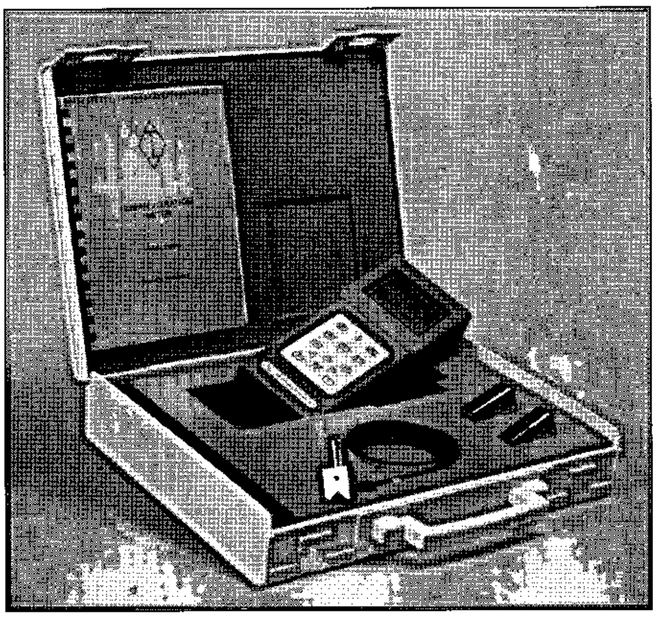

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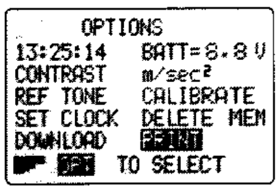

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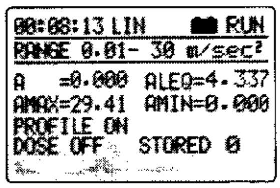

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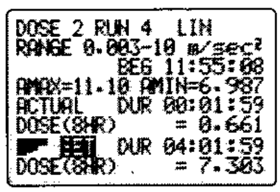

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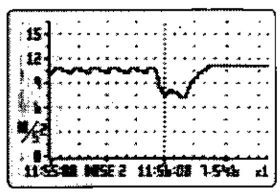

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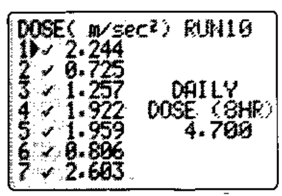

The result 'A 8' daily dose displayed on screen.

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OPTIONS
13:25:14   BATT=8.8 V
CONTRAST   m/sec²
REF TONE   CALIBRATE
SET CLOCK  DELETE MEM
DOWNLOAD
           TO SELECT
```

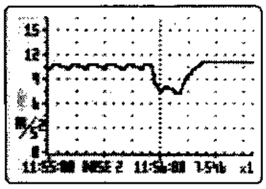
Clear and concise menu screen allows for easy set up & use.

```
00:00:13 LIN      RUN
RANGE 0.01- 30 m/sec²
A    =0.000  ALEQ=4.337
AMAX=29.41  AMIN=0.000
PROFILE ON
DOSE OFF    STORED 0
```

Comprehensive display of all measurement parameters both in memory and while collecting data.

```
DOSE 2 RUN 4   LIN
RANGE 0.003-10 m/sec²
           BEG 11:55:08
AMAX=11.10 AMIN=6.987
ACTUAL     DUR 00:01:59
DOSE(8HR)       = 0.661
           DUR 04:01:59
DOSE(8HR)       = 7.303
```

99 user runs - each can contain 7 dose set ups for various machines.



Full profile capability of every dose.

```
DOSE( m/sec²) RUN10
1 ✓ 2.244
2 ✓ 0.725
3 ✓ 1.257      DAILY
4 ✓ 1.922    DOSE (8HR)
5 ✓ 1.959      4.700
6 ✓ 0.806
7 ✓ 2.603
```

The result 'A 8' daily dose displayed on screen.

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