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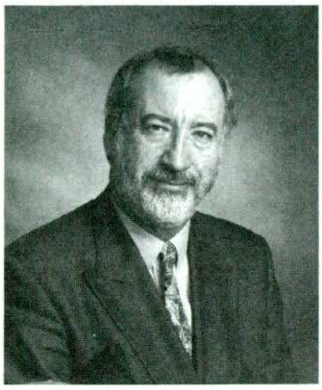

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Sincerely yours

Bernard Berry

Bernard Berry

MODERN MODELLING FOR IC ENGINES – INTAKE AND EXHAUST SYSTEM DESIGN

Bernard J Challen MIOA

Summary

Optimising the design of intake and exhaust systems for modern engines poses many interesting challenges. This article examines a current development in this challenging design topic, with some illustrative examples. What was once a development exercise with much 'black art' has now become a relatively straightforward design process, although the scope for engineering creativity remains as great as before, and there are increasing performance demands to be met.

The key to this change is outlined – the application of full one-dimensional wave equation solution software. Originally intended for engine performance modelling, high levels of accuracy and usability allow its use as a silencer design tool. In this way, the designer generates not only acoustic data but also engine performance information for candidate designs. Enhanced design creativity results from the increased freedom and knowledge and also a more direct route to optimisation across size and cost specifications.

Introduction

The fundamentals of internal combustion engine silencer design are simple – provide adequate flow area and expansion ratio. These rules were adequate (but not always followed) for many years. The penalties for failure were once a loss of engine performance due to excessive pressure loss if the gas flow area was too small for either intake or exhaust, or inadequate silencing if the expansion ratio was too small. Penalties today may be a loss of market share or worse. Complications arise since the acoustics are complex, involving pulsating flow and complex physical topologies. Various tuning features are employed in silencer designs which present challenges to acoustic modelling – pipe wall perforations, wall flexibility and acoustic absorption materials internally. In some design areas, such as thermal gradients, the acoustic effects are not clearly understood even in relatively simple cases.

Simplistic guidelines changed rapidly as competition increased and the elements of cost-control, weight reduction and space limitations became crucial. More recently, customer expectations in the passenger car market have become very sensitised to noise and vibration characteristics, with the final buying decisions made based on relatively small differences between competitors. The subjective issues of harshness and refinement have become vitally important in a competitive marketplace. Similar issues have developed in truck and off-highway equipment, where the operating cabin can be home for many hours and so the levels of comfort required are high.

Below, we will examine the application of a modern engine simulation code, illustrated with some real examples and consider where the future development path may lead.

Commercial Constraints

Increasingly in the automotive market, the time to produce a given design is almost as important as the overall quality of the design itself. The costs involved are substantial and competitive pressures require rapid evolution of new designs. The preparation of a new vehicle design is a very expensive project and program managers for new designs require high confidence levels of success. In this context a design technique is required, rather than a development process, so that high confidence can be achieved – a 'right-first-time' tool.

These concerns are reinforced frequently by a lack of suitably skilled and experienced engineers and other design resources. Although the industry now relies more on the first tier suppliers and other design agencies for assistance, the maintenance of clarity and accuracy when describing the system and its operation are critical to close co-operation. Such a description becomes a design specification. Not only is such a specification useful in maintaining quality, but it can facilitate improved co-operation between vehicle manufacturers and suppliers. Reductions in the time taken to refine and agree both specification and the costs/prices of systems are always welcome.

From the supplier's perspective, it is clearly vitally important to meet the customer's need – both the immediate manufacturer and the end-user. The solutions need to be determined rapidly, with an associated stress on identifying any associated critical issues. These are usually in the area of how much space is available and how it may be used. For example, as the requirements for reduced intake noise continue to become more strenuous, the available space around the engine is reducing. Creative use is being made of the 'dead' volumes within wheel arches and behind bumpers in attempts to maximise the useful volume, but these needs must be identified early and design co-ordination ensured.

The cost of systems can also be more effectively controlled if the design is well-founded and not so subject to last-minute emergency changes to meet some real or imagined short-fall in performance. Improved design tools can therefore largely pay for themselves – but they do need an acceptance period, where the engineering procedures and the engineers themselves become accustomed to, and confident in, the range of new capabilities.

Tools

In addition to the traditional (and still popular) practical development, often referred to generically as 'cut-and-try', we have had a number of acoustical modelling tools available. These have used simplified acoustic theory coupled with approximations of pipe behaviour to provide a rapid computation of insertion losses.

Interested readers will find papers over the years from Prof P O A L Davies [1], who has long worked in this field, together with a number of his graduate students. A further step forward was made by a collaborative effort of MIRA and Loughborough University [2] who developed a lumped-parameter insertion loss modelling system, where systems could be assembled from pre-defined objects. Some engine and vehicle manufacturers have developed systematic approaches themselves, along similar lines. Some, such as that employed by FIAT in Italy, have become complex and comprehensive.

Such approximate models have provided a valuable guide to development engineers, but their accuracy has been limited since the acoustical modelling itself has been limited. In particular, assumptions are usually made about the local gas conditions and the geometry of the system.

The forcing function from the engine itself is complex, both on the intake and exhaust sides, with high mean flows (approaching 0.2 Mach in exhausts) and high exhaust gas temperatures and temperature gradients. Added to this challenge is a wide operating range – for the noise concern is no longer just at the high-speed, high load condition, but covers practically the entire operating range.

The traditional development technique is therefore understandable and reasonably safe – but slow. An iterative approach to the desired solution is made using a series of development prototypes, until a manufacturing-ready sample is approved. The disadvantages are that the process takes too long, costs too much and requires hardware to carry out the tests. Increasingly we need 'paper' tools for design – before prototyping is possible. The objective is one prototype – as proof of design.

To provide some indications of the level and type of design decisions to be made, a modern mid-range saloon car intake system might be considered. The intake system supplier has to agree a specification for the system that will ensure both good engine performance and the appropriate acoustic attenuation. The engine performance requirement will be based on both the flow resistance at the highest flow operating point and also the absence of any interference with the operation of mass-flow meters, which are sensitive to pressure pulsations. The acoustic specification may embrace both an objective function and also some form of subjective assessment. The options available to the designer include the volume of the air-cleaner box and its location, the use of specifically tuned absorbers such as quarter-wave and Helmholz resonators. With the latter, the positioning for maximum effectiveness is a further variable. For the exhaust system, a catalyst box, probably close to the exhaust manifold will be the first of three or four expansion boxes. These are arranged along the length of the system for both maximum acoustic efficiency (locations at antinodes) but also to conform to the vehicle underside, fitting as smoothly as possible into the available space. The aerodynamics of the vehicle are an increasingly important part of achieving reasonable fuel economy figures.

It is the continuing development of computer-based models that has been effective in this area. For the past 30 years, the engine simulation field has made considerable strides in both the modelling of the gas flow and the combustion processes within engines. The dramatic reductions in processing costs, which have made so many computing tasks affordable, have had their effects here as well, so that it is now possible to apply the most advanced simulation codes to silencer design.

It is ironic that there is also an additional burden placed on the system designer, in that detailed engine information must be used to provide a good overall simulation. Sometimes there is resistance to this detail, but the comparison may be drawn with finite element stress analysis, where, in order to provide a substantially improved and detailed result, a considerable amount of extra input effort must be invested. In the present case, the labour involved in formulating the model is not great, measured perhaps in a few hours or a couple of days for an entirely new engine model. This assumes that the data is itself available. In practice, it is quite easy to provide some approximate, typical, figures for the engine, where real data is not available, but the initial adaptation process takes time. As a management lesson, this is important.

The use of such a computer-aided design approach matches other processes in engine and powertrain design, so that the overall system can be optimised. Discussions involve trade-offs in:

* Power/torque curve tailoring
* Installation volume/arrangement
* Level of refinement against system cost
* Manufacturing techniques and materials

All of these have no simple singular answer: they are classic design questions where some form of compromise must be selected. The availability of reliable data is crucial to the improved quality of these decisions.

Full Engine Gas Flow Modelling

It is beyond the scope of this article to describe the details of the GT-Power simulation code employed [4]. Essentially it is a full one-dimensional solution to compressible, unsteady flow, including specialised models to cover specific engine-related processes, such as heat transfer, combustion and exhaust emissions. The code has been developed over many years for engine simulation and has been shown to be sufficiently accurate for acoustics use up to around 1 kHz.

GT-Power was used together with the GT-Sound post-processing options supplied. Quasi-3D flow elements allow geometrical descriptions in three dimensions, so that realistic descriptions can be compiled of real systems. A finite-difference solution is employed, based on a range of pre-defined elements that are then sized and arranged for the specific model. Working from the ambient conditions of the air inlet, through the engine cylinders and the combustion process to the exhaust system.

Gas properties and flow characteristics are tracked all through the flow path. In this way, a fully integrated solution is obtained. The time-histories pressure at intake and exhaust can be post-processed appropriately, predicting the radiated noise from the intake and the exhaust pipe openings.

Validation Examples

The validation for these acoustic sections of the code was carried out in a number of ways, but the acoustic validation compared the results of controlled experiments on transfer function test systems as well as measurements in transmission loss test rigs and on running engines. The procedure adopted was to measure the transmission loss by a 2-microphone sound power method in the TL test rig, using broad band excitation. This was compared with the calculated TL of the model, again where this was assessed by a sound power calculation, using a 'sound power' module in the code, with the microphone separation set to be the same as the measurement case.

The classic example, since it is readily compared with simple theory, is the simple expansion box seen in Figure 1. The acoustic results, below the figure, illustrate that the flow code gives results that are close to the measurements and provide the designer with a good indication of the performance of his system. The results are generally as good as, or even better than, many specific acoustic codes.

Of interest to many exhaust system designers, the resonant chamber, seen in simple form in Figure 2, forms the basis for many systems. In this design, the extended pipes within the chamber act as quarter-wave cancellation filters. The results of this addition are clear by comparison with the previous results. The code provides results that are once again in good agreement with the measured data.

Since automotive engine applications are essentially variable speed, it is a requirement for the silencer design that is effective over a wide speed range. One method of achieving this is to use a series of perforations, which tend to spread the range of attenuation. There is a wide design choice involved in this area, which has traditionally been resolved with considerable prototype testing, since the number of variables is large. Modelling of perforations is accomplished in this case by choosing a series of elements along the pipe, each covering one hole or set of holes longitudinally. The results are seen in Figure 3, where good agreement is found over most of the frequency range, although some peaks are overstated.

The use of acoustic absorption material has been common practice in systems for many years, either in the form of rock wool or wire wool in exhaust systems or, increasingly, foam plastic and other materials in intake systems. These have been problematic for simple models, since the density and distribution of the absorption material must be represented, together with the propagation of the pressure waves through the material. Development work was undertaken to specify the flow resistance of a range of typical absorption materials so that this could be included in the flow model. The results seen in Figure 4 illustrate that a complete solution is effective in this case. The curve of transmission loss also indicates why this combination of perforations and absorption material is often an attractive solution, since the curve maintains a usefully high TL across a wide frequency range.

Engine Excitation

The complexity of the engine intake and exhaust has often been underestimated. Although straightforward in

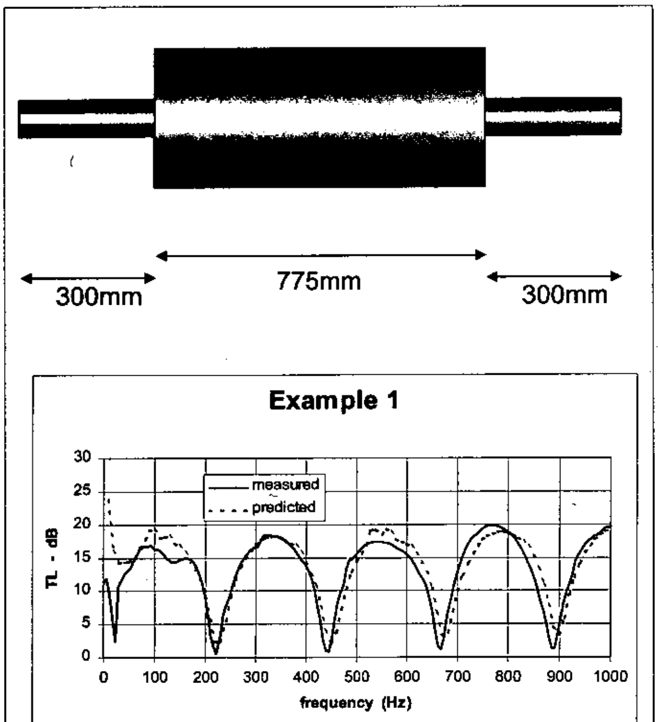

Fig. 1

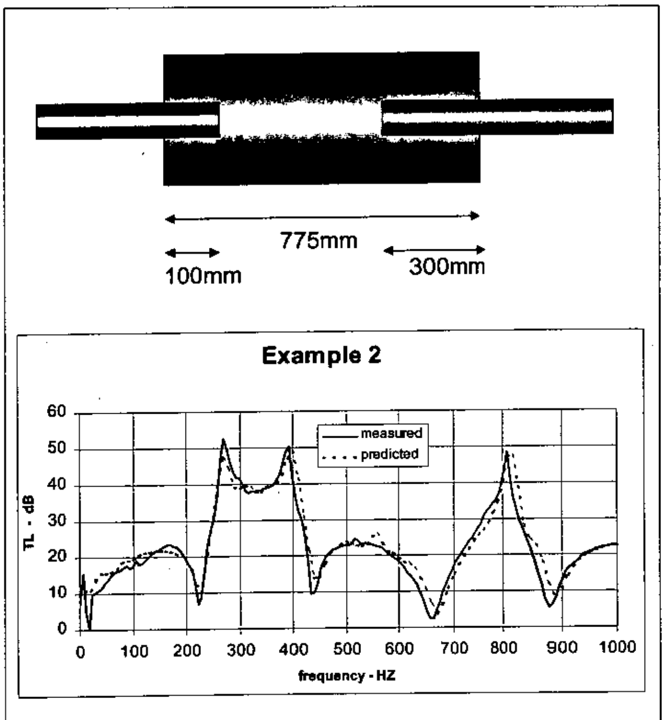

Fig. 2

simple engine configurations, the influence of differing length pipes in the intake and exhaust manifolds ('runners' in the jargon) can have significant spectrum-shaping effects, together with an impact on the subjective assessment. In order to provide a full prediction of the engine intake and exhaust noise, it is necessary to account for the variations that occur in individual cylinders and the gas pulsations in the manifolds, leading to the transmission effects of the silencers. The simulation code allows all the elements of the engine to be specified and the cylinders are treated independently. The radiation from the pipe ends is handled conventionally.

The results for the complete engine exhaust simulation are illustrated in Figure 5. The overall dB(A) level plot is clearly missing a substantial portion of the radiated noise. This turns out to be the higher-frequency flow noise, which currently is not modelled. The engine pulsation harmonics are, however, accurately predicted, as seen in the lower part of the figure. Work is now underway to include sub-models of flow noise within the code.

Future Activities

As confidence accumulates through use, it will be more common to include the performance of intake and exhaust systems alongside the original engine design. Experience has shown [3] that the combustion models used within the predictive code work satisfactorily for both gasoline and diesel engines but that it is important to include the valve profiles reasonably accurately, since these can have some significant effect on radiated noise.

Clearly it is necessary to include the flow generated noise in the acoustic model, and work is underway by the code designers to accommodate this.

A further area for future development is the topic of surface radiated noise, using the pressure calculations within the system together with knowledge of the physical structural characteristics.

In addition to the inclusion of flow noise, further improvements are foreseen in the usability of the code. The simulation data is entered as modules using a graphical user interface, with the associated dimensional numeric data typed in. These modules can already be grouped and moved, so that complete acoustic elements can be handled easily. This eases the construction of complex models and also reduces the probability of data entry errors.

The subjective performance of these systems is often critical – a system may achieve the acceptable dB(A) value, but it has the wrong 'sound' for the application. One enhancement that acoustic development engineers can now apply with this code is the ability to replay the digital pressure signal in order to gauge the subjective result.

If we look forward further, the ability of the designer to sit at his console and explore the full range of possibilities from the engine layout through the intake and exhaust sound signatures under any conditions, such as a drive-by test, is now not too far off. For those among us who have enjoyed the disciplines of drafting designs and then testing them on a cold, windswept, test site, where each change of system leads to regret over the creativity that leads to the construction of additional prototypes, this will come as welcome news.

Conclusions

Increasing market and legislative demands have led to even more stress on the design of automotive intake and

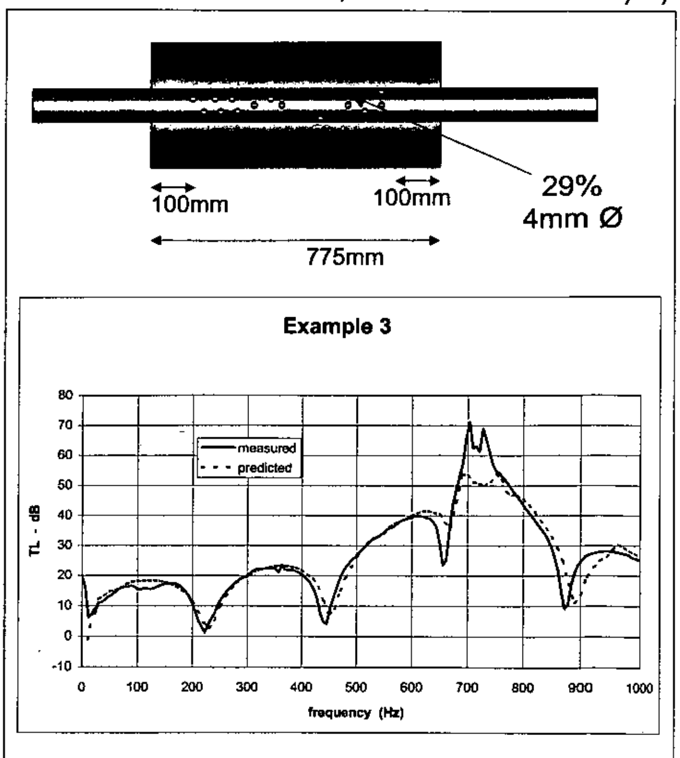

Fig. 3

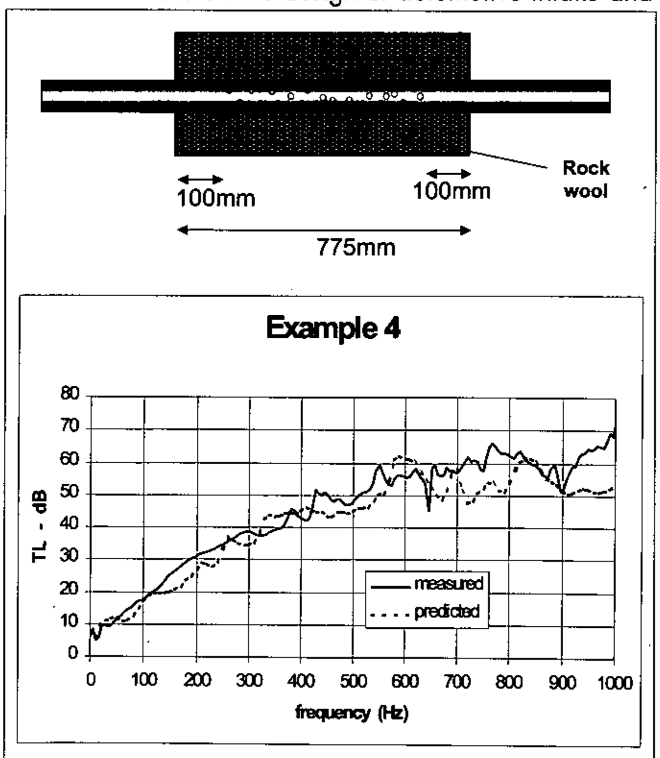

Fig. 4

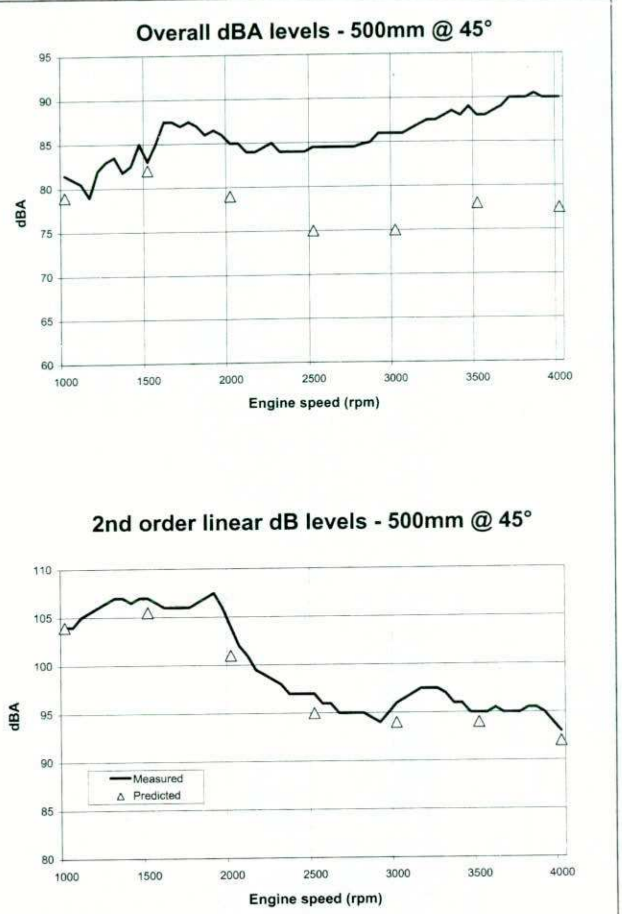

Fig. 5

exhaust systems. These now must provide high levels of attenuation while occupying smaller volumes and giving a subjectively acceptable result. Affordable computing can provide a route, coupled with the appropriate simulation code, to an effective engineering design tool, providing system designers with a fast route to system performance prediction, so that many more options may be studied. This enhances creativity and reduces program time and costs. Fundamental physical and acoustic principles can now be applied in a useable and fast tool for engineering designers.

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[4] Gamma Technologies Inc, Chicago, USA (info@gtisoft.com)

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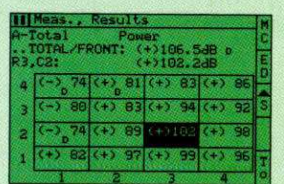

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HELMHOLTZ RESONATORS FOR THE NEW RUSSIAN ORTHODOX CHURCH IN LONDON

Tony Pretlove FIOA

Introduction

A new Church is shortly to be built at Chiswick for the Russian Orthodox Church Abroad (previously the Russian Orthodox Church in exile), see Figure 1. Architects Douglas Norwood Associates of Newbury have been briefed to follow the design of traditional Russian churches in the Pscov region. One aspect of the design, with which this work has been concerned, is the acoustical quality of the building.

Much of the sound in Russian churches consists of priests chanting the liturgy from behind a tall screen called the iconostasis. A small door in the screen is left open for part of the time, from which direct sound is transmitted to the congregation. At other times during the order of service the door is closed and sound reaches the congregation over the top of the screen. This form of worship developed centuries ago as part of the Orthodox tradition. To optimise the clarity of sound transmission from behind the screen to the congregation in front, acoustic absorbers are needed which operate across a frequency range centred at about 200 Hz (approximately the G below middle C). This range, from about 100 Hz to 300 Hz, corresponds to the average male voice. In Russian churches the traditional method of achieving this absorption is to mount ceramic pots in the masonry with their openings flush with the wall surface. These act as Helmholtz resonators and there are sometimes as many as 300 of them.

Unfortunately it is not easy to build ceramic pots into a modern blockwork construction because the geometry is unsuitable. This work has therefore investigated the possibility of using standard hollow concrete blocks with holes cut into their faces so as to make artificial pots with appropriate acoustic properties. It has proved possible to adapt these standard blocks in various ways so that not only do they have the required acoustic properties but also they will look exactly like the traditional ceramic pot when viewed from inside the building.

The Russian Practice

In traditional Russian churches (and also in some other countries such as, for example, Sweden [1] and Greece) clay pots are embedded in the walls to provide acoustic absorption. This is achieved by Helmholtz resonator action giving narrow band energy absorption dependent on the natural frequency of the resonator. A range of sizes can be provided to give a broader band coverage. Figure 2 shows an old drawing of a cross-section of a Russian church building in which the pot openings can be seen. Figure 3 shows a sketch of a sixteenth century pot from a church in the Pscov region of Russia. Three other such sketches were also made available. Two modern Russian pots of this kind were received in the laboratory for testing and one is shown in the photograph, Figure 4.

During church services much of the sound consists of male voice chanting, probably close to 200 Hz (this is the frequency of the G below middle C and is mid-range for a baritone). It is thus clear that such absorption is required to reduce multiple acoustic reflections in this range and hence enhance the intelligibility of the chanting. This appears to be particularly important in Orthodox churches where, for much of the time, the priest is chanting from behind the screen.

Fig. 1. Architects model of the preliminary design for the new Church.

Fig. 2. An old drawing of the east-west section of a Russian Church showing pot locations in the sanctuary (to the left) and in the lantern tower.

Initial Experiments and Calculations

A brief study of these pots, both by experiment on the two pots made available and by calculations for the pots shown in the sketches, indicates that the natural frequencies generally lie in the range 150 to 300 Hz as expected.

The two actual pots which were sent from Russia were tested in various ways to determine their absorption characteristics. In each case a microphone was placed in the base of the pot for testing. The acoustic measurements were made by three different methods each of which gives a slightly different result. A summary of the pot dimensions and results from the different kinds of test are as follows:

Larger Pot:

- Externally: 325 mm high
- Internal neck: 95 mm diameter
- Peak Acoustic Absorption: at about 230 Hz
- Singing in sympathy: 228 Hz
- Noise excitation: 236 Hz
- Tuning with pure tones: 241 Hz
- Bandwidth (3 dB down): 231–243 Hz

Smaller Pot:

- Externally: 295 mm high
- Internal neck: 105 mm diameter
- Peak Acoustic Absorption: at about 275 Hz
- Singing in sympathy: 270 Hz
- Noise excitation: 272 Hz
- Tuning with pure tones: 282 Hz
- Bandwidth (3 dB down): 279–285 Hz

The variability in these results for a given pot is partly a result of the presence of the microphone and lead, and partly because the individual resonance has a bandwidth as measured and shown. This latter feature is important because it means that the pot can absorb significantly over a frequency band and not just at a single frequency. In a good design for a building there must be several absorbers with overlapping bandwidths so as to cover a range.

Calculations for the four ancient pots shown in the sketches supplied, of which Figure 3 is an example, give natural frequencies of approximately 167 Hz, 202 Hz, 236 Hz and 224 Hz.

The Task

The task therefore has been to provide acoustic absorption of an appropriate amount and in the frequency range 100 to 300 Hz, to make the appearance of the walls the same as if pots were embedded, but yet to try to adapt the actual form of the absorbers to fit in with modern building methods and materials. The chosen route has been to simulate the traditional pots and their action using hollow concrete block with circular holes cut into their sides to simulate the neck of the pots. Control of the natural frequency of the resonator obtained has been achieved by varying the diameter of the hole or the volume of the void inside the hollow block.

The Use of Hollow Concrete Blocks

The standard British hollow concrete building block (440 x 215 x 215 mm) contains two voids each measuring about 120 x 120 x 215 mm. The wall thickness to the void is therefore about 50 mm. However, in a building a plaster layer of about 15 mm will be applied so that the wall thickness to the void is likely to be about 65 mm. Using these dimensions two blocks had two holes each cut in their sides to produce a range of predicted natural frequencies from about 150 Hz to 240 Hz. Four pot sizes were thus simulated in this way for testing. In the first set of tests the two test blocks were built up with a slate placed between them in order to seal off the cavities. A later but similar experimental configuration, with separating blocks rather than slates, is shown in the photograph, Figure 4. The prediction of hole sizes was made using the standard formulae for a Helmholtz resonator taken from [2]:

The natural frequency of the resonator, f, is given by:

$$f = (c/2\pi)\sqrt{[S/L'V]}$$

where, for the resonator, V is the enclosed volume, S is the neck area and L' is the effective length of the neck given by:

$$L' = L + 1.7a$$

a being the radius of the (round) neck. The speed of sound in air is c. The sharpness of resonance measured by its quality factor Q is given by:

$$Q = 2\pi\sqrt{[VL'/S]^3}$$

and the bandwidth is given by:

$$\text{Bandwidth} = f/Q$$

In the application of these results to an acoustic absorber for a room the determination of the effective absorbing area is a more difficult matter treated in [3]. However, it is worth pointing out that this effective area is generally much greater than the cross-sectional area of the resonator neck because the energy losses are not confined solely to the neck itself. For a resonator at 200 Hz the effective area of absorption is about 0.4 m^2.

The actual holes cut through the block walls had the following dimensions and the table also shows the predicted natural frequencies using the above formulae:

Resonator No	Hole Diameter	Predicted frequency
1	53 mm	131 Hz
2	73.5 mm	169 Hz
3	87.5 mm	193 Hz
4	100 mm	212 Hz

In every case the void volume was 0.00329 m^3 and L = 0.065 m.

Initial Test Results

The outer surface of the blocks was plastered to a depth of 15 mm. Once again two different tests using harmonic excitation and white noise excitation were carried out to determine the natural frequency. The harmonic excitation test was used to determine the bandwidth. In brief, the summary results were as follows:

Resonator No	Natural Frequency	Bandwidth
1	137, 147 Hz	132 to 153 Hz
2	176, 189 Hz	173 to 183 Hz and 187 to 192 Hz
3	190, 201 Hz	188 to 193 Hz and 199 to 205 Hz
4	221, 227 Hz	217 to 232 Hz

In every case there was a double resonance. Although the origins of this are not known it was conjectured that it may result from coupling between adjacent cavities. This coupling may result from the thinness of the intermediate slate which might not have been providing a sufficient vertical isolation between cavities in adjacent blocks, or that the porosity of the material may have allowed coupling between two cavities in one block (adjacent horizontally). As a result the experimental set-up was rebuilt with an intermediate solid block in place of the slate. The tests were all repeated but with almost identical results. This is an important piece of information because it means that intermediate slates can be used in the real construction permitting a higher density of absorbers.

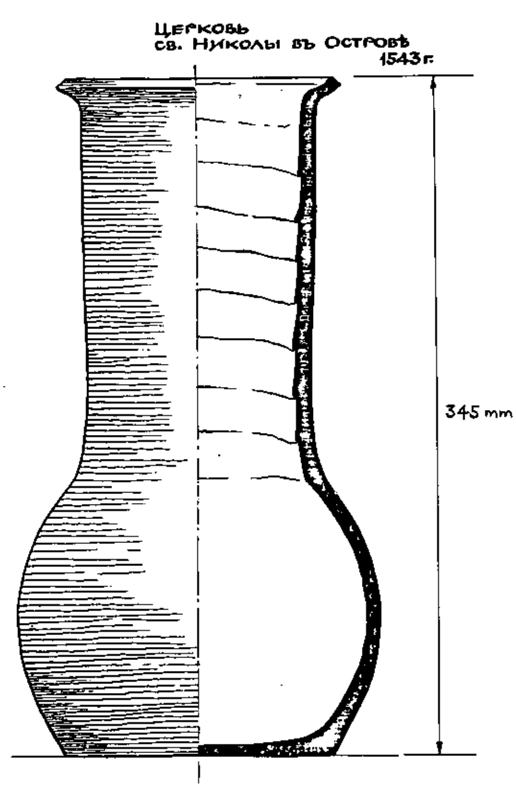

Fig. 3. Sketch of a pot Helmholtz resonator taken from a sixteenth century Russian Church. The caption reads 'from the church of St Nicholas at Ostrov, 1543'.

Final Tests

One of the initial tests made use of white noise acoustic excitation. The spectrum of sound inside the cavity (as measured by the microphone with subsequent FFT analysis) then revealed its natural frequency. It was clear from these results that the resonators were not absorbing as much acoustic energy as desired, the signal/noise ratio at the spectrum peaks being much less than for the ceramic pots. This, it seemed, was a result of the very porous surfaces inside the void in the concrete blocks. In the final tests the inside surfaces were therefore thinly plastered so as to block up the pores. Not only should this improve the absorption but also it might remove any coupling between adjacent cavities in one block. The set-up was then re-established with an intermediate slate. The tests were then repeated as before with the following results; note that in two cases the double resonance merges into one. This table also shows a prediction of all the absorption characteristics.

Resonator No	Natural Frequency (Prediction/Test)	Bandwidth (Prediction/Test)
1	131/144 Hz	1/5 Hz
2	169/187 Hz	3/9 Hz
3	193/210 Hz	5/5 Hz
4	212/227 Hz	7/13 Hz

The prediction for bandwidth presumes perfectly smooth and reflective inner surfaces. Thus the experimental bandwidths, which are generally higher, are almost certainly a measure of the remaining roughness and porosity. The predicted frequencies are all a little low. The presence of the microphone in the tests may partly account for this.

Fig. 4. The testing arrangement for resonators cut into hollow blocks showing a microphone in place for testing. One of the Russian pots is seen alongside.

Recommendations

On the basis of these test results a range of sizes for holes to be cut in hollow blocks and suitable surface treatments have been recommended. A set of 25 slightly different hole sizes are needed to cover the frequency range from 150 to 260 Hz.

To easily achieve a range of hole sizes a standard-sized larger hole is cut in the block which is then fitted with a plug containing the hole of the required size. To simulate the number used in traditional Russian churches the set of 25 'pots' will have to be repeated about eight times to give a total of 200 Helmholtz resonators. Figure 5 shows how these resonators may be located in the final design.

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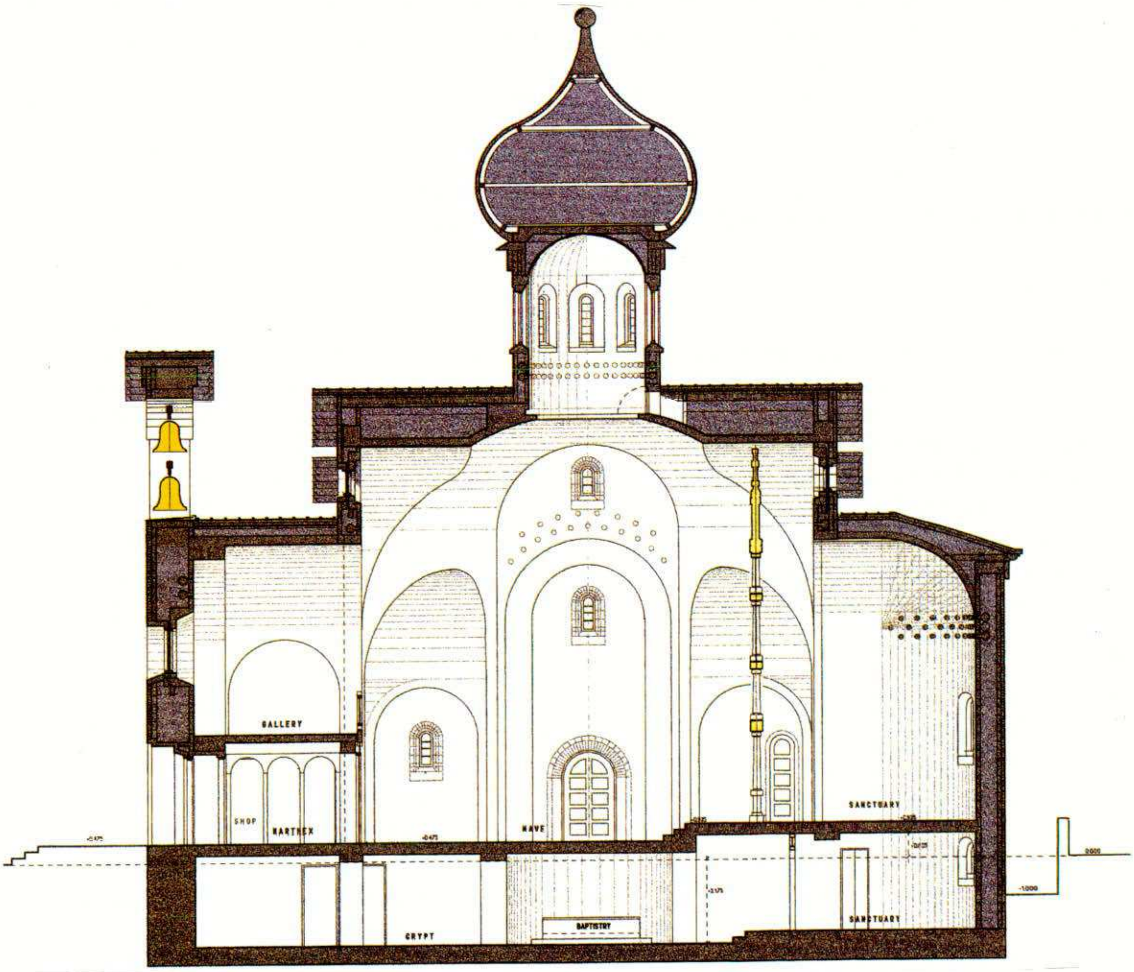

Fig. 5. Architects drawing of a cross-section of the preliminary design for the new Church showing notional pot locations (copyright Douglas Norwood Associates).

CONSTRUCTION NOISE MANAGEMENT UNDER THE CONTROL OF POLLUTION ACT

Michael Young MIOA

Introduction

Environmental noise legislation in the UK does not prescribe construction noise standards nor does it require the mandatory regulation of construction works. Rather, it provides a discretionary framework which broadly allows either (i) the relevant local authority to initiate action to remedy a noise nuisance which is already occurring or is likely to occur; or (ii) the person responsible for carrying out the works to initiate a dialogue with the relevant local authority with a view to preventing/ avoiding a noise nuisance.

The Control of Pollution Act (CPA) was introduced in 1974 to legislate for a wide range of environmental pollution. Part III of the Act deals specifically with noise and was designed *'to strengthen local authorities' existing power to control environmental noise'* [1]. These powers have largely been superseded by the Environmental Protection Act 1990 (as amended), though Sections 60 and 61 of the CPA which relate to the control of noise on construction sites are still in place. Both these sections of the Act aim to provide an equivalent level of environmental control to *minimise* construction noise without causing *'undue hindrance or disruption to the works'* [1].

Construction Noise and Best Practicable Means

Construction noise control, because of its nature, can pose specific difficulties compared with other types of noise nuisance. They are mainly carried out in the open, they are temporary and transitory in nature. The location can be adjacent to noise sensitive neighbours and the nature of the noise can vary enormously from the impulse noise of impact piling to the tonal whine of a concrete 'poker' [2]. Many factors can influence the degree of disturbance from construction noise, which range from the actual level of noise created, to the prior knowledge of its expected level and duration, to the personal relationships between the parties involved and any previous loss of goodwill [3].

Thus, the level of control required for particular construction works will vary from site to site depending on, for example, the nature of the construction works; the time of day the noise occurs, and the sensitivity of those affected. The CPA is not prescriptive in terms of the specific measures which may need to be taken to control construction noise but rather relies on the principle of *best practicable means* to provide the flexibility needed and allow the local authority discretion to balance local conditions and circumstances with technical feasibility and the possible financial implications. The principle of the *best practicable means* is well established in pollution control policy and practice in Britain, having first been applied in 1842 to control a smoke nuisance in Leeds [4].

In relation to construction noise, British Standard 5228 [5] is the approved code of practice and sets out good practice for the reduction of construction noise and is therefore central to any interpretation of *best practicable means*. The aim of the CPA is that the *best practicable means* should be used to *minimise* construction noise, although to give the phrase a tangible meaning 'presumptive' noise limits are sometimes used. These 'presumptive' noise limits can, for example, relate to an acceptable internal noise so as not to cause interference with the ordinary comfort of a person in their home, or, for a noise sensitive neighbour like a school, assert that noise should not interfere with spoken communication. The *best practicable means* will in general initially involve on-site control measures, such as control of hours of work, choice of noise suppressed plant or work methods. Where these prove inadequate and certain 'presumptive' noise limits are exceeded it may be necessary to consider the provision of noise insulation or even temporary re-housing.

Section 60 (Control of Noise on Construction Sites)

This section of the CPA allows the local authority, either before or after works have commenced on site, to specify various measures to control noise by serving a notice on the person responsible for the works. The specific measures can relate, for example, to the hours of work, the type of machinery to be used, the level of noise to be emitted from the site. Though Section 60 allows action to be taken by the local authority either before or after the works commence, it is generally implemented as a reactive measure, used when a noise nuisance has arisen from a particular construction site. The service of a Section 60 notice follows the traditional enforcement culture of the local authority sanitary officer and can lead to an adversarial relationship between the local authority and the contractor.

Local authority officers have traditionally favoured this mechanism as it is considered to allow the local authority flexibility by retaining the option of taking action as and when a problem arises. It is also considered resource efficient as staff time is spent dealing with construction sites that have an actual problem of noise nuisance and a *laisser faire* approach is taken to those which do not. It can also be easier to specify solutions once the precise nature of the noise nuisance is clear. Though from a local community point of view, it is clearly preferable to avoid the occurrence of any noise nuisance in the first place.

The onus is on the local authority to prescribe specific conditions to control noise, although the contractor, with his detailed knowledge of the works, is well placed to help strike the right balance between the need to take action to minimise construction noise and the need to avoid undue hindrance to the works. The contractor can appeal to the local magistrate against the terms of a Section 60 notice and where a local authority has specified inappropriately onerous conditions, perhaps due to inadequate information, the local authority could be liable for costs incurred by the contractor.

Section 61 (Prior Consent for Work on Construction Sites)

This section of the CPA, on the other hand, allows a person who intends to carry out construction work to approach the local authority to seek prior consent for the intended works putting forward any proposed noise mitigation measures. Where mitigation measures are acceptable and the local authority consents to the works then the person is exempt from subsequent action under Section 60. However, an individual aggrieved by construction noise can still take action under Section 82 of the Environmental Protection Act 1990 to remedy the situation. Compliance with a local authority Section 61 consent does not itself constitute a defence.

Local authorities have traditionally been wary of the prior consent process as it requires them to commit themselves to a particular noise control regime in advance and can restrict scope for further action where a problem arises. This is borne out by a recent survey in London [6] which confirmed local authority officers' preference for the Section 60 process. Furthermore, the process can be time consuming and bureaucratic particularly if it relates to smaller sites which are unlikely to cause a noise nuisance.

The Section 61 process generally involves informal discussions allowing the local authority to determine the exact nature of the works and the potential for noise nuisance. It also allows the contractor to understand the standard of noise control and mitigation measures required by the local authority. Mitigation measures, which have been mutually agreed with some understanding of both the need to avoid nuisance to the local community balanced against the engineering restrictions and cost implications, are more likely to result in better compliance than those imposed unilaterally by the local authority. The Section 61 process is essentially one of negotiation in which a working relationship is developed. The process involves compromise on both sides and, contrary to the traditional local authority view, can provide a flexible framework to cope with the unforeseen which inevitably arise on major construction sites.

Relatively few applications are made for prior consent. This is in part due to a lack of awareness on the part of developers and a reluctance to become involved in more bureaucracy than is absolutely necessary. However, with foreknowledge of the local authority requirements the contractors can plan their working well in advance so as to mitigate noise nuisance and thereby reduce the possibility of costly delays to the works. Where noise nuisance is unavoidable there is still adequate time to notify the affected community of the likely disturbance and its duration and perhaps consider novel forms of mitigation. During unavoidable noisy works over a Bank Holiday weekend on an infra structure project in London, affected residents were offered the option of a day trip to the coast as a respite to the works.

Though cost is a necessary consideration in determining the *best practicable means*, it is likely that the contractor will be more acutely aware of these matters and is another reason to be actively involved with the local authority in negotiations to agree the appropriate noise control regime.

Conclusion

In many cases of small developments it may not be in the interests of either the developer or the local authority to enter in to the formal procedures provided by Sections 60 and 61 and often where problems arise they can be resolved by informal agreement. However, on larger developments, it may well be in the interests of the developer to apply for prior consent so that possible noise problems can be foreseen and the possibility of costly delays to the works programme are avoided. Local authorities have traditionally been reluctant to enter into the Section 61 process but rather favour the Section 60 approach as this allows them to retain the option of taking action as and when a problem arises. However, the Section 61 process allows them to obtain detailed information and therefore to make more informed judgements as to appropriate mitigation measures.

Though relatively little use has been made of the Section 61 provisions of the Control of Pollution Act it is likely with the more formal and systematic approach to environmental legislation required by environmental management systems, that the use of the prior consent process will increase. Many of the major infrastructure projects currently in progress in the London area have contractual requirements that prior consent is obtained from the appropriate local authority before work commences on site.

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TRACING A TONAL NOISE SOURCE ON A LARGE INDUSTRIAL SITE

Paul Bassett MIOA

Introduction

'We know that we have a tonal noise emission but we can't find out where it's coming from', explained the Environmental Manager at a large industrial processing factory, 'we need some help'.

The presence of the tonal noise had been mentioned informally to the factory by an employee who lived nearby. Having confirmed that there was indeed a tonal noise, the company, in accordance with its commitment to the Chemical Industry Association's Responsible Care programme, was eager to trace the source of the tonal noise and undertake appropriate measures to reduce it.

The Site

The factory is located on the bank of the Dee Estuary in North Wales. Inland there is a housing estate in an elevated position which overlooks the industrial site and the estuary beyond. The factory, which is used for the manufacture of additives to soap powders and detergents, operates 24 hours a day on seven days a week. Between the factory and the housing is a busy coast road and railway line, but at night the background noise climate is lower and it was found that a tone was clearly discernible.

During an initial site visit we were encouraged to find that the tone was a mid frequency 'hum' which tends to be easier to trace than a low frequency 'drone'. However, whilst the frequency of a tonal noise can often be readily identified at a considerable distance away from the noise source, actually measuring and tracing the source of the noise on an industrial complex can prove difficult due to the masking effect of a myriad other plant noise sources nearby. This was the case here. When one walked around the processing plant area at the factory, it was not possible to hear the tone. It was clear that, in order to trace the source of the noise, a tone matching technique using narrow band frequency analysis would be required.

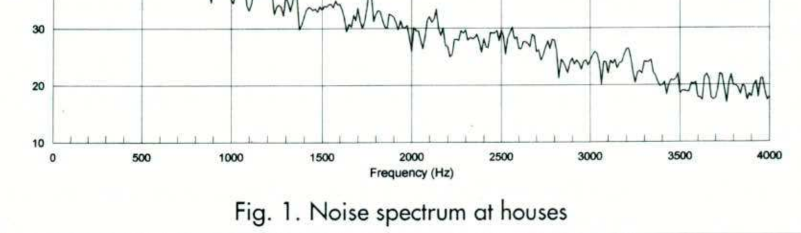

Fig. 1. Noise spectrum at houses

The Approach

The Environmental Manager feared that the noise source was likely to be one of the many chimney stacks on the site and that we would need to measure noise in the flues or on top of the stacks. Not being overly keen at this vertiginous prospect, we suggested that a more systematic approach should be adopted on terra firma. We considered that it should be possible to 'home in' on the area of the tonal noise by carrying out narrow band frequency analysis initially at ground level. Once the general area of the tonal noise had been defined it was hoped that further investigation at higher elevations on the plant would reveal the source of the noise. Failing this the contingency plan was to carry out a noise survey after the annual shutdown by assessing the noise as each plant process was switched on in turn.

It was decided, therefore, to determine the frequency of the tone at the housing site by narrow band analysis, and then to repeat the narrow band analysis on the industrial site. The latter could have been done on a grid basis, but the company were also interested in noise levels at a number of specified plant areas around the site. Therefore it was agreed that the survey would comprise noise measurements and analysis at these points which were distributed over the whole industrial site.

Noise Monitoring

A noise monitoring point was established on the edge of the housing area with a clear line of sight to the factory. The survey was carried out late at night in order to minimise the influence of non-factory noise sources (road traffic, trains, etc). Noise levels were monitored using a Brüel & Kjær Type 2231 Sound Level Meter connected to a Diagnostics Instruments PL21 Real Time FFT Analyser and Diconix printer. As well as 'A' weighted noise measurements this set-up enabled narrow band frequency analysis to be carried out in order to identify any problematic tonal elements.

The noise from the factory site was characterised by a constant, and fairly broadband, background noise over which was superimposed a continual intrusive mid-frequency tonal noise which we estimated by ear to be around 500 Hz. The narrow band frequency analysis enabled this tonal element to be identified at a frequency of 487 Hz. The measured frequency spectrum is shown in Figure 1.

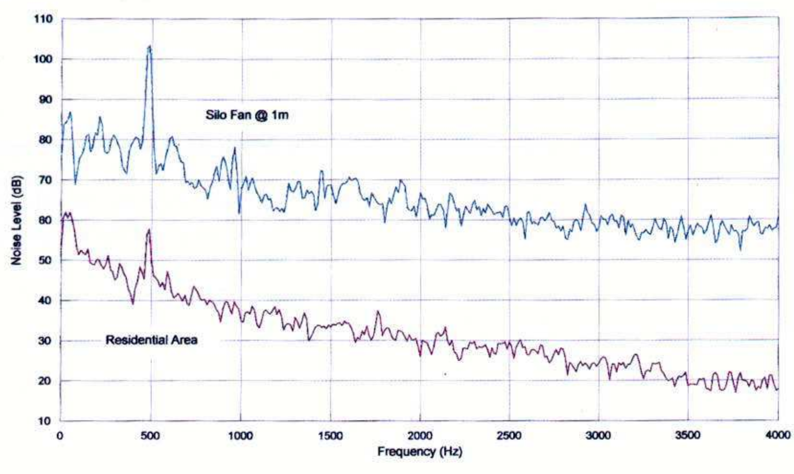

Fig. 2. Showing the 497 Hz peak from the silo fans

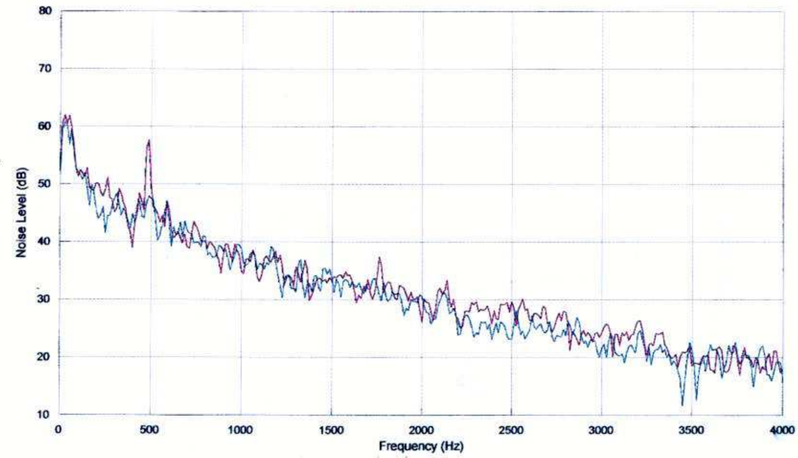

Fig. 3. Spectra at houses before and after noise control

From the results of the noise survey and the distance to the plant, it was considered that the 487 Hz noise source would be generating a very high noise level at the factory, in excess of 100 dB at one metre, and therefore should be fairly easy to locate.

During the on-site noise survey the 487 Hz tone was picked up successfully in the south-western area of a large granulation plant installation. However the relatively low noise level of the tone (87 dB at 487 Hz measured near to a scrubber fan) indicated that the source of the tone was likely to be in the vicinity but higher up on the plant.

Following further investigation our interest was drawn not to the main processing plant building, or to the associated maze of external fans, scrubbers, ductwork and piping nearby, but to the top of some very high, but inert looking, silos – an area rarely visited by factory personnel. They were sceptical, 'there's not much up there' we were told. Nevertheless, armed with the necessary permits to climb the gantry up to the top of the silos, we found that each had a small exhaust fan on top and it was these fans that were generating the 487 Hz tone. Each fan unit was found to be emitting the tone at the same intensity. The measured frequency spectrum at a distance of one metre from one of the silo fans, together with the spectrum measured at the nearest residential area, is shown in Figure 2. The correlation of the peak at 487 Hz can clearly be seen. Displaced air from each of the silos is exhausted via a ten blade paddle fan located on top of the silo.

There is a clear line of sight between the top of the silos and the residential area. The primary source of noise emission was found to be a gap between the fan outlet and the cowl of the ducting above. This gap enabled the exhaust noise from the fan to radiate freely to atmosphere. The net result is that there were five high intensity noise sources located in an elevated position with no acoustic screening between the silos and the nearest residential area.

Noise Control

We were able to give a number of options for reducing the tonal noise ranging from simply installing ductwork between the fan outlet and the cowl above to eradicate the gap, through to replacement of the fans with a different type which do not generate the dramatic blade pass frequency tones which are characteristic of paddle blade fans working at high speeds. In the end, the company opted for fitting silencers to the fan exhausts but, to our consternation, still maintained a small gap between the silencer outlet and the ducting above. Nevertheless, during a follow-up survey it was found that the noise level on top of the silos had been dramatically reduced and, at the houses, the tonal noise had been rendered inaudible. The spectrum measured at the houses after the fitting of the silencers is shown in Figure 3.

Therefore the tonal noise problem has been successfully resolved. In order to check that this situation is maintained we are carrying out six-monthly repeats of the environmental and on-site noise measurements. This enables any deterioration in noise levels, and tonal components, to be identified and rectified before becoming a problem. A single instrument, a Svantek 912 Analyser, is now being used for the noise survey work instead of the original monitoring set up.

The tone matching technique employed in this case was found to be very successful. It is a useful tool of the acoustic engineer made easier these days by the increasing availability of robust, highly portable, instrumentation which allows real time FFT analysis to be carried out with confidence in the field.

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OF SOUND MIND

Alex Burd FIOA

I am grateful to the Editor for offering me the opportunity to reminisce about forty-plus years spent in acoustics. I am grateful too for the opportunity to express my thanks to the many colleagues with whom I have worked over the years. I acknowledge that I am essentially a team man whether in a section of engineers in a research department, in a consultancy practice of acousticians and architects or in a design team covering all the necessary and diverse aspects of building design. No fundamental laws or books or great discoveries bear my name – although a range of low-frequency sound absorbers to be found in television studios at one time were known in the trade as 'Bu(i)rd boxes'!

Success in any pursuit benefits from a wide range of experience and the ability to learn from these experiences. I believe National Service taught me to get on with people and to exercise authority benevolently. A degree in Physics gave me an insight into the properties of materials which affect their response to acoustic signals. University research taught me that I was not fitted for pure research but that the world of building acoustics contained fascinating practical problems which I could enjoy solving. The Festival of Britain took place during my undergraduate days and, along with several colleagues, I spent a weekend in London of which my main memory is a concert in the Festival Hall; perhaps this was a formative experience for the rest of my life.

I was fortunate to discover acoustics at an early age and, as I am sure many of you will also have found, it proved to be a satisfying way of life. In the fifties there were no university courses on acoustics; however, there were, as now, the three non-university research bodies – NPL, BRS (now BRE), and BBC. Having met Messrs Somerville and Gilford (respectively Head of Electro-acoustic Group and Acoustics Section in the BBC Engineering Research Department) I elected to join the BBC. Acoustics work at that time was still housed in a converted convent in Balham but, eventually, we would all come under one roof in a country mansion down at Kingswood Warren in Surrey.

The acoustic interests of the BBC obviously centred primarily on studio design, equipment and operations. From the earliest days of broadcasting it had been appreciated that the restriction to a single, aural, channel of communication emphasised the need for quiet background noise levels and non-reverberant spaces. This necessitated critical design criteria and building standards for the construction of studio premises.

The BBC's standards of acceptable background noise in studios of various types were developed from first principles by combining measurements of existing studio noise levels (largely ventilation noise) with subjective ratings for each of the studios. These background levels, together with measured noise levels created by programme activities, allowed the necessary sound insulation criteria to be calculated while measurements on many samples of typical studio constructions built up a catalogue of possible designs.

The design of sound absorbers, and particularly low-frequency panel and membrane absorbers, was a major part of my acoustic experience for the first few years in the BBC. Broad band absorbers consisting of four resonant sections superimposed one above the other were used to reduce the strength of first reflections in a stereo listening room. But other specialised types were also developed; anti-carpet absorbers which had a trough in their absorption characteristics where good quality carpet had a peak: line scan whistle absorbers which had a peak at 10 kHz (in the days of 405 line TV) and many others.

Diffusion was the holy grail of BBC acoustics. It was generally accepted that a degree of diffusion was necessary in studios – as in other buildings. But no-one knew how much was needed or even how to measure how much one had. And, of course, one needs to measure a thing in order to find the most efficient means of creating it. Opinions differed; the French believed that hemi-cylindrical surfaces were the most efficient for diffusing sound while we in the BBC were sure that rectangular protuberances were the best. Finally, we convinced ourselves that interspersed absorbers were as effective as any projections and looked much better. Correlation, such as might now be found to be indicative of diffusion, was beyond the powers of our measurements in those days and most of the methods for measurement relied on an examination of the statistical properties of the sound in the studio and tended to be extremely tedious to determine.

During my time I certainly visited all the major and most of the minor studio centres in the UK and Northern Ireland. Studio testing – whether for acceptance of new studios or for trouble shooting in existing studios – was jealously guarded as a part of our role in spite of the strongly held view of the management that it was not research. Our feeling that it was important for us to keep contact with the user's needs may have been a rationalisation of our interests but the challenge of solving problems was real. And it was also generally interesting – even good fun – although testing could be tiring on occasions. A sleeper to Edinburgh, which in those days provided an excellent breakfast and allowed one to start work at 9am, meant that the studios there could be tested by lunch time, allowed travel to Glasgow with the afternoon and evening spent testing those studios followed by an overnight sleeper back to London. By 9am we could be back at work in Balham.

A more unusual request was to be asked to go to Kingston to carry out some tests on a consultancy basis. My expectation that Kingston upon Thames was the site proved far wide of the real situation and I set out for

Kingston, Jamaica, to test and carry out the acoustic treatment design of studios for their tourist authority. Even in those far off days carrying a 0.45 in revolver for test purposes on transatlantic flights was frowned on and I was fortunate enough to be able to borrow a policeman with revolver and blank ammunition for some of the tests; the same possibility did not materialise in Cardiff many years later when the police refused even to consider the possibility of their revolvers ever being used with blank ammunition!

For some of our testing we used stage maroons, the medium size of which simulate infantry fire. My Health and Safety instincts were aroused when I found that part of the wadding from such a maroon had gone through the perforated hardboard front of a studio absorber. I built a cylindrical shield of 50% open area perforated metal and was even more impressed when the first explosion reformed it to a largely spherical shape. Although I prefer balloons for some applications it has to be admitted that the greater energy is needed when structures capable of 90+ dB average sound insulation are under test.

The development of one-eighth scale model testing to predict the acoustic behaviour of studios was a challenge to the many specialities of our engineers. Loudspeakers covering the frequency range from 1 – 100 kHz, microphones and amplifiers with the same range and low background noise levels and tape recorders to provide the necessary frequency shift. My interest lay in the provision of music with no natural reverberation (recorded in the BRE free field room in co-operation with BRE, BBC, Salford and Bradford Universities) and the selection of materials which reproduce acoustic characteristics at the scaled up frequencies. The fact that in the end it was well nigh impossible for a group of people to make consistent judgements on the programme material was a pity. I am sorry also that some members of a well-known university who had hoped to make a lifetime's work from the research felt that we had 'trampled all over the problem'!

Increasing responsibility in the Section meant more time spent in Committee work and this, together with new management techniques introduced by McKinsey, brought my time in the BBC to an end after eighteen years. This had been a formative period of my life and I find it difficult to imagine a better grounding for consultancy.

I wanted to return to acoustic design work which I felt was my forte. Fortunately Sandy Brown, who had joined the BBC as its Acoustic Architect at the same time as I joined as a research engineer, was looking to increase the strength of his consultancy practice and offered me a place and a partnership in due course if we proved to be compatible. This stage of my life was to last for a further 18 years and still exists as I work part time as a consultant to the practice – but able to choose the projects that I get involved in!

Probably the first major change that I noted on leaving a research department and entering consultancy was the necessity to be an instant expert – to be sent into meetings with no detailed knowledge of the project and generally no time to do any preparatory work.

Other changes which many of you will recognise included clients whose interests lie in making money rather than in the artistic merits of the project we were designing; and certain bodies which arrange committee meetings or design meetings lasting all day because they had no intention of returning to their own offices!

The most straightforward part of the job was, of course, studio design which constituted a major part of the work at the time that I joined the practice. Our field of activity extended throughout the world so I visited and worked in America, Africa, Middle East, Far East and, eventually, Australia in connection with new studio design. In many of the countries the broadcast engineers had been trained by the BBC which gave us a useful point of contact. Although we have felt at various times over the years that studio design had reached the end of the line, in fact it has remained an important part of our practice workload.

However, that said, my early projects included council offices, barracks, schools for the disabled, railway station sound systems and many similar buildings and subjects each with their own interesting aspects. The extension of our design experience into more specialised areas was obvious with drama studios and television theatres leading to theatre and performance space design while orchestral studios, although usually only having limited audience seating, laid the basis for the design of concert halls.

Of course, I rate the design of St David's Hall in Cardiff as the major achievement of my life – albeit a regrettably well-kept secret among UK performance spaces! I can remember the heart searching during the last few months of the project; had one found the correct amount of low-frequency absorbing surfaces; would the diffusing ceiling prove adequate; would the orchestra be able to hear one another? It was a relief when the first concerts passed with general satisfaction; it was a delight when conductors and soloists like Andre Previn and Oistrakh wrote letters of commendation and the final accolade came very recently when St David's Hall featured in Beranek's new book *Concert and Opera Halls – How They Sound* as one of the group of nine international halls graded as excellent.

I have continued together with my colleagues in Sandy Brown Associates as the concert hall designers to

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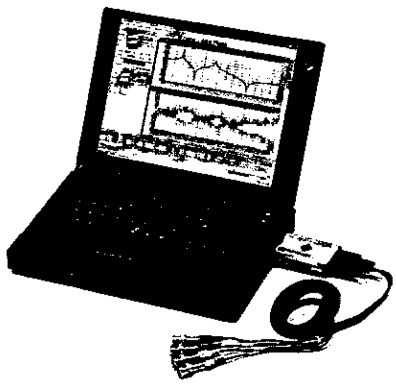

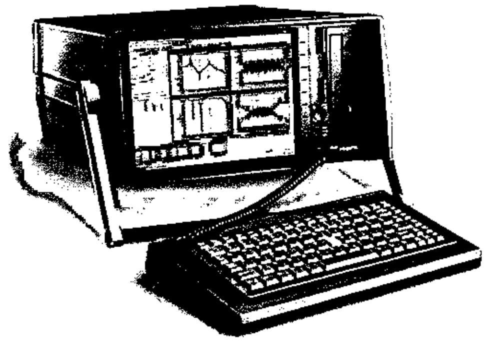

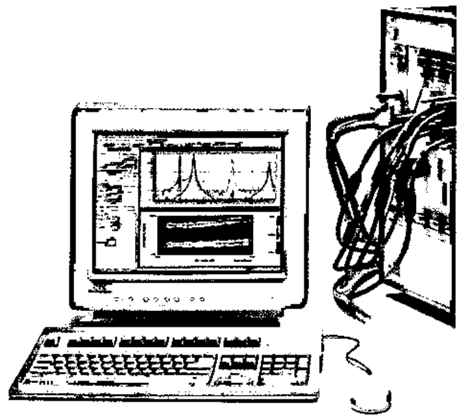

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ONE-DAY MEETING NOTICE

The Noise Act 1996

(Organised by the Measurement & Instrumentation and Environmental Noise Groups)

Leeds Metropolitan University

3 March 1998

The Noise Act 1996 introduced a new night noise offence and a new procedure for the confiscation of noise-making equipment. Local authorities are now able to use these powers and this meeting, which updates a meeting on this topic held in February 1997, will deal with some of the issues involved.

The morning session, beginning at 10 am, will include invited presentations on the development and use of the offence, and its relation to other neighbour noise issues:

Developments in neighbour noise policy *Stephen Benton, Department of the Environment, Transport and the Regions*

Different perspectives on neighbour noise *Colin Grimwood, Building Research Establishment*

Managing with the Noise Act *Cécille Darrol, London Borough of Southwark*

Noise Act - initial experiences from a rural district *Jeremy Hutchinson, Newark & Sherwood District Council*

Lunch and refreshments will be provided. The afternoon sessions will comprise demonstration exercises of the measuring techniques required by the Act, run by Brüel & Kjær (UK) Ltd, CEL Instruments Ltd, Gracey & Associates and Larson·Davis Ltd.

There will be ample opportunity for discussion of the issues raised by the Act, and the meeting will be valuable for all those concerned with the Act and other issues of neighbour noise. Certificates of attendance for CPD purposes will be available to delegates.

Please note that the Proceedings issued to delegates at this meeting will be the same as those for the One-Day Meeting held in February 1997 (Proc IOA Vol 19:Part 1). However, delegates will also receive supplementary material describing subsequent developments.

Meeting organisers:
Richard Tyler FIOA (Chair, Measurement & Instrumentation Group), CEL Instruments Ltd, 35-37 Bury Mead Road, Hitchin, Herts SG5 1RT Tel: 01462 422411 Fax: 01462 422511 email: richardt@cel.ltd.uk and Colin Grimwood (Environmental Noise Group), BRE, Watford, WD2 7JR

The Noise Act 1996, Leeds Metropolitan University, 3 March 1998

Name:

Organisation:

Address:

Tel: Fax: email:

☐ Please register me as a delegate to the one-day technical meeting and invoice me for the meeting fee which includes lunch & proceedings

☐ Members £95.00 + £16.63 VAT = £111.63 ☐ Others £125.00 + £21.88 VAT = £146.88

Institute of Acoustics, 5 Holywell Hill, St Albans, Herts AL1 1EU
Tel 01727 848195 Fax 01727 850553 email Acoustics@clus1.ulcc.ac.uk Registered Charity No 267026

FIRST ANNOUNCEMENT

One-Day Meeting

Good Practice In Acoustical Measurements: Six Hands-on Tutorials

(organised by the Measurement and Instrumentation Group)

London Venue
9 June 1998

This meeting comprises six workshop tutorials, three in the morning and three after lunch, on the following topics:

- *Calibration techniques for measurement microphones, and the use of the sound calibrator in calibrating sound level meters and analysers.*
- *Statistical indices, including percentile spectra, and their measurement methods.*
- *Sound power level determinations - various methods and when to use them.*
- *Use of DAT recorders for measurement applications.*
- *FFT analysers for noise measurements - synthesis errors and how to avoid them.*
- *Environmental noise measurement and unattended monitoring - wind noise and windshields, self-noise, and care of microphones.*

These workshops will be planned and co-ordinated by members of the Measurement & Instrumentation Group Committee.

Certificates of attendance will be available for CPD purposes.

Meeting Organiser:

Richard Tyler FIOA (Chair, Measurement & Instrumentation Group)
CEL Instruments Ltd
35-37 Bury Mead Road
Hitchin
Herts SG5 1RT
Tel: 01462 422411 Fax: 01462 422511 Email: richardt@cel.ltd.uk

Institute of Acoustics, 5 Holywell Hill, St Albans, Herts AL1 1EU
Tel 01727 848195 Fax 01727 850553 email Acoustics@clus1.ulcc.ac.uk Registered Charity No 267026

EDUCATION

Certificate of Competence in Workplace Noise Assessment

The following were successful in the October 1997 examination

Amber
Moss, D F

Bristol
Cox, M
Davies, P A
Rose, M J
Wainwright, P T

Colchester
Cook, D P
Gains, W
Gardner, N J
Jones, B
Parker, B S
Sutton, B E
Walker, A

Leeds
Bradley, T I
Page, W A
Singleton, B
Taylor, W
Thomas, D

Liverpool
Richards, J I

Loughborough
Austin, C
Barnes, N
Beaman, T
Brindley, R F
Bywater, J
Clark, R A
Davies, G P
Del-Mar, P
Dunning, R T
Elsworth, M W
Geffert, M
Henderson, N
Poole, S J
Rainey, D
Thompson, S W
Turner, M A

NESCOT
Bateman, K J
Nicholson, J

Staffs
Dandy, M I
Denton, M C
Plant, M D

Certificate of Competence in Environmental Noise Measurement

The following were successful in the October 1997 examination

Bell College
Hogg, I

Birmingham
Brownstone, M S
Clarke, A S
Downes, M
Large, L
Mumford, C P
Price, C
Starsmore, S J
Taylor, J S
Woodcock, S L

Bristol
Budd, J W
Ford, N K
Greenham, E G
Wilkinson, A L K

Colchester
Gayler, K J
Hodges, L S
Miller, G S
Pedder, C J
Pringle, I
Sheldon, K A
Thompson, I M
Tuplin, S E

Derby
Rayers, M W
Webster, D
Webster, D L

Liverpool
Belfield, P B
Bracken, S W
Clampton, S J
Clinch, R C
Elliot, R P
Hullock, T E
Naisbitt, N J
Pritchard, A
van Beever, R
Weller, S I

NESCOT
Booth, J M
Didcock, S
Guiney, G A
Metland, K
Nunez, L
O'Donnell, G W
Vandyck, E

Staffs
Beakes, S J

Strathclyde
Friels, M
Irvine, I A
Parker, K A
Steel, F
Wood, D R
Woodcock, V

The United Engineers' Exuberant Summer Ball

London, 30 May 1998

This unique social occasion aims to bring engineers together for the first time at a national social event and provide a chance for engineers to meet with others in a relaxed environment while enjoying a splendid occasion. Offers of assistance with organising the event and requests for further information should be directed to:

Gavin Palmer, Co-chairman UEEBC
27 Mapledale Avenue, East Croydon, Surrey CR0 5TG Tel: 0181 654 2712

INSTITUTE DIARY 1998

18 FEB
London Branch
Afternoon Visit-Shakespeare Globe Theatre

25 FEB
Eastern Branch
Evening Meeting - Sound Insulation in Buildings
Braintree

25 FEB
North-west Branch
Evening Visit and Meeting - Gunfire Noise Control
Openshaw

26 FEB
IOA Medals & Awards, Council
St Albans

27 FEB - 1 MAR
IOA Diploma Distance Learning Laboratory Weekend 97/6
St Albans

3 MAR
Instrumentation & Measurement Group
One-day Meeting - The Noise Act 1996
Leeds Metropolitan University

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

10 - 12 MAR
Health & Safety Exhibition, Olympia, London (IOA exhibiting)

18 MAR
Eastern Branch
Evening Meeting - Clay Target Shooting
Ipswich

18 MAR
London Branch
Evening Meeting - Sounds from the ASA CD
London

31 MAR - 2 APR
Acoustics '98 IOA Spring Conference
Cranfield University

22 APR
London Branch
One-day Meeting
Construction Noise and Vibration
London (note change of date)

23 APR
IOA Publications, Meetings Committee
St Albans

30 APR
IOA Membership, Education Committee
St Albans

12 - 14 MAY
RoSPA Exhibition, NEC, Birmingham (IOA exhibiting)

14 MAY
IOA Medals & Awards, Council
St Albans

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

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

9 JUN
Instrumentation & Measurement Group
One-day Meeting
Good Practice in Acoustical Measurements
London

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

18 - 19 JUN
Diploma examinations
Accredited Centres

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

20 - 21 JUL
Underwater Acoustic Calibration and Measurements Symposium
Underwater Acoustics Group
National Physical Laboratory

17 SEP
IOA Publications, Meetings Committee
St Albans

24 SEP
IOA Membership, Education Committee
St Albans

1 OCT
IOA Medals & Awards, Council
St Albans

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

22 - 25 OCT
Reproduced Sound 14
Electroacoustics Group Conference

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

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

10 NOV
Instrumentation & Measurement Group
One-day Meeting
Measurement Protocols: Noise Measurement in Buildings
London

12 NOV
IOA Publications, Meetings Committee
St Albans

12 - 15 NOV
Autumn Conference: Speech & Hearing
Speech Group

3 DEC
IOA Membership, Education Committee
St Albans

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

10 DEC
IOA Medals & Awards, Council
St Albans

15 - 16 DEC
Sonar Signal Processing
Underwater Acoustics Group Conference
Loughborough University

Association of Noise Consultants Council Meetings
23 March 1998

MEMBERSHIP

The following were elected to membership at the meeting of Council on 16 December 1997

Fellow
Tsoi, S P S

Member
Bladon, C M
Bramwell, S R
Bromilow, I D
Cheung, T H
Critchley, I C
Dean, L J
Horsley, P
Mahmood, A
Nicholson, J R S
Rogers, P J
Smith, S
Stigwood, M A
Waters-Fuller, T
Wedgbury, S J

Associate Member
Bowen, I C
Collins, D
Donaidson, R P
Flatt, S J
Gittins, A E
Higgins, A S
Malone, N J
Morgan, S
Ng, K W
Scott, S C
Willfratt, J M

Associate
Arianto, F
Mushref, M

Student
Burton, N J S
Davis, L
Gupta, A
John, A S
Jones, S D
Manning, F J
Mellor, S A
Murray, C L
Steel, C
Whittingham, R L

the UK regional cities with subsequent designs for both Glasgow and Belfast (described recently in the Bulletin) together with many other auditoria world-wide.

The opportunity to travel the world has been both a bonus of the job and, on occasions, a hardship to be borne. To those who don't travel, the chance to visit the Presidential palaces of an African state, to explore the back street markets of Lusaka, to sail on the reservoirs of Kano or the harbour in Sydney, and to see for the first time the Sydney Opera House are added benefits indeed. And I enjoyed them all at the time. However, those of you who have shared these or similar experiences will also remember the long evenings spent in hotel rooms or bars because there are no public entertainments and walking the streets is hazardous; or, perhaps, like me you have experienced the inability to buy a pair of socks of any colour at all in any shop in the city; that was not Sydney I hasten to add!

Perhaps the most potentially hazardous situation occurred following the assassination of the President during my time in Nigeria. Panic reigned on the streets of Lagos for the first days; the airports were closed down and a curfew imposed; news was hard to come by and rumours were rife; international phone calls took a full day to get through even after some connection with the outside world was restored. Once I found my way to a good hotel and made contact with other consultants in the same position, things improved and I even practised driving a speedboat while a colleague learned to waterski.

The President of another state had a reputation for extreme noise sensitivity and we were employed to quieten the air-conditioning and all other noise sources to virtual inaudibility (NR10 in most rooms). It was only when the job was successfully completed that I visited the presently occupied palace to find that the air-conditioning had tonal components at perhaps NR40 which indicated that the sensitivity, while understandable, had perhaps been exaggerated.

Acoustic measurement equipment represents one of the major areas of change during my working life. In the early days sound level meters had A, B and C weightings but, of course, the inclusion of octave band pass filters was out of the question. We carried a set of filters for measurements which filled one carrying case and weighed 11 kg. On the very limited number of occasions that one-third octave filters were necessary, a trolley with three 19 in rack enclosures full of iron-cored chokes had to be man-handled by two people.

Correlation measurements were one area which I had the pleasure of exploring in the BBC. Such measurements were shown to be able to separate paths through structures by their transit times or to determine reflection coefficients from materials. However, the continuously variable delay required to plot the auto-correlation coefficient as a function of delay time was obtained from a tape loop with the replay head driven by a screw thread coupled to the drive shaft of a level recorder. It worked and was used on a limited number of occasions in studios to find leakage paths or verify absorption of surfaces but it certainly wasn't a portable set of equipment.

I class as the third strand of my professional life, service to the profession. My recent period as President elect, President and now Immediate Past President is the final accolade following earlier involvement. In the 1960's, first with Michael Delany and later Geoffrey Parfitt, I was the joint Hon Sec of the Acoustic Group of the Physical Society; I continued with the organisation of Sixth Form Lectures for the British Acoustical Society and eventually chaired the Education Committee. Finally, I chaired the joint Committee of IOA and other interested parties which produced the format and initial syllabus for the IOA Diploma.

Obviously the early part of this involvement occurred during my time in the BBC and latterly followed my partial retirement. During the middle part of my life I found, as have many others, that self employed consultancy is not really compatible with the time or availability necessary for such tasks. Nevertheless, I would stress that it is vital to the continuing success of the IOA and all similar bodies that they have the support of universities, colleges and public bodies in allowing their engineers and personnel to undertake committee work and the other necessary voluntary tasks.

Finally, I should express my grateful thanks to my family who put up with my long working hours including commuting time, with many periods of absence from home, with periods of abstraction when the job was not going well and a few periods of euphoria when it was. In spite of it all, some of them are even acousticians! That must say something for the subject. ❖

PIONEERS OF BRITISH ACOUSTICS

Tom Somerville

After obtaining his BSc at Glasgow University in 1926 Tom Somerville spent nearly three years in industry with a Glasgow firm, Electronic Control Ltd. Then in June 1929 he obtained relief work with the BBC at Glasgow and at the end of that year joined the BBC Research Department, an association which lasted throughout the rest of his working life. Somerville was initially attached to the Field Strength Section and became head of this department in December 1936 when it was combined with Propagation Studies. This work involved the measurement and prediction of field strength distribution of radio transmitters and site surveying for the aerials, a most valuable contribution to the subsequent radar defence systems against enemy aircraft in the second World War.

Tom had never intended to make a career in radio and the great expansion of the overseas services of the BBC gave him the opportunity in 1942 to transfer to recording and he became head of the recording section of the design and installation department, which finally led in January 1946 to his control of the then newly-formed electroacoustics group of the research department, which comprised recording, audio-frequency and acoustics sub-sections. The respective heads of these sections were P Axon, G Shorter and C L S Gilford, the overall director of the Research Department being H L Kirke who was the first Chairman of the Acoustics Group of the Physical Society on its formation in 1947.

In this new post Somerville was responsible for the scientific basis of the BBC post-war development of studios, magnetic (and later video) recording, microphones, loudspeakers and all other audiofrequency apparatus. The limitation of space will allow only a detailed mention of his work on concert hall and music studio acoustics which was incorporated in the acoustics section under the immediate direction of Dr Gilford, to whom I am indebted for much of this information. Somerville's keen interest in music and its reproduction largely motivated and guided the work and he had the rare ability of forming and remembering an accurate impression of the sound of speech and music and to correlate the impressions with the visual appearance of an auditorium – a faculty which credited him with possessing 'golden ears'. This skill was in evidence during a tour of concert halls and music studios in Britain and Scandinavia (1947) when he noted that in halls and studios designed with fan-shaped plans, splays and reflectors to increase the sound intensity in the rear seats, the tone of an orchestra was 'hard' and unmusical compared with traditionally shaped halls after the 'Leipzig' pattern. As a result of this discovery he set up an acoustics programme of investigation on the effects of diffusion, on the Haas effect for horizontally and vertically related sources, and to ascertain the reason for the sound level differences between the back and front in halls of various shapes. His conclusion from this work was that diffusion played a very important role in determining both tonal quality and definition. The presence of reflectors and other design features, which increase the direct to reverberant sound intensity, degrade artificially the quality and cause irregular definition.

For many years these views were widely disputed but they have been vindicated subsequently and after 1955 only vestigial reflectors or splays were seen again. His ideas were accepted abroad and Winckel and Kuhl in Germany, for example, used copious scattering surfaces in three large music studios built during the middle sixties. Throughout his activity in the field of concert hall acoustics Somerville never ceased to emphasise that the only way to learn the truth was to listen to the result. He organised many subjective and listening sessions to which musically interested people were invited and in this way he hoped to establish a consensus of opinion among listeners. This aspect of his work was carried on continuously in parallel with the analytical and diagnostic scientific research.

Tom Somerville did not neglect the professional side of acoustics and was active in supporting the creation of the Acoustics Group of the Physical Society and later of The British Acoustical Society. He served on the committee of the Acoustics Group from 1949 to 1953 and later became its Chairman. He was a Fellow of the Institute of Physics (1949), a Member of the IKE (1946) and a Senior Member of the IRE (1947). He retired from the BBC in July 1966 but continued private consulting work from his home on the Scottish island of Luing.

This article, which first appeared in the early years of Acoustics Bulletin, was part of a series written by the first President of the Institute, Dr R W B Stephens HonFIOA. It is reprinted here because many of the present membership will not have seen it; others in the series will appear in future issues ❖

1997 AUTUMN CONFERENCE – NOISE AND VIBRATION, CODES, STANDARDS AND CRITERIA

Hydro Hotel, Windermere, 27 – 30 November 1997

The 1997 IOA Autumn Conference, on environmental noise, took place in the now familiar surroundings of Bowness in what may be described as fairly neutral weather conditions, compared to the blizzard conditions which concluded last year's Autumn Conference. This enabled the many family members present to enjoy the several trips laid on by the organisers as well as independent forays into the beautiful scenery.

About 140 delegates attended and 33 papers were delivered together with two successful workshops.

This conference was enhanced not just by the usual excellence of the presentations, but also by the three medal presentations and lectures. These were, in order of occurrence: Rayleigh Medal Lecture given by Professor Leif Bjørnø FIOA entitled *Noise pollution of the seas;* the inaugural RWB Stephens Medal Lecture given by Professor Robert C Chivers FIOA, entitled *Sounds unheard – a glimpse at the silent acoustical world of ultrasonics* and the Tyndall Medal presentation Lecture, given by Dr Simon N Chandler-Wilde MIOA on *The boundary element method in outdoor noise propagation*.

The citations for these medal awards were printed in the November/December 1997 issue of Acoustics Bulletin. The 1996 ANC Prize for best IOA Diploma project was presented to Mr C M Gasgoigne AMIOA.

I am indebted to chairpersons of sessions for the following summary of the main technical proceedings.

The opening session was very interesting, and was started by Ken Dibble playing a recording he had made of Bernard Berry being interviewed by the local radio station earlier that morning.

This was followed by a very informative paper from Bernard describing the work of NPL in the acoustics field from its inception, up to the present and beyond, and introduced the concept of Eurodecibels. Some of the historic photographs Bernard presented, showing experiments on subjective response to noise, may go some way to explaining the divergence of opinions that are often put forward!

John Seller then described the work that had gone into the recent revision of BS 4142. He explained that the brief of the working party was not to undertake a full technical revision but rather to clarify the document where there had been ambiguities. The major changes were then discussed in more detail.

A session followed on Clay Target Shooting Noise, which was organised and chaired by Colin Grimwood of the Acoustics Centre at BRE, coinciding with the launch of the public consultation draft of the CIEH/CPSA/BSSC Code of Practice on Clay Target Shooting. (CIEH stands for the Chartered Institute of Environmental Health, CPSA for the Clay Pigeon Shooting Association and BSSC for the British Shooting Sports Council).

'First in the firing line' was Philip Wright of BRE who presented the results of research carried out by BRE on behalf of the Department of the Environment, Transport and the Regions (DETR). Philip recommended that shooting noise level should be defined as the average of the 25 highest L_{AFmax} shot levels taken within a half-hour period. Using this definition, BRE found that *widespread annoyance is unlikely below around 55 dB(A)* but *likely above around 65 dB(A)*. Second 'on the stand' was Gordon Brown of Suffolk Coastal DC who introduced himself as a PBI (ask him!) and spoke as both a shooter and an enforcing officer. Gordon called for tightly defined noise limits in any code whilst expressing his concern that such a code should not provide an excuse to get rid of sites.

'Third down the line' was Mel Kenyon of Martec on behalf of the CIEH Ad Hoc Technical Group on Clay Target Shooting Noise. His opening comment – an assertion that the draft Code of Practice still had not been finally agreed with the CPSA nor the BSSC – was intriguing. His paper gave a review of the BRE research and compared the recommended measurement method with others in common use.

The 'final shot' was from Steven Glass of the London Borough of Bromley who used a specific case study to illustrate the use of common sense, informal advice and formal action under the Environmental Protection Act to bring about a reduction in noise complaints at the site. However, the final outcome of this case was that the shoot stopped – thus reminding delegates of the concerns expressed earlier by Gordon Brown.

Clearly the clay target shooting noise debate looks set to continue. Copies of the draft CIEH/CPSA/BSSC Code of Practice can be obtained from Graham Jukes, CIEH, Chadwick Court, 15 Hatfields, London SE1 8DJ. CIEH have requested comments by 31 March 1998.

In parallel with these papers a second session was opened by Richard Greer, of Arup Acoustics, who discussed the pitfalls of specifying trackforms in order to provide reduction in the levels of vibration and groundborne noise from railways. Richard pointed out that there were no standard methods of prediction or specification, and demonstrated that vibration reductions quoted from different authors that did not use a common reference should be treated with caution. He also noted that each component in the system should be specified and tested and, where possible, the complete system should be tested.

Carl Hopkins then presented a paper, co-authored by Robin Wilson of the University of Nottingham and Bob Craik of Heriot Watt University, which discussed some work undertaken at BRE on a possible new method of specifying wall ties.

The current regulations restrict the flexibility for designers and contractors but do prevent unsuitable ties being used. Carl and his colleagues have proposed a method for testing butterfly ties, and have concluded that a suitable alternative tie can be specified by its dynamic stiffness. Carl concluded that there would be a benefit to regulators and industry if a method were established for the determination of the dynamic stiffness in either a British or European Standard.

Sound Insulation and PPG 24 was the title of a session after lunch on the first day. This was also chaired by Colin Grimwood having been organised by Colin with support from the IOA Building Acoustics Group.

The first paper was from Nigel Cogger of Arup Acoustics who presented some BRE work on sound insulation complaints from several years ago, but then drew different conclusions.

The second paper was from Professor Jens Rindel of the Technical University of Denmark. He gave details of a draft INSTA standard on the sound classification of dwellings that has been proposed for use in the Nordic Countries and Estonia. The standard appears to reach aspects of sound insulation that Approved Document E has yet to consider, although questions remained on the accuracy of low frequency measurements at the end of the session. The third paper, from Nick Tinsdeall of BRE, detailed the results of sound insulation field tests on converted and refurbished properties which give cause for concern about the performance of some proprietary floating floor systems.

After tea we were given a harrowing account of an HMO fire fatality by Paul Edwards of Gillingham BC. The fatality had prompted an investigation which found that 62% of the fire alarm systems tested did not achieve the required level of 75 dB(A) at the bedhead. The final paper of the session was given by Rupert Taylor who summarised the findings of his review of the application of PPG 24, Planning and Noise carried out for DETR. Many questions remained on this important topic when the session was brought to a prompt close in order that preparations could be made for the multimedia extravaganza by Professor Chivers to follow.

A session on Noise at Work related issues was chaired by Dr R N Vasudevan of NESCOT and this was also held on the Friday afternoon. This opened with an interesting paper by Mervyn Randall of Foster Wheeler Energy Ltd. The presenter discussed various aspects of design criteria for noise reduction and control of safety valves with a view to establishing a design model to assist in conforming to customer and regulatory limits.

Keith Broughton of HSE presented a novel Risk Rating Procedure. This was a numerical method of establishing a rating number using a variety of parameters involved in determining noise exposure levels. The system allowed the user to establish (i) the level of risk and (ii) to identify

The 1997 Rayleigh Medal recipient Professor Leif Bjørnø with the President

the dominant parameter. This would enable the user to focus on control efforts in the area which would result in the most effective reduction of the risk.

Harry Lester, also from HSE, outlined the current revision of the Noise at Work guides. The existing guides have been in place for approximately 10 years and requirement by government on deregulation together with HSE's Revision of Guidance necessitated their revision. The paper outlined the main areas of revision, the change of format of the guides, eg one booklet instead of two and the new guides will be in six parts instead of eight. Updating the guides to reflect the progress in standards was also outlined.

Patrick Corbishley of the HSE presented reasonably practicable noise control techniques in relation to Regulation 7 of the Noise at Work Regulations 1989. The example used was a large quarrying vehicle which was the subject of enforcement for noise reduction. The speaker outlined the procedure that needs to be followed when taking enforcement action with particular emphasis on the need to provide information of known noise control techniques.

Martin Hassett from MW Kellogg provided an insight into the present situation within ISO with regard to standardisation of procedures for noise control in open plant. The plants in question were large chemical plants and the speaker reviewed the current systems used when designing large installations. This procedure could be used to formulate a European Standard which will help to ensure that all countries in Europe will be working to the same guidelines.

The session closed with a lively demonstration on practical noise control techniques in an area which is common in most industries – air discharge. David Bull of Colchester Institute demonstrated the various sources and showed the benefits of simple techniques available to control noise at source. The range of products available vary in performance and application but the overall message was clear – 'There is no need to endure this sort of noise problem in industry today, when the technique available to control it is often simple and cheap to apply'.

On Friday evening, Ken Collins and Stuart Dryden led a workshop on the progress made so far by the joint working group of the Institute of Environmental Assessment (IEA) and the Institute of Acoustics which was producing guidelines on noise assessment. Martin Baxter from the IEA was also present and joined in the discussion which followed the presentation. Ken started by giving a brief description of the chapters that were in the guidelines,

The recipient of the first R W B Stephens Medal, Professor R C Chivers FIOA with Reverand Harold Stephens, RWBS's son and reported that all of the chapters except one had been written. He was now editing the chapters into a standard style. However, he also reported that the key chapter, the one on the assessment process itself, was not yet written, although much thought and discussion had gone into it, and it was hoped it would be drafted soon after Christmas. Stuart then gave a very entertaining description of the chapter on baseline noise level, and how it impinged on the other sections of the guidelines. A lively discussion followed, and included discussion on the stability of different noise indices over long periods and also the revision of BS 4142, and its relevance to noise assessment of new projects and planning.

On the Saturday morning John Hinton chaired a session primarily concerned with noise generated from motor sports activities. The proceedings were opened by Martin Baily from High Peak Borough Council, who discussed the development and use of the Code of Practice on Noise from Organised Off-Road Motorcycle sport which was published by the Noise Council in 1994. Martin also talked through the problems currently being experienced in updating and republishing the document.

Martin's efforts were followed by the first of two presentations by Mike Fillery of the University of Derby. Mike reviewed existing codes of practice and guidelines for motorised recreational activities. In particular, he addressed the role of a code of practice, set out the basic requirements for such a code and compared the contents of several of the existing codes. Mike then floated the idea of forming a joint working party from the different branches of motor sport which would work toward the unification of the different codes presently available within a single methodology.

The third paper of the session was given by Andy Watson from Acoustic Consultancy Services, a familiar face at IOA conferences. Andy referred to a programme funded by the RAC Motor Sport Association and the Association of Motor Racing Circuit Owners, which began in 1994, and resulted in the publication of guidelines for the control of motor sport noise in 1996. During his presentation, Andy discussed the need for these guidelines, the main issues addressed and some of the reactions that publication of the document has produced.

After coffee, the session was treated to an entertaining presentation of the NSCA Code of Practice for the Control of Noise from Oval Motor Racing Circuits by John Gledhill of Tameside MBC. John is the co-author of the code, along with Alan Watson of Rochdale MBC. Both are avid stock car enthusiasts who have worked from within the sport to reduce noise. John's enthusiasm was very much in evidence when he presented a video recording on the various forms of oval circuit motor racing which demonstrated that such activities are not for the faint-hearted even if one is just a spectator.

The penultimate paper of the session was Mike Fillery's second contribution and concerned the research which he has undertaken into the prediction of the equivalent continuous noise level of a motor sport event race from drive-by measurements. The model that has been developed shows reasonable prediction of the noise impact at track-side but further work needs to be undertaken.

Finally, Simon Butler from the Dorset Engineering Consultancy, reported on the results of research he has undertaken, whilst at the North East Surrey College of Technology, into the benefits of using 'quiet' road surfaces. The findings suggest that residents of properties near to main traffic routes will clearly benefit from the selection of quieter road surface materials.

The session was surprisingly well attended considering the strong competition from a parallel session which dealt mainly with construction noise. At the end of the formal presentations, a lively debate on motor sport issues ensued.

In parallel with that session, Bernadette McKell, of Stanger Science and Environment, chaired a session on construction site noise. This opened with a paper presented by Frank Carpenter of the University of Liverpool. This paper set the scene for what was to be a very interesting morning.

Frank outlined the objective of the recent one-day workshop on BS 5228 on which he was reporting and its place in the research project presently underway at the University of Liverpool, funded by EPSRC. Other than considering the feedback the research team have received on the use and application of BS 5228 he contrasted the standard deterministic approach with alternatives namely; artificial neural systems (ANS) and stochastic models. At this point some of the audience probably wondered if they were in the right session since the deterministic approach seems to be so entrenched that alternatives may not be too easily digested. The ANS approach would appear to have taken a back seat in the current research and attention is being focused on stocastic modelling. Frank's explanation of the stochastic modelling paved the way for a later paper presented by another member of his research team.

The next paper was presented by David Leveredge of Symonds Travers Morgan who eased the audience back into the morning with a colourful presentation. David explained that in his experience the prior consent procedure available under Section 61 of the Control of Pollution Act has seen little use. He presented his view of the benefits to all concerned in the construction industry of actually using the procedures. He also highlighted that BS 5228 is often guilty of over-prediction and this theme was continued later and was the subject of much discussion.

The paper presented by Keith Jefferson of Stanger Science and Environment picked up nicely on the theme of BS 5228 over-predication. Keith's well-documented and presented research illustrated the staggering over-predictions to be obtained by the precise application of the methodology outlined in BS 5228. Various avenues were considered in trying to explain the severity of the-over-predictions and Keith concluded that at the very least the accuracy of the BS 5228 prediction method should be quantified as is possible with other models such as CONCAWE and ISO 9613-2.

He also made the very important point that if all concerned in prediction work were playing off a level field then maybe some of the inaccuracies would be minimised. He suggested that a common up to date database of octave band and dB(A) source levels together with realistic on-times would go a long way to improving matters. Many of the points raised in Keith's paper were discussed at the end of the session.

The coffee break enabled the audience to brace themselves for the paper entitled 'Stochastic Models of Construction Site Noise' presented by John Lewis. John is not an acoustician and this maybe helped him see 'the wood beyond the trees'. He presented a very interesting approach to the problem highlighted by Keith in the previous presentation.

John described how it is usually possible to estimate limits within which the values (predicted levels) will lie and also to estimate how the probability of occurrence of values will be distributed between these limits. The research is at a very early stage and the model is being improved and refined. This will not happen overnight but it promises to yield some very interesting ideas which may affect how predictions of construction site noise are generally undertaken.

A slight change of tack followed when Mike Rickaby from the London Borough of Hillingdon presented a fascinating account of his research into the 'Assessment of the tonality of aircraft taxiing noise'. Mike highlighted the difficulties he had encountered in the detection of audible tonal components. He detailed the failing of the 5 dB $^1/_3$ octave tests of BS 7445 and ANSI S12.9 in giving an objective demonstration of the presence of clearly aud-

Certificate of Competence in Measurement of Sound Transmission in Buildings

Following the success of the Institute of Acoustics' certificates in Workplace Noise Assessment and Environmental Noise Measurement, the IOA is launching a new certificate in Measurement of Sound Transmission in Buildings. As with the existing certificates this is envisaged as being a one week course and will be assessed by written examination and by a practical test.

The aim of the course is to train appropriately qualified people to a standard where they are competent to carry out measurements of sound transmission in buildings. Courses will include an introduction to basic theory as well as giving students practical experience in measurement. At the end of the course students should be able to carry out the measurement of sound transmission in a variety of situations with different types of equipment, carry out all the calculations and write an appropriate report.

Due to pressures on time, only a limited time will be devoted to wide issues such as interpreting Building Regulations, measurements in industrial or commercial buildings and in noise control measures.

Institutions interested in holding such courses should contact Roy Bratby, Chief Executive, at the IOA for further information.

An attentive audience at one of the sessions

ible tones. He described the usefulness of narrow band analysis for such identification and discussed with clarity the complications which surround the application of critical band theory to real life sounds. He concluded that in such circumstances objective methods should inform subjective judgement rather than replace it.

The session drew to a close with Carl Hopkins of BRE and his presentation of 'Energy flow measurement between walls containing a window aperture'. Carl explained how openings in flanking walls can be used to reduce the transmission of vibration between separating and flanking wall leaves.

He pointed out that the Building Regulations are fairly prescriptive in the placement of these openings and his research is aimed at understanding the mechanism of such transmission so that designers can maybe place the openings where they would like them to be. Carl gave an account of the measurement techniques involved and his conclusions will be reported at a further meeting as the work is still in progress.

The question session was very lively with interesting comparison on accuracy of BS 5228 type predictions and constructive comments from Professor Gibb of the University of Liverpool on Carl's research work.

A very interesting morning, very interesting papers and it is hoped that all who queued in the corridor could hear what was going on!

Following workshop discussions held during 1996 regarding noise from pubs and clubs, a working party was set up with the task of developing this Code of Practice. On the Sunday morning time was set aside during which the progress to date was described and presentations were made from both the regulatory and industry viewpoints. These were given by John Hinton, Peter Hepworth, Latha Vasudevan, Maria Gavin, Nigel Burgess and Eleanor MacOmish.

There was an additional brief contribution from Ken Dibble. A lively and valuable discussion followed coffee during which delegates were able to contribute their views on the subject.

So another successful autumn conference came to a close. Thanks are due to the organisers of the technical sessions, to the presenters, the exhibitors and to the staff of the Institute Office for their usual excellent organisation of the hotels and other administration without which the conference could not proceed. It almost goes without saying that the staff of the Hydro Hotel performed to their usual high standard.

John W Tyler FIOA

Dr S N Chandler-Wilde MIOA, Tyndall Medalist with the President

UNDERWATER BIO-SONAR AND BIOACOUSTICS SYMPOSIUM

Loughborough University, 17 – 18 December 1997

Some 60 international delegates representing Japan, Singapore, India, the USA and most of Europe attended this first meeting held by the Institute of Acoustics on Underwater Bio-Sonar and Bioacoustics. Some 33 papers were accepted for this meeting which provided an up to date record of the state of research in a variety of underwater bioacoustic areas. The two day meeting comprised a series of sessions on: Sound Production and Reception Mechanisms in Marine Organisms; Impacts of Underwater Sound – Environmental Assessment; Data Capture Systems; Performance Evaluation of Biological Sonars; Classification/Analysis Techniques for Bio-acoustic Signals. The meeting concluded with a visit to the local Bell Foundry to see the latest (circa 1800) acoustic technology in action.

The symposium was opened by Professor Bryan Woodward FIOA of Loughborough University who described the development of the University and the long history of research in underwater acoustics and sonar system design in the Electronic and Electrical Engineering Department. Bioacoustic research at Loughborough originated with fish-stock assessment sonar signal processing some years ago through close working relationships established with the Ministry fishery laboratories at Lowestoft and in Aberdeen. The topic has grown in recent years to include dolphin sonar studies and the Underwater Acoustics Group is currently involved in the development of both passive and active acoustic deterrent devices intended to reduce the mortality of dolphins in commercial fishing nets and also in the development of appropriate technologies to study the underwater behaviour of these animals around pelagic trawls and other fishing gear.

Dr Simon Pomeroy MIOA of Loughborough University chaired the first session on Sound Production and Reception Mechanisms in Marine Organisms. The key speaker introducing this session was Dr Mats Amundin who is the research director at Kolmårdens Djurpark in Sweden. Mats provided an overview of biological sound production and hearing mechanisms which ranged from the snapping shrimp to the blue whale. This paper was followed by Nick Felgate from DERA Farnborough who described the creation of the Sea Animal Noise Database (SANDS) now being developed for the MoD as a UK equivalent to the established USN biological sound archive at Woods Hole in the USA. This recent development addresses the need to train naval sonar operators to examine biological sound sources more carefully. Among many examples Nick showed the 'knocking-like' signals produced by echolocating sperm whales which have traditionally been called Carpenter Fish.

A detailed interpretation of the harbour porpoises' sonar signals which including measurements of their Source Level and power spectrum was then provided by Dave Goodson MIOA of Loughborough University. He used a simple computer model to explain the unusually narrow band nature of this animal's sonar signals. This hypothesis implicates the deeply corrugated floor of the 'saddle-like' vestibular airsacs in the head surrounding the sound source suggesting that they are acting as a series of delay lines in a tuned baffle. The resulting signals, which are believed to originate as dolphin-like wide band impulses, become extended in duration by reflections within this passive mechanism and peak sharply at the observed 130–140 kHz centre frequency of this biosonar.

Harbour porpoise sonar signals were also the subject of the final paper in this session as James Flint also from Loughborough University introduced Transmission Line Matrix (TLM) modelling as a technique which can now be applied to a graded index lens-like structure, taking the harbour porpoise 'melon' as his example. The density data for this study originated from CAT scans of this animal's head and the 2D TLM model very clearly illustrated that the lower sound velocity fatty core surrounded by progressively higher sound velocity tissues efficiently 'wave-guides' the sound and couples the resulting beam into the water without internal reflections. This graded index wave guide 'lens' also flattens the wavefront and hence significantly reduces the near/far field transition distance.

Session 2 (chaired by Ed Harland MIOA of DERA Winfrith) was entitled Impacts of Underwater Sound – Environmental Assessment. The first speaker in this session should have been John Richardson of LGL Ltd, Canada, but unfortunately he was unavoidable detained at the last minute and his paper was introduced by Bryan Woodward. John faxed his presentation material and Bryan had a sleepless couple of nights as he prepared to review the subject of *Marine mammals and man-made noise: current issues.* The presentation went well and the points that John had highlighted were then used to initiate a discussion at the end of this session. This introductory presentation was followed by Tony Heathershaw from DERA Southampton Oceanograhic Centre whose paper was entitled *Understanding the impact of sonars on the environment.* Tony discussed the increasing constraints placed on a sonar system designer by recent and proposed environmental legislation. Tony indicated three developments of particular importance: the awareness that sound energy constitutes a form of pollution; the emergence in environmental legislation of the precautionary principle; and the obligation within legal frameworks of a 'duty of care'. Tony then provided a

The visit to Taylor's Bell Foundry

comprehensive review of an Environmental Auditing Process Model designed to assess the impact of sonars on the environment with examples which included ATOC and the development of the SURTASS LFA system. This first part of the session was concluded by a presentation by Joe Johnson of the US Space and Naval Warfare Systems Command on *The US Navy's Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) – Protecting the marine environment in system deployment.* The paper addressed the environmental consequences of deploying this new sonar and in particular recognises the difficulties experienced by the public when faced by underwater Source Level measurements where dB reference levels are not the same as those used in airborne audiometry. This presentation provided a detailed guide from which future environmental assessments can be modelled.

The final two papers in this session were presented by Kristin Kaschner from Freiburg and Loughborough Universities and by Lisa Browning of Durlston Coastwatch. Kristin's paper entitled *Species characteristic features in communication signals of cetaceans: source level estimates for some free ranging North Atlantic odontocetes* used recorded data obtained from a single hydrophone attached to a pelagic trawl which was fished along the continental shelf break between SW Eire and Spain. The original sea trial studies by Loughborough University concerned the detection and unobtrusive observation of dolphin behaviour around the trawl which was typically fished some 80 m deep and some 500 m behind the fishing vessel. Kristin's study of the dolphin communication calls from this large data set has shown that echo-ranging using bottom and surface reverberations is a practical tool that can be exploited in these particular conditions and her statistical study of source levels calculated using this ranging method showed that two frequently encountered species, common dolphins and white-sided dolphins, differ significantly in their whistle vocalisation SL's making discrimination between such signals possible when visual sightings were unavailable, as at night.

The final paper presented on the first day was by Lisa Browning of Durlston Coastwatch on *Cetacean disturbance by high speed ferries: a preliminary assessment.* Lisa discussed the underwater sound levels and the noise spectrum produced by the new high speed catamaran 'wave piercing' ferries now operating out of Poole to the Channel Islands. The route taken by these ferries as they depart from, or approach, Poole harbour crosses part of the designated Marine Research Area off Durlston Head where a permanent seabed hydrophone system has been installed to monitor cetacean and other bioacoustic activity. The sound signatures of these unusual vessels were carefully recorded and analysed and they appear spectrally quite different from those obtained from other classes of vessel. Initial concern for the possible impact of these ferries on a local bottlenose dolphin population has eased as sighting surveys coordinated by the Durlston Coastwatch team have not shown statistically-significant behaviour changes when compared to the data obtained prior to the introduction of this ferry service.

The first day finished with a poster session which included thirteen additional presentations.

The conference dinner was held that evening in Royce Hall and the after-dinner speaker was Ron Mitson FIOA. Ron's recollections included some playback tests which provided interesting challenges for those accustomed to listening to sounds underwater. Ron's recollections also included some dolphin observations made in 1970 on the former MAFF research vessel Clione which was equipped with a high resolution 'within pulse' scanning sonar. On the occasion in question white beaked dolphins were observed in the North Sea apparently fishing for sand eels and the animal's own sonar pulses were clearly detected on this 300 kHz equipment. The data may be best explained by a non-linear effect in the water enhancing a second harmonic of the dolphin's sonar pulse but as the signals generated in the water were real could this species have developed a sense to exploit them? – if so they may have invented Nature's first parametric sonar!

The second day of the symposium started with the session on Data Capture Systems chaired by Dr Gary Heald MIOA of DERA Bincleaves. The first speaker was

Ed Harland whose paper was entitled *New technologies for marine mammal data capture.* Ed illustrated the advances that have been made in recent years with the advent of digital consumer electronics and PC-based signal processing which now makes relatively low cost data capture systems of very high quality available to bioacoustic researchers. The need for lower cost good quality hydrophones remains, as there is no high volume consumer market to drive down the cost of these devices. Chosrow Lashkari from Monterey Bay Aquarium Research Institute at Moss Landing, California, then described an ocean acoustic observatory for passive monitoring of the ocean. This is a sophisticated multi-channel data acquisition and signal processing system that can be deployed using towed hydrophone arrays or configured to exploit a variety of static seabed sensors. The multi-channel signal processing unit permits precision beamforming to help localise sound sources and the signal characteristics of different marine mammals can be identified and displayed in real time as multiple 'Lofar-grams'. Detection ranges differ for different species but harbour porpoises and sea otter calls can be localised at short ranges to around 300 m and Californian grey whales and killer whales over many kilometers. The system can also sense low frequency sounds associated with seismic events and is clearly a versatile research tool for monitoring geological underwater events in an area where tectonic plate activity is significant.

Dave Mellinger, also from MBARI, spoke on *A low cost high-performance sound capture system for the sub-tidal zone.* This system comprises a seabed-deployed 8 hydrophone array and cable to shore passing through a surf zone. The problems of maintaining such deployments over time are quite significant and the solutions described will be of value to any researcher attempting to emulate this work. The data capture system needed for this multi-channel system has to handle very large volumes of data which at the maximum frequencies needed for seal vocalisations (6 kHz) involve rates of some 2.3 Gigabits per day for each hydrophone. The inovative use of a digital tape streamer to emulate a hard disk provided an economic and flexible file capture system and this particular feature is one that will be worth considering for many other applications.

The next session, Performance Evaluation of Biological Sonars, was chaired by Dave Goodson MIOA of Loughborough University. The key speaker was John Sigurdson from SPAWAR, San Diego. John's presentation *Analysing the dynamics of dolphin biosonar behaviour during search and detection tasks* provided a real insight into the capabilities of these animals to rapidly search an area of seabed for a known target. As the dolphin carried an instrumentation package in its mouth which could accurately sense its orientation and record its outgoing signals it was possible to reconstruct the sonar search pattern and examine the signal spectrum employed as animals carried out the task. Some of the details were fascinating, for example a less experienced dolphin would search with a nominal 10 degree bearing change between 'pings', approximately matching the −3 dB beam pattern of the transmission at 120 kHz, whereas a more experienced animal could complete the same 360 degree search out to 80 metres radius using only half the number of emissions. The dolphin's very wide band pulse appears bi-modal with peaks which can appear at 120 kHz or at 60 kHz or both. These animals also demonstrated a controlled change in this power spectrum between signals employed in the 'search mode' and those used as the target was detected.

John Sigurdson's paper was followed by Peter Dobbins FIOA of BAeSEMA, Bristol, who set out to model the performance of a bottlenose dolphin's sonar as if this was a man-made sonar or radar homing system. As part of this study Peter examined two receiver models which have been postulated in the literature for the dolphin and he examined their performance in limiting conditions of both noise and fine-scale fluctuations that can occur in shallow water turbulent conditions. His conclusion that the dolphin should be able to achieve the angular resolution that has been published with either receiver model is interesting, but performance in noise limited conditions would appear to favour the endfire receiver array model.

The final session on Classification/Analysis Techniques for Bioacoustic Signals was split into two parts and chaired separately. John Sigurdson chaired the first half and Sekharjit Datta, from Loughborough University, the second. The first paper was by Tom Hayward of NRL, Washington, on *Statistical characterisation and classification of marine mammal sounds by multiple resolution encoding of training data distributions.* Tom discussed the problems to be solved by automated classification algorithms for application to marine mammals' sounds and he proceeded to describe the development of an efficient classification and training data compression algorithm with potential to be applied in real time. The approach implemented can achieve very high data compression ratios (over 2000 to 1) without loss of computational efficiency or classification performance.

Loughborough University's Chris Sturtivant continued this recognition theme with his presentation on *Automatic dolphin whistle detection, extraction, encoding and classification.* This software has been developed to scan through large tape records to identify parts of the recordings which contain whistle-like sounds. The software can extract the frequency-time-intensity contours of these calls from background masking noise and then apply automatic pattern recognition techniques to classify them against previously extracted signals. The application of this pattern recognition software to signals recorded in the wild has shown that pods of animals can be identified by their call characteristics and individual whistles associated with these with considerable confidence. The method can be applied as an alternative to photo-id with a much greater detection range and in sea conditions where close-up camera operation is impossible. The work was originally developed in order to determine if dolphins interacting with fishing net deterrents had visited the same site previously or were naive.

Gianni Pavan from Pavia University discussed software tools for real-time IPI measurements on sperm whale sounds. The fact that sperm whale echolocation clicks include a weak reverberant component believed to originate from multiple internal reflections along the axis of the animal's spermaceti organ has been investigated by several authors. The general conclusion that this 'Inter-Pulse-Interval' (IPI) carries information about the size of the animal makes the detection and extraction of this signal component a potential classifier whenever these underwater sounds can be detected. The development of real-time cepstral analysis methods to extract and measure such weak signal components in the field is a significant achievement that will assist researchers attempting to discriminate between vocalising animals.

Dr Datta chaired the final part of this session which was started by Tomonari Akamatsu of National Research Institute of Fisheries Engineering, Japan with a presentation on *Real time click interval acquisition system for dolphin echolocation signals*. Tom described a 'click' detection system which had been developed to record both amplitude and inter-click timing intervals from high frequency echolocation signals on low bandwidth (DAT) recorders. He was able to show comparative click train examples obtained from several species including the Baiji (Lipotes vexillifer) the rare Chinese river dolphin which is now believed close to extinction. Gennady Zaslavski from Israel's University Authority for Applied Research and Industrial Development, presented some interesting experimental data showing that the time resolution of a bottlenose dolphin asked to discriminate a double pulse stimuli appears to be significantly better than has been previously reported and much shorter than the integration time measured by backward masking. It would appear that three independent time constants may operate in this animal's hearing process and the author suggests that they process echo data in the time domain.

Klaus Lucke of the Institut für Meerskunde, Kiel, re-examined recordings made from a solitary wild dolphin whilst this animal foraged for and caught fish. The data set included a number of recordings where the echolocation sounds from this animal were known to precede a fish being captured that was subsequently displayed in the dolphin's mouth. Analysing these sequences showed that the different behaviour phases could be partitioned as foraging search, target detection, target interception and capture.

A fifth phase was also isolated in some recordings which was classed as target release and may indicate either the loss of the target or the return to a search mode. Although these partitions had been previously isolated by signal analysis and were supported by an acoustic engineering interpretation of the sonar system functions, this study examined more examples taken from the original tape archive and confirmed that the partitions described were statistically significant. It is suggested that these click rate patterns provide reliable indicators of underwater behaviour that can be applied whenever suitable signals are detected in the wild. Such underwater acoustic data adds significant value to field observations which otherwise rely on sightings of dolphin surfacings.

The formal part of the Symposium was closed by Peter Dobbins (Chairman of the Institute of Acoustics' Underwater Acoustics Group). Peter summarised the proceedings and thanked the participants and in particular the authors, the symposium's conveners and all the Loughborough University and IOA staff involved in the organisation of the meeting.

A final informal addition to this Institute of Acoustics Symposium took place on the following morning with a visit by a number of the delegates to Taylor's Bell Foundry and the associated bell museum in Loughborough. Taylor's are one of only two bell foundries still operating in the UK and are one of the largest bell makers in the world. The guided tour included a detailed history of bell making, a tour of the works while a bell mould was being prepared ready for casting and some of the delegates were able to return in the early afternoon to see the bell metal being cast. This foundry operates with traditional techniques which have remained almost unchanged since the 1800's although bell tuning does now involve the use of machine tools and tuning forks – we only observed one concession to this century in the form of an electronic phase meter and an oscillator. This guided tour also included a visit to the yard where the cast iron casings used to support and register the sand moulds are stored. One of the casings in the yard was the original used to make Great Paul the largest bell cast in the UK and which still hangs in St Paul's Cathedral.

Sound Intensity – Theory and Practice

Building Research Establishment, Watford, 11 November 1997

BRE hosted the latest in the series of one-day meetings organised by the Institute's Measurement and Instrumentation Group. Fifty-two delegates were attracted by the international cast of speakers and workshop leaders, who were able to discuss and demonstrate the many aspects of sound intensity measurements in a manner suitable for both beginners and seasoned professionals.

The Meeting Organiser, Alistair Mackinnon opened by introducing the speakers, beginning with Svein-Arne Nordby (Norsonic). Svein-Arne described the process involved in performing determinations of sound power level by measuring sound intensity according to ISO 9614. Both Parts of this Standard require the user to choose both an appropriate shape for the measurement surface and the desired grade of accuracy of the result. Svein-Arne demonstrated how software could help the user to calculate the sound power level and achieve the desired accuracy.

In the second paper, Gunnar Rasmussen of GRAS Sound & Vibration described the important features of sound intensity probes and microphones with reference to their specification standard, IEC 61043. Gunnar explained from first principles the advantages of using various probe configurations in different measurement situations.

John Shelton of AcSoft discussed the benefits of the use of PC-based sound intensity systems, where a computer performs many of the functions of a stand-alone analyser. The requirements for acquisition hardware and calibration of the system were also explained. Brüel & Kjær's Bernard Ginn used a hand-held measurement system to demonstrate how technological advances have enabled sound intensity measurements to be performed more easily in unusual environments.

The use of intensity techniques in performing sound insulation measurements was described by Carl Hopkins of the Building Research Establishment. Carl showed how sound intensity measurements allowed the transmission through both separating and flanking elements to be quantified, and provided an example of the technique to demonstrate its potential.

The morning session concluded with Roger Higginson of Higginson Acoustics describing the latest developments in ISO standards that involve the measurement of sound intensity.

After lunch, the delegates were split into small groups in order to take part in the four workshop sessions. A workshop on calibration was led by Stephen Watkins from the National Physical Laboratory. With the aid of Brüel & Kjær (UK), Stephen showed the delegates how intensity instruments should be calibrated and how the performance of the instruments can be checked during measurements.

Gunnar Rasmussen shared some of his considerable experience in designing and using intensity probes with the delegates in his workshop. He discussed the basic limitations and uses of the various probe configurations, and demonstrated some solutions to common measurement problems.

A third workshop illustrated the topic of sound intensity mapping. Ian Campbell of Gracey & Associates supervised the delegates as they performed their own mapping of a mystery noise source, demonstrating the skills required to locate the 'hot spots' of a complex machine. The flexibility of measurements made under the control of PC-based software was demonstrated by John Shelton in the fourth workshop, which also allowed discussion of the hardware requirements for an intensity system.

Before the meeting closed, the delegates were brought together for an open forum to discuss the issues raised during the entire day, and it was clear that the meeting had been found informative and beneficial for people at all levels of expertise in sound intensity measurement.

Peter Hanes MIOA ❖

Hansard

7 November 1997
Noise Control
Mr MacGregor: To ask the Secretary of State for the Environment, Transport and the Regions what proposals he has to develop policies to reduce road and rail traffic noise, in respect of recommendations contained in the twentieth report of the Royal Commission on Environmental Pollution.
Ms Glenda Jackson: The Government is concerned about the impact of noise pollution generally and is aware of the increasing public concern about both road traffic noise and, to a lesser extent, rail noise. It is exploring a range of policy options to mitigate the impact of noise on the environment, and will take the recommendations of the Royal Commission on Environmental Pollution's report into account in its work towards a White Paper on integrated transport.

1 December 1997
Factory Noise
Mr Hinchliffe: To ask the Secretary of State for the Environment, Transport and the Regions what plans he has to review permitted noise levels from urban factories.
Angela Eagle: It is for local authorities to deal with noise pollution from urban factories. Noise from certain factories will be considered as part of my Department's continuing consultation on the future implementation of EC Directive 96/61 'Integrated Pollution Prevention and Control'.

16 December 1997
A34 (Noise Pollution)
Dr Harris: What representations (the Minister) has received on the noise pollution caused by the surface of the A34 passing by Gosford, Watereaton, Islip and Kidlington; and if he will make a statement.
Dr Strang: I have received numerous representations requesting that this section of road be re-surfaced to reduce traffic noise. Traffic noise is one of the issues being addressed by the wide-ranging transport review that we are undertaking at present.
Dr Harris: Will the Minister consider holding a meeting with me and others to discuss the measures necessary to reduce noise on that road? Does he agree that one reason why the surface is the noisiest in Britain is the use of deep-brushed surfacing, which was recognised as a problem but not legislated against when the road was built?
Dr Strang: The level of noise is certainly greater than was predicted by the Transport Research Laboratory when the road was built, but the hon Gentleman will understand that serious traffic noise occurs in many other parts of the country. However, if he would like to discuss the matter with me I shall be delighted to see him.
Noise
Mr Paice: To ask the Secretary of State for the Environment, Transport and the Regions what proposals he has for noise reduction measures on existing roads.
Dr Strang: There are several alternative approaches for reducing the noise of traffic on existing roads which need to be considered more fully. Tackling the problem of traffic noise will be an important element in our Integrated Transport Policy which will be published as a White Paper next year.
Fiona Mactaggart: To ask the Secretary of State for the Environment, Transport and the Regions what plans he has to provide assistance to people who are subject to the effects of transport noise.
Dr Strang: The adverse impacts of transport noise are an important concern for Government. There have been significant reductions in the noise from new road vehicles and aircraft, which have led to marked improvements in the noise climate, although in the longer term projections suggest that without further improvements, previous reductions in noise from vehicles would be offset in many areas by traffic growth. We are considering policies on noise as an important strand in the development of our Integrated Transport Policy on which we will be publishing a White Paper next year.
Mr Fallon: To ask the Secretary of State for the Environment, Transport and the Regions if he will make provisions in the Highways Agency budget to provide greater soundproofing of existing motorways.
Dr Strang: There are several approaches to reducing the noise of traffic on existing roads which need to be considered more fully. Tackling the problem of traffic noise will be an important element in our Integrated Transport Policy which will be published as a White Paper next year.
Extracts provided by Rupert Taylor FIOA

Law Report

Murdoch and Another v Glacier Metal Co Ltd

Before Lord Justice Nourse, Lord Justice Pill and Lord Justice Thorpe
Judgment January 19
Night time factory noise that was marginally greater than the World Health Organisation's recommended level above which the restorative value of sleep could be affected, did not constitute an actionable nuisance to a family living close by when all the surrounding circumstances were taken into account.

The Court of Appeal so held dismissing an appeal by the plaintiffs, Mrs Ann Murdoch and Mr Duncan Murdoch, from the dismissal by Mr Recorder Trethowan in Yeovil County Court on September 27, 1996 of their action against the defendants, Glacier Metal Co Ltd.

Mr Peter Wadsley for the plaintiffs; Mr Roger Eastman for the defendants.

LORD JUSTICE PILL said that the claim arose out of operations at the defendants' factory at Winterhay, Ilminster, that was close to the property where the plaintiffs had lived since 1988.

The plaintiffs also owned 2.6 acres of land on which they had planning permission for six houses. The A303 Ilminster bypass ran at no great distance from their house.

The noise, of a fluctuating nature, was described by Mrs Murdoch as a low droning noise from which they could not escape.

The judge in concluding that the noise did not constitute an actionable nuisance had applied the correct test, namely whether according to the standards of the average person and taking into account the character of the neighbourhood, the noise was sufficiently serious to constitute a nuisance: see Walter v Selfe ((1851) 4 De G&S 315) and Sturges v Bridgman ((1879)11 ChD 852).

The plaintiffs, the judge found, were genuine people whose lives had been affected. Expert evidence giving noise level readings had been called by both parties.

Reference was made to the World Health Organisation report Environmental Health Criteria 12: Noise published in 1980 which stated: *Studies have indicated that the disturbance of sleep becomes increasingly apparent as ambient noise levels exceed about 35 dBA.*

The judge, having stated that the WHO report was the evidence that had most assisted him, concluded that the evidence showed that the agreed measurement of the noise level at night in the plaintiffs' house was the same, or marginally above, the WHO recommended level.

Mr Wadsley submitted that the judge had misunderstood the effect of that recommendation and the report's emphasis on the importance of undisturbed sleep to human life.

He relied on the expert evidence of noise readings taken at night in the house with the windows open and on the adverse effect of fluctuating noise on sleep.

Sleep was a matter of importance but there was no proposition of law that there was a common law nuisance if sleep in a house in an area such as that in the present case was disturbed. Other considerations had to be borne in mind.

The judge was entitled to take into account the overall situation including the proximity of the bypass and the paucity of complaints from others living nearby. He was entitled to reach his conclusion and dismiss the action.

Lord Justice Thorpe gave a concurring judgement and Lord Justice Nourse agreed.

Solicitors: Stephens & Scown, Exeter; Penningtons.

BSI News

New and Revised British Standards

BS 5228: Noise and vibration control on construction and open sites

BS 5228-5: Code of practice applicable to surface mineral extraction (except coal) sites – gives recommendations on measures for the control of noise and vibration to be adopted to ensure that the community is subject to minimum disturbance. This standard aims to assist architects, contractors and site operatives, designers, developers, engineers, local authority environmental health officers and planners. No current standards are superseded.

BS 6840: Sound system equipment.

BS 6840-4: 1997 Microphones. Recommends characteristics to be specified and the methods of measurement for sound system microphones. Supersedes BS 6840-4: 1987.

British Standards Withdrawn

BS 3549-2: 1981 Electrical and acoustic measurements at audio frequencies. Superseded by BS EN 60107-2: 1997.

BS EN Publications

The following are British Standard implementations of the English language versions of European Standards (ENs). BSI has an obligation to publish all ENs and withdraw any conflicting British Standards (BSs) or parts of BSs. This has led to a series of standards (BS ENs) using the EN number.

BS EN ISO 266: 1997 Acoustics – Preferred frequencies. Supersedes BS 3593: 1963.

BS EN ISO 8662: Hand-held portable power tools – Measurement of vibrations at the handle. No current standard is superseded.

BS EN ISO 11654: 1997 Acoustics – Sound absorbers for use in buildings – Rating of sound absorption. No current standard is superseded.

BS EN ISO 11821: 1997 Acoustics – Measurements of the in situ sound attenuation of a removable screen. No current standard is superseded.

BS EN 12096: 1997 Mechanical vibration – Declaration

and verification of vibration emission values. No current standard is superseded.
BS EN 12099: 1997 Mechanical vibration – Declaration and verification of vibration emission values. No current standard is superseded.
BS EN 61019: Surface acoustic wave (SAW) resonators.
BS EN 61019-2: 1997 Guide to the use. No current standard is superseded.

CEN European Standards

The following International standards have been adopted as ENs.
EN 1793: Road traffic noise reducing devices – Test method for determining the acoustic performance.
EN 1793-1: 1997 Intrinsic characteristics of sound absorption.
EN 1793-2: 1997 Intrinsic characteristics of sound absorption.
EN 1793-3: 1997 Normalised traffic source spectrum.
EN 60551: (IEC 60551)(CENELEC) Determination of transformer and reactor sound levels. Amendment A1: August 1997 to EN 60551: 1992 (IEC 60551: 1987/ A1: 1995, modified).

ISO Standards

ISO/TR 140-13: 1997 Acoustics – Measurement of sound insulation in buildings and of building elements – Part 13: guidelines. Will only be implemented as a British Standard if ratified by CEN.
ISO 140-1: 1997 (Edition 3) Requirements for laboratory test facilities with suppressed flanking transmission. Following ratification by CEN will be implemented as BS EN ISO 140-1, to supersede BS 2750-1: 1980.
ISO 140-8: 1997 (Edition 2) Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor. Following ratification by CEN will be implemented as BS EN ISO 140-8, to supersede BS 2750-8: 1980.
ISO 10843: 1997 Acoustics – Methods for the description and physical measurement of single impulses or series of impulses. Unlikely to be implemented as a British Standard due to technical problems with the content.
ISO 11819-1: 1997 Acoustics – Measurement of the influence of road surfaces on traffic noise – Part 1: Statistical Pass-By method.
ISO 10846: Acoustics and vibration – Laboratory measurement of vibro-acoustic transfer properties of resilient elements.
ISO 10846-1: 1997 Principles and guidelines. Will be implemented as BS ISO 10846-1: 1997.
ISO 10846-2: 1997 Dynamic stiffness of elastic supports for translatory motion. Will be implemented as BS ISO 10846-2: 1997.

European Telecommunications Standards Institute (ETSI)

Publications

ETS 300 753: October 1997 Equipment engineering (EE): Acoustic noise emitted by telecommunications equipment.

IEC Publications

IEC 60268-4: August 1997 (Edition 2) Sound system equipment - Part 4: Microphones.

International New Work Started

IEC 61094-5 Measurement microphones – Part 5: Method for pressure calibration of working standard microphones by comparison.
This list was compiled by John Tyler FIOA from recent issues of BSI News

ANC Guidelines

Noise Measurement in Buildings

Part 1: Noise from Building Services

Part 1 of the ANC Guidelines on Noise Measurement in Buildings: 'Noise from Building Services' has now been published.

Although standards and guidelines are available for many types of noise measurements, members of the Association of Noise Consultants (ANC), no doubt among others, have found some areas where there is no specific guidance available. The measurement of sound in buildings is one of these areas. The result of this concern has been the publication of *ANC Guidelines – Noise Measurement in Buildings Part 1: Noise from Building Services*. This is a document intended to offer a consistent approach to the problem of specificying and undertaking measurements of noise levels inside buildings.

It offers advice on, amongst other things, the appropriate noise unit to be used, measurement positions, the time over which the noise should be measured and on the effects of performance variations between sound level meters. It is, however, not meant to replace any standards or guidelines already in existence, rather it will give sensible help to those who have to make measurements in real situations.

Part 1 of the Guidelines is priced at £7.50 and may be obtained from the ANC office at 6 Trap Road, Guilden Morden, Near Royston, Herts SG8 0JE. Cheques should be made payable to the Association of Noise Consultants and sent with the order.

Part 2 of the Guidelines, which deals with noise from external sources such as road and rail traffic, will be available shortly.

Book Reviews

Computing Prosody
Yoshinori Sagisaka, Nick Campbell and Norio Higuchi
Springer-Verlag 1996, 450 pages
ISBN: 0387–948–04X £60

The book presents a collection of papers from the Spring 1995 workshop on computational approaches to 'processing the prosody of continuous speech' held at ATR interpreting laboratories in Kyoto Japan. Certainly it is not for beginners. If you are not familiar with concepts such as 'pitch accent', 'contrasting intonational morphemes' or even 'rhythmic prominence' then it is probably not yet the book for you!

This is a book for experts written by experts and it will be therefore be of interest mainly to those who are already deeply involved in aspects of speech and language processing especially those concerned with Text to Speech generation and Speech Recognition.

Divided into four major sections – The Prosody of Spontaneous Speech, Prosody and the Structure of the Message, Prosody in Speech Synthesis and Prosody in Speech Recognition the chapters range from those concerned with linguistic theory to those concerned with practical measurements of prosodic phenomena.

The significant number of Japanese papers (fortunately presented in English) made this, for me, a particularly interesting read as they addressed purely Japanese phenomena. Having been struggling to learn Japanese for several years I found myself particularly entranced and distracted by these – however that makes it hard to judge how a person who doesn't share this interest of Japanese would relate to it.

Overall this is a theoretical book – full of complex ideas – but ideas supported primarily by anecdotal and descriptive evidence rather than formal experimentation. That said, one of the papers *Effects of Focus on Duration and Vowel Formant Frequency in Japanese* by Kikuo Maekawa made significant progress in quantifying and statistically analysing major effects. This, of course reflects the fact that the whole subject remains an under-researched area and, as is gently pointed out in the introduction to the final section, few of the ideas spanned are yet mature or robust enough to be used to have had a major impact yet upon practical speech systems.

Overall then, the value of the book lies in that it provides an up to date broad survey of the topic. It will be useful primarily to those interested in linguistics and is especially recommended for those keen to find new ideas for research projects.

Denis Johnston

Scroggie's Foundations of Wireless & Electronics, Eleventh edition
S W Amos and R S Amos
Newnes 1997, 293 pages
ISBN: 0-7506-3430-8
Paperback price: £19.99 (First published in 1936)

This is a new edition of a book to which I became attached many years ago in an earlier edition (and in an earlier world).

It is principally about simple electronics with particular reference to radio transmission and reception. It might therefore be thought odd that I should review it for Acoustics Bulletin.

However there are many points of contact with our Acoustics World: not only do we make much use of simple electric circuit analogies in acoustics (the concept of impedance is taken straight from electronics) but also there are parallel concepts and ideas in wave mechanics, transmission lines, radiation characteristics, imaging and so on. Then there is our direct interest in hi-fi and audio and the design of loudspeakers, as well as instrumentation.

There are 28 chapters compressed into about 280 pages. The early chapters cover fundamentals of electricity, alternating current circuits, resonance, devices (including triodes still, which I thought had departed this life but, apparently, not so), transmission lines, radiation (from antennas) and audio amplification. These are followed by radio and video specific chapters on detection, selectivity, rf and if amplification and electronic imaging.

Finally there are some more general chapters which include waveform generators, switches and power supplies, as well as two specifically digital chapters. The new matter compared with the previous edition (1984) is largely an extensive revision of digital electronic techniques, new information on video recorders and cameras, liquid crystal displays and analogue/digital conversion.

The book is wide-ranging and full of useful and interesting information but the treatment is very largely non-mathematical. It is most attractively written by a father and son team who manage to write seamlessly so that it is not possible to detect two different styles.

If you are not deeply knowledgeable about electronics this book makes an admirable general introduction to many of the intellectually challenging concepts of modern electronics. It does this in a style which is relaxed enough to qualify the book as bedtime reading. This is very good value, particularly if you have a passing interest in the subject already.

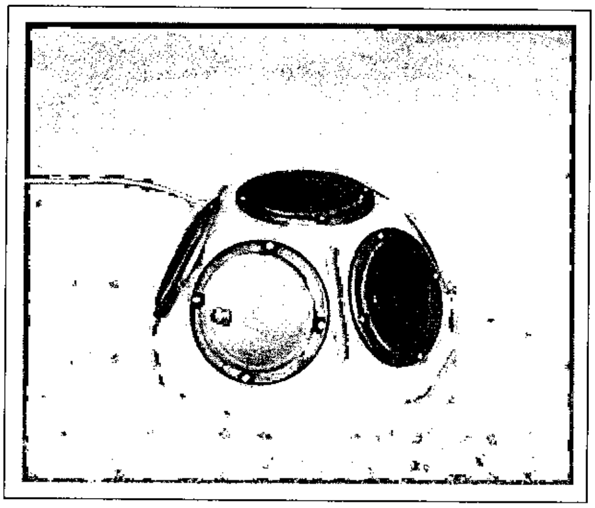
A J Pretlove FIOA ❖

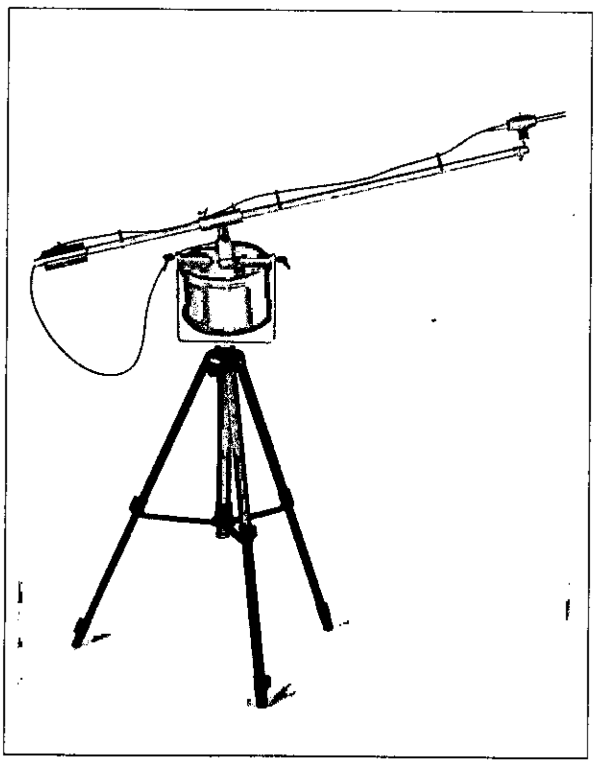
New Products

GRACEY & ASSOCIATES

NOR-250 Omi-directional Hemi-dodecahedron Loudspeaker

There is an increasing trend towards compact and comprehensive instrumentation for field measurements of the acoustic performance of structures. However there has remained a problem with loudspeakers in that to achieve the required radiation pattern they have been large and heavy. The NOR-250 has been designed to address this problem by employing the hemi-dodecahedron principle and using the reflections from the floor to obtain the required pattern. A considerable reduction in weight is achieved as the number of speakers is halved and it is no longer necessary to use a heavy-duty tripod to hold the speaker the required height above the ground. By careful co-operation between the acoustic and speaker design teams it has been possible to achieve sound power output levels that are comparable to the conventional full dodecahedron types. The levels at the extremes of the frequency range have also been increased as these are the frequencies that most frequently give problems in the measurement of both reverberation time and transmission loss. The NOR-250 has a companion power amplifier type NOR-260; this delivers an electrical output of 200 watts continuous, 1 kWatt peak, and is available with internal noise generators. There are two options for the generator, one with MLS for use in broad band systems whilst the other has sequential filters for use with traditional instrumentation systems. The loudspeaker is also available as a stand-alone device for use with conventional power amplifiers and noise generators.





NOR-252 Oscillating Microphone Boom

Modern instrumentation used for measurements in building acoustics performs the time domain averaging with a high degree of precision; there can however be technical and time penalties involved in undertaking the spatial averaging that is also required by the standards. Either each position must be measured separately or a large number of microphone positions set up and scanned via a multiplexer. The alternative is to use an oscillating microphone boom that will scan the test space and allow the analyser to make an average in time and space at the same time; this brings about a saving in both time and equipment deployed in the measurement process. The NOR-250 Oscillating Boom is compatible with the range of standard measurement microphones and their associated preamplifiers in current use and meets the requirements of the International and British Standards. The sweep angle may be selected as either 180 or 360 with sweep radii of between 0.3 and 1.8 meters. Increments in the sweep rate provide selections in the range 8 to 32 seconds. An option also provides for a stepping mode of operation giving 12 fixed positions for boom that may be remotely selected. Particular attention has been given in the design to minimising the noise level of the system and in the worst case configuration, maximum speed and load, levels are less than 22 dB(A).

For further details please contact Gracey & Associates, High Street, Chelveston, Northants NN9 6AS. Tel: 01933 624212 Fax: 01933 624608

Gracey & Associates is a Sponsor Member of the Institute.

CEL INSTRUMENTS LTD

Night Noise Meter

CEL Instruments have developed a dedicated Night Noise Offence meter. The CEL-1-2-3 automates the measurement and determination procedure of the underlying noise, the L_{Aeq} source noise and the Level Difference between the two in accordance with the Department of the Environment circular. The operator simply operates the Offence 'hot key' to display the measurement results. At the completion of a measurement a direct hard-copy print-out can be generated on a standard battery powered, inkjet printer, which is included in the kit. The information for both the pre and post measurement calibration is given in addition to the offence details.

An internal real-time calender-clock will time stamp all measured data and also enables the instrument to be set to operate a fully automated offence detection system. In this mode the CEL-1-2-3 starts a 15 minute data run until it is automatically terminated by the clock or stopped by manual command.

The data can also be retained in the instrument's memory for inspection or downloaded at a later date. For further details contact CEL Instruments Ltd, 35-37 Bury Mead Road, Hitchin, Herts SG5 1RT. Tel: 01462 422411 Fax: 01462 422511. E-mail: sales@cel.ltd.uk. Website: htCp://www.cel.ltd.uk.
CEL Instruments is a Key Sponsor of the Institute.

THURLBY THANDAR INSTRUMENTS LTD

Two-channel dynamic signal analyser

The SR785, now available from TTi (Thurlby Thandar Instruments), is a 2-channel dynamic signal analyser which is suitable for analysing both electrical and mechanical systems.

Typical applications include modal analysis, machinery diagnostics, vibration testing, control systems and acoustic measurements.

The computational heart of the SR785 is a 32-bit floating point digital signal processor which delivers a true 102.4 kHz real time bandwidth on both channels.

Two precision 16 bit analogue/digital convertors provide 90 dB dynamic range in FFT mode and 145 dB in swept-sine mode. With up to 800 lines of spectral resolution, the SR785 allows the user to zoom in on any portion of the 47 mHz to 102.4 kHZ range.

Each input channel functions as a separate analyser with its own span, centre frequency, resolution and averaging modes.

Simultaneous storage of all measurements and averaging modes is provided. Vector-averaged, RMS-averaged and unaveraged data are all available without the need to start the measurement again.

Because of the speed of the SR785, there is no need for a separate 'fast averaging' mode. For example, in a fullspan FFT measurement with a 4 ms time record, 1000 averages take exactly 4 seconds, during which the analyser still operates at its maximum display rate.

Features include octave analysis, swept-sine measurements, time capture and an order tracking feature to evaluate the behaviour of rotating machinery. In addition, a facility known as 'user math' allows the entry of any equation involving time or frequency data, stored files, constants, or an array of supplied operations including arithmetic functions, FFT, inverse FFT, jw, d/dw, exp, ln x and many others.

A built-in 3.5 inch 1.44 Mbyte floppy disk drive, GPIB and RS-232 interface ports and a Centronics printer port combine to allow flexibility in saving, printing, plotting or exporting measurement data.

A full context-sensitive help screen is also available.
For further details please contact Thurlby-Thandar Instruments Ltd, 2 Glebe Road, Huntingdon, Cambs PE18 7DX Tel: 01480 412451 Fax: 01480 450409.

MEMBERS

Professor S J (Eric) Yang FIOA
Died 31 October 1997

Friends and colleagues were saddened to hear of the death of Eric Yang after a protracted illness on 31 October 1997.

Eric was a Fellow of the Institute and sometime Specialist Examiner for the Measurement elective paper for the Institute's Diploma in Acoustics and Noise Control and Institute members who met him in that role remember him with respect and affection.

Eric was born in Wusan, China in 1932 and graduated in Electrical Engineering from Hong Kong in 1964 and followed this with an MSc two years later. He completed a PhD at Queen Mary College, London in 1970. Eric subsequently moved to British Rail and then to the Department of Electrical and Electronic Engineerindg at Heriot Watt University in Edinburgh. He was appointed Professor in the department in 1993, retiring last year.

Always a popular member of the department, Eric worked with quiet dedication and enthusiasm while exhibiting a self-effacing modety.

The Institute extends its deepest sympathy to all his family.

Ronald K McLaughlin MIOA
Died 9th October 1997

Ron McLaughlin was a Member of the Institute and a Chartered Engineer. Ron served on the Scottish Branch Committee for many years and latterly as Treasurer to the Branch.

He was educated at Bellahouston Academy before going on to achieve a BSc (Hons) in Mechanical Engineering in 1957. He worked briefly in industry before moving into teaching at Whitehill Senior Secondary School where he found his vocation in education.

After lecturing in various educational establishments, his last two posts were at the Glasgow College of Building and Printing and Glasgow Caledonian University as a senior lecturer in Environmental Science. In was while at these two institutions that he developed a specialism in the sound insulation area of building acoustics and gained an MSc in acoustics, vibration and noise control from Edinburgh's Heriot Watt University in 1983.

He continued tos work in acoustics through semi-retirement in 1994 until his death at the age of 62 and is survived by his wife, a son and a daughter.
Items for inclusion in this section should be sent to John Sargent MIOA, Oak Tree House, 26 Stratford Way, Watford WD1 3DJ ❖

John Barry Large FIOA

It is with great sadness that the death has been announced of Professor John Large in a car accident on 15 January 1998.

John Large was Professor of Acoustics at ISVR and a prominent member of the Institute since its formation in 1974.

A full obituary will be published in the next issue

Non-Institute Meetings

March 4–5, 1998: 4th Annual Conference of the Society of Acoustics (Singapore), Singapore
Contact: Dr W S Gan, Acoustical Services (1989) Pte Ltd, 209–212 Innovation Centre, NTU, Nanyang Avenue, Singapore 639798, Republic of Singapore; Tel: +65 7913242, Fax: +65 7913665 email: wsgan@singnet.com.sg

March 23–26, 1998: DAGA 98, Meeting of the German Acoustical Society, Zurich, Switzerland
Contact: German Acoustical Society DEGA; Univ Oldenburg, Dept Physics/Acoustics; D-26111 Oldenburg; Tel: +49 441 798 3572; Fax: +49 441 798 3698; e-mail: DEGA@aku.physik.unioldenburg.de

April 5–8, 1998: Noise-Con 98, Ypsilanti, MI, USA
Contact: INCE, PO Box 3206, Arlington Branch, Poughkeepsie, NY 12603, USA; Fax: +1 914 462 4006; e-mail: inceusa@aol.com

May 12–15, 1998: IEEE International Conference on Acoustics, Speech and Signal Processing, Seattle, WA, USA
Contact: L Atlas, Dept EE (FT 10), Univ of Washington, Seattle, WA, USA; Fax: +1 206 543 3842; e-mail: atlas@ee.washington.edu

May 18–22, 1998: 7th Spring School on Acoustooptics and Applications, Gdansk, Poland
Contact: B Linde, Institute of Experimental Physics, University of Gdansk, Poland; Fax: +48 58 41 31 75; e-mail: school@univ.gda.pl

May 25–27, 1998: Noise and Planning 98, Naples, Italy
Contact: Noise and Planning, via Bragadino 2, I-20144 Milano, Italy; Fax: +39 2 48 01 88 39; e-mail: md1467@mclink.it

June 8–10, 1998: Joint EAA/EEAA Symposium Transport Noise and Vibration, Tallinn, Estonia
Contact: East-European Acoustical Association, 196158, Moskovskoe shosse 44, St Petersburg, Russia; Fax: +7 812 12 79 323; e-mail: krylspb@sovam.com

June 9–12, 1998: 8th International Conference on Hand-Arm Vibration, Umea, Sweden.
Contact: National Institute for Work Life, Conference Secretariat HAV98, PO Box 7654, S-90713 Umea, Sweden; Fax: +46 90 16 50 27; email: hav98@niwl.se

June 20–26,1998: Joint Meeting of the 16th International Congress on Acoustics (ICA) and the 135th Meeting of the Acoustical Society of America (ASA), Seattle, Washington, USA
Contact: ICA/ASA '98 Secretariat, Applied Physics Laboratory, Univ of Washington, 1013 NE 40th Street, Seattle, WA 98105-6698, USA; Tel: +1 206 543-1275, Fax: +1 206 543 6785, E-mail: ICA/ASA98@apl.washington.edu

June 21–26, 1998: 13th US National Congress of Theoretical and Applied Mechanics, Gainesville, FL, USA
Contact: M Eisenberg, AeMES Department, University of Florida, PO Box 116250, Gainesville, FL 32611-6250, USA; Fax: +1 352 392 7303; e-mail: meise@eng.ufl.edu

June 26–July 1, 1998: International Symposium on Musical Acoustics – ISMA 98, Leavenworth, Washington State, USA
Contact: ISMA 98 Secretariat; The Catgut Acoustical Society; 112 Essex Av, Montclair, NJ 07042, USA; Tel: +1 201 744 4029 (Thursday only); Fax: +1 201 744 9197 e-mail: catgutas@msn.com; http://www.boystown.org/isma98

June 27–30 International Phonetic Sciences-98 (IPS-98) Bellingham, WA, USA
Contact: R Weiss, Linguistics Program, Western Washington University, Bellingham, WA 98225, USA Fax: +1 360 650 4837; e-mail: weiss@henson.cc.wwu.edu

September 7–9, 1998: Nordic Acoustical Meeting 98, Stockholm, Sweden
Contact: Swedish Acoustical Society, c/o Ingemansson AB, Box 47321; S-10074 Stockholm, Sweden; Fax: +46 818 2678; e-mail: nam98@ingemansson.se

September 14–16 Iberian Congress of Acoustics, Lisbon, Portugal
Contact: CAPS-Instituto Superior Tecnico, Av Rovisco Pais, 1096 Lisboa Codex, Portugal; Fax: +351 1 352 3014; email: capsist@alfa.ist.utl.pt

September 16–18, 1998: International Conference on Noise and Vibration Engineering, Leuven, Belgium
Contact: Ms L Notre, KU Leuven, Division PMA Celestijnenlaan 300B, B-3001 Leuven, Belgium; Fax: +32 16 32 29 87; e-mail: lieve.notre@mech.kuleuven.ac.be; Web: http://www.mech.kuleuven.ac.be/pma/events/isma/isma.html

October 12–16, 1998: 136th Meeting of the Acoustical Society of America, Norfolk, VA, USA
Contact: Elaine Moran, ASA, 500 Sunnyside Blvd, Woodbury, NY 11797 USA; Fax: +1 516 576 2377; e-mail: asa@aip.org

November 16–18, 1998: Inter-Noise 98, Christchurch, New Zealand
Contact: New Zealand Acoustical Society Inc, PO Box 1181, Auckland, New Zealand

November 20, 1998: Recreational Noise, Queenstown, New Zealand (In association with the above)
Contact: P Dickenson, Ministry of Health, PO Box 5013, Wellington, New Zealand, Fax: +64 4 496 2340; e-mail: philip.dickenson@mohwn.synet.net.nz

November 22–26, 1998: Biological Effects of Noise, ICBEN 98, Sydney, Australia
Contact: N Carter, National Acoustics Centre, Chatswood, Sydney, Australia; Fax: +61 2 411 8273

November 30–December 4, 1998: 5th International Conference on Spoken Language Processing, Sydney, Australia
Contact: Tour Hosts, GPO Box 128, Sydney, NSW 2001, Australia; Fax: +61 2 9262, 3135

March, 15–19, 1999: 2nd Forum Acusticum and 137th and Meeting of the Acoustical Society of America and 25th Meeting of the Cerman Acoustical Society, Berlin, Germany
Contact: Elaine Moran, ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA; Fax.: +1 516 576 2377; e-mail: asa@aip.org

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