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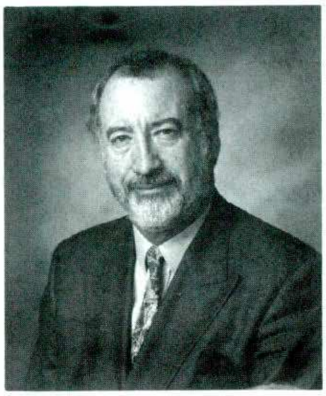


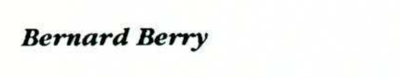
Dear Fellow Member

I am writing this letter soon after the 1997 Annual General Meeting, and just over half way through my two-year term of office. The past year has certainly been eventful and challenging. Much hard work by many people culminated in the success of Internoise 96, and, in January 1997, we saw the beginning of new arrangements for the Secretariat of the Institute, under which the Institute is now the direct employer of the staff at Agriculture House. In meeting these and other challenges, my task has been made easier by the tremendous support of the staff and of my colleagues on the Executive Committee and Council.

The Annual Report of Council for 1996, which was presented at the AGM, and will be printed in the next issue of the Bulletin, demonstrates very effectively the variety and vigour of the Institute's activities, and covers the work of the 7 Standing Committees, the 9 Specialist Groups and the 8 Regional Branches. The Chairmen of Committees and the Chairmen and Secretaries of the Groups and Regional Branches are named in the Annual Report, and I would like to use this opportunity to thank them all for the invaluable contribution which they make to the success of the Institute. But I would also like to thank all those members who support the Institute, through their voluntary efforts and enthusiasm in committee work.

As I look forward to my second year as President, I have no doubts that the future holds yet more challenges, but also tremendous opportunities. For example, new initiatives are being explored in our educational role, including plans to have more involvement with schools through the use of CD-ROM teaching packages. The Institute is to proceed with negotiations with the Engineering Council to seek nominated body status for Chartered Engineeer. And, following recent further discussions in Belfast, attempts are being made to accelerate the process of setting up a new Branch of the Institute to serve the needs of present and future members in Northern Ireland and the Irish Republic. News of these and other developments will appear in future issues of the Bulletin .

Sincerely yours



Bernard Berry

ACOUSTIC SCALE MODEL TESTING OVER 21 YEARS

Mike Barron MIOA

Introduction

Models have long been valued as a way of visualising or investigating the complex behaviour of sound in enclosures. As long ago as 1843 Scott Russell experimented with 2D water wave models [1]. In 1912 W C Sabine, the father of quantitative room acoustics, first photographed the more precise 2D air-wave models by using the Schlieren technique [2]. Acoustic scale modelling also has a long history [3], being first used by Spandöck in the 1930s. Since then considerable experience has been built up in scale modelling but computer modelling now presents a challenge, with the convenience of requiring no more than a computer to generate not only objective results but also auralisation (aural simulations of music or speech as would be heard in the space).

The principle behind acoustic scale modelling is actually simple. The complex behaviour of sound when it meets finite size surfaces or obstacles depends on the relationship between the size of the surface and the wavelength. If this ratio is kept constant, acoustic behaviour is reproduced in miniature. From reference to the fundamental equation: Speed of sound = frequency x wavelength, we see that if the wavelength is reduced the frequency must be increased. But the propagation medium (air) in the model is the same as at full size, so for a 1:10 scale model we need to increase frequency ten times.

Thus scale modelling takes care of the complexities of wave behaviour. Computer models on the other hand are based on tracing sound rays; wave behaviour is only incorporated with difficulty. Computer models also need to find ways of dealing with reflection off diffusing surfaces and some method for handling the enormous quantity of sound rays which make up the reverberation. Techniques for dealing with these various complications will take time to optimise and require very careful validation.

The Principles of Practical Scale Modelling

Because acoustic modelling involves high frequencies, one issue which needs to be confronted is air absorption. By using either dehumidified air (around 2% rh) or bottled nitrogen, the so-called molecular component of air absorption can be all but eliminated, which leaves the unavoidable but smaller classical component. In fact at 1:8 or 1:10 scale, the air absorption can be almost perfectly modelled in this way [3]; at smaller scales excess gas absorption can be easily corrected for when tests are made with dry air or nitrogen.

In auditoria the variety of different surface materials is often small. Hard materials can be simulated by varnished timber or sheet plastic. Absorbing materials need to be selected for models, usually on the basis of a trial-and-error method. Absorption is generally measured in a model reverberation chamber using the standard technique. In auditoria audience seating, or audience, usually constitute the major absorbing surface. Because these elements also scatter incident sound, it is important to reproduce their physical shape as well as their absorption coefficient.

For microphones, $^1/_4$" and $^1/_8$" capacitor microphones are almost ubiquitous. Source transducers often require some ingenuity. Loudspeakers tend to have the problem that even if they can generate the required frequency, they are often highly directional and their magnets can produce a serious acoustic shadow. An array of electro-static transducers can be used for the high frequencies.

For objective measurements spark sources are very attractive because they produce a short impulse from a very small volume. The duration of the spark, and hence the frequency of maximum energy, is determined by the energy discharged in the spark. At 1:50 scale only 4 mJ of electrical energy can be dissipated yet this is sufficient for a decay of 50 dB in a model of a large concert hall, Figure 1 (traditionally the reverberation time is assessed from −5 to −35 dB).

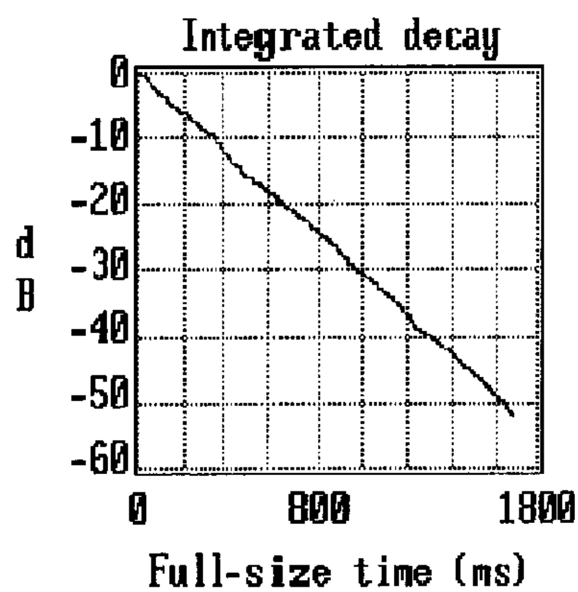


Fig. 1. Integrated decay of response to a spark source in a 1:50 scale model of the Glasgow Royal Concert Hall.

The Choice of Scale

The basic theory of acoustic modelling suggests that modelling at any scale is valid. Apart from the question of air absorption, the modelling is basically pure with no further corrections required beyond the scaling of dimensions, frequency and time etc. It is practical considerations which determine the choice of scale. A major constraint relates to transducers which tend to have a high frequency limit around 100 kHz, both in the case of loudspeakers and microphones.

In practice model scales fall into large, medium and small. Under the category large, the common scales have been 1:8 and 1:10. 1:8 has the advantage of being a whole number of octaves; the other point in its favour for analogue work is that tape recorder speeds traditionally vary by multiples of two. 1:10 is of course a very common scale for architectural drawings.

While models at these large scales can be very accurate and versatile, they have practical limitations as design aids. They are expensive and require spaces with more than normal ceiling height to house the models. Perhaps even more important than these is the problem of the time it takes to construct the model, which means that the model cannot get fully integrated into the design process. A more flexible model is required in which major geometrical modifications are possible. In physical terms models of concert halls at 1:50 scale, for instance, are around 1 m long and can easily be carried by two people.

At 1:50 scale some measurements can be made in the 100 kHz octave (2 kHz full-size), most measurements are limited to a maximum frequency of the 50 kHz octave (1 kHz full-size) up to which the directivity of the microphone is only a minor problem. Impulse responses can be replayed at scaled down speed through a loudspeaker, but otherwise only objective measurements are possible.

Intermediate scales of 1:20 or 1:25 represent the medium group, with advantages intermediate between the large and small.

Measurements in Acoustic Models

Measurements in auditoria are divided into objective, which give numerical values, and subjective, which involve assessment by listening to speech or music. The traditional objective measure is reverberation time but objective assessment of auditoria relies at least as much on the newer measures. For concert performance these include [4]:

- Early decay time (decay rate over first 10 dB of decay, it matches the sense of reverberance better than reverberation time)
- Early-to-late sound index (C_{80}, a ratio measured in dB relating to perceived clarity)
- Early lateral energy fraction (relating to the sense of source broadening caused by early lateral reflections)
- Relative total sound level ('relative' referring to the sound power of the source, a correlate of loudness)

For speech conditions, there are several measures corresponding to intelligibility, of which the 50 ms early energy fraction (D_{50}) is often used. The principle behind this measure and the early-to-late sound index for music is the same.

The first part of a model testing programme will generally consist of measurements of reverberation time (and early decay time) in the empty model, followed by the model with seating and the other absorbing materials installed. With the model fully furnished, impulse response measurements are then undertaken at a dozen or more receiver positions. Sound level distribution is also measured.

Subjective testing involves playing speeded up music or speech through the model, making a simultaneous recording which can then be replayed at slow speed for listening over headphones or loudspeakers. The demands on small scale transducers are considerable. One major development by Xiang and Blauert [5] has been a 1:10 scale model head with scaled outer ears, which enables truer recordings to be made.

Analogue Versus Digital Signal Processing

During 21 years, analysis has switched from being almost completely analogue to almost wholly digital. It is interesting to compare the two. For both approaches though it is important to bandpass filter microphone signals to avoid signals being swamped by irrelevant noise.

Analogue techniques involved many boxes and some fairly bulky equipment. The most bulky was a multiple speed 4 track tape recorder with the facility for simultaneous playback and recording. This recorder was used to implement the interrupted noise method for reverberation time measurement with the decay traces plotted out on a traditional level recorder. The tape recorder was also used for subjective testing of models with music or speech.

Many objective quantities involve integrated energy. A purpose-built analogue squarer and integrator was used for this. However if a spark source is used, no two spark signatures are the same and a digital store for impulse responses is invaluable. To measure the ratio of early-to-late energy could involve as many as 12 boxes of equipment; the operator had a choice of about 40 knobs he could adjust!

For digital analysis, only a microphone amplifier, bandpass filter, storage oscilloscope and computer with A/D convertor are necessary. The sophistication comes in the writing of the software with a flexibility way beyond the opportunities of analogue solutions. For instance, the dynamic range of the decay in Figure 1 was extended by about 5 dB by first subtracting the background noise intensity and then starting the integration with the energy of the extrapolated decay. With digital analysis considerable time is required to develop the software, but the end result is a rapid measuring system which involves less operator involvement.

From Large to Small Scale

In 1974 Professor Peter Parkin initiated a research project into acoustic scale modelling at the Building Research Station, Watford. This project moved to Cambridge University in 1975 when I was asked to join, shortly to be followed by Raf Orlowski. The chosen scale was 1:8 and we had two models: the Barbican Concert Hall and the Olivier Theatre (Figure 2), both in London. The models were built of varnished timber and were connected up to a continuous drying plant. They were tested both objectively and subjectively; experiences with each are described below.

For reasons mentioned above, experiments were conducted in 1977 into the feasibility of testing at 1:50 scale. We worked first with a simple rectangular box and then with a model of the Cambridge University Music School auditorium which we were most kindly lent by the architects. With access both to the model and the full-size building, we were able to develop and validate the testing techniques. The investigation of small scale modelling had to consider source transducers and microphones, gas/air absorption and model materials [6]. The author has now tested seventeen auditoria at 1:50 scale as part of the design process including concert halls, drama theatres, opera houses, a council chamber, an atrium and a lecture theatre. 1:50 scale testing has also been adopted by several other consultancy practices.

Scale Modelling of Concert Halls

For the 1:8 scale model of the 2000 seat Barbican Concert Hall, testing took place before completion of the real hall. The primary aim was to investigate the value of a series of diffusing spheres which had been proposed for the ceiling space. It was concluded that the spheres were performing a useful role in improving acoustic uniformity throughout the space.

The acoustics of the Barbican Concert Hall have had their fair share of criticism since the hall opened in 1982 [7]. Commenting on its acoustics is complicated by the fact that there is not one but several faults. The most obvious problems in the real hall were independent of the model exercise; they are concerned with the reverberation time. The hall volume is too small for a satisfactory mid-frequency reverberation time. But this is compounded by a short low frequency reverberation time, the most likely cause of this appears to be excessive low-frequency absorption by the audience seating. The 2000 diffusing spheres were removed from the hall in an early effort to increase the reverberation time at 125 Hz.

Objective assessment of the model also used the newer measures related to the impulse response. It is now clear that there was a lot more to learn about interpreting these measures. For instance in the case of the early-to-late index (C_{80}), we had recommendations by Reichardt et al [8] for music of the Classical and Romantic eras, Figure 3. The total range considered acceptable for both these musical styles was 6 dB, but was this appropriate? For a 2000 seat concert hall should we perhaps just be applying the criterion for Romantic music? And what frequency range should we be applying this to? Should we take the mean over 5 octave frequencies 125 – 2000 Hz, as used for Figure 4, or a smaller frequency range?

On the other hand, there is a predicted value for the ratio based on an exponential decay:

$$C_{80} = 10 \log_{10} (e^{1.11/T} - 1)$$

For a 2.0 s reverberation time, the predicted value is −1.3 dB. If we measure values significantly different from this, should we be concerned?

It has taken a while to resolve these issues. Perceived musical clarity, which is thought to be related to the early-to-late ratio, is now considered to be linked to just the mid-frequencies, 500 – 2000 Hz. (The low frequency ratio is influenced by attenuation at grazing incidence, also known as the seat dip effect, which presumably has

Fig. 2. 1:8 scale model of the Olivier Theatre, London.

bring some seating blocks closer to the stage, (b) to rotate some surfaces in plan in the Stalls to provide more reflections to rear Stalls positions and (c) a substantial redesign of the ceiling and suspended elements, with in particular a raised soffit at the rear of the hall opposite the stage. The effect of these changes on the EDT was to increase values so that they were now closer to the reverberation time, Table 2. This demonstrated that the acoustics were now more diffuse, almost as diffuse as St David's Hall, which has ratios of mean EDT/RT close to unity, Table 1.

Modification (b) improved conditions at the rear Stalls (problem 1), while the raising of the soffit at the rear (modification c) resolved problem 2 for seating at the highest level. The echo paths (problem 3) involved reflection off the cornice between the walls and ceiling; these paths were obscured in the redesign of the ceiling. Figure 6 shows squared impulse responses at the same position (front of highest balcony opposite the stage) for the first and second models. In the first model the echoes, delayed around 120 ms, are clear, while in the second model the impulse response follows the preferred 'fir tree' criterion [1, p421].

Model testing of the Waterfront Hall demonstrated very clearly how testing at 1:50 scale can be fully integrated within the design programme and influence the design in major ways.

Scale Modelling of Drama Theatres

The 1:8 scale model of the Olivier Theatre (Figure 2) was not tested during the design process but was pressed into urgent service once the theatre was about to open in 1976. There were clearly acoustic difficulties and the first question concerned the nature of the problem: were the problems due to echoes or associated with the impulse response? Echoes are an obvious fault and the theatre had some examples which could be tracked down in the model. Yet echoes proved to be more a symptom of the fundamental problem rather than the cause. Experience with the Olivier model formed the foundation of an understanding of theatre acoustics, which was confirmed in the Acoustic Survey of British Auditoria [7].

Twenty years previously in 1953 Thiele had proposed the concept of the early energy fraction as a correlate of speech intelligibility. It just remained to establish what influenced the fraction in a drama theatre. In theatres with intelligibility problems there are usually insufficient early reflections, though a reverberation time shorter than 1 second is also desirable. The directional nature of the source is crucial as well and poor intelligibility is normally restricted to situations where the actor is facing away from the listener.

To conduct full sets of tests at 1:8 scale, a model directional speech source was developed by Orlowski [13]. This was also used for subjective tests and produced persuasive recordings of the effect of the actor turning round, for instance.

With a single objective measure determining success or failure for speech, 1:50 scale model testing for drama theatres is a reliable procedure. Several drama spaces have been tested at this scale. A good example is the 1270 seat Theatre Royal, Plymouth. A directional spark source is used to match the directivity of an actor. The emphasis in the tests is on the situation where marginal theatres fail: namely with the actor facing across stage and listeners in the half of the auditorium behind the speaker. In the Plymouth theatre, inadequate intelligibility was discovered at the highest seating level and improved by redesign of the suspended ceiling. The full-size theatre opened in 1982 with satisfactory intelligibility for all audience locations.

Scale Modelling of Opera Houses

Four models at 1:50 scale have been tested for use for opera. If we had difficulties deciding how to interpret

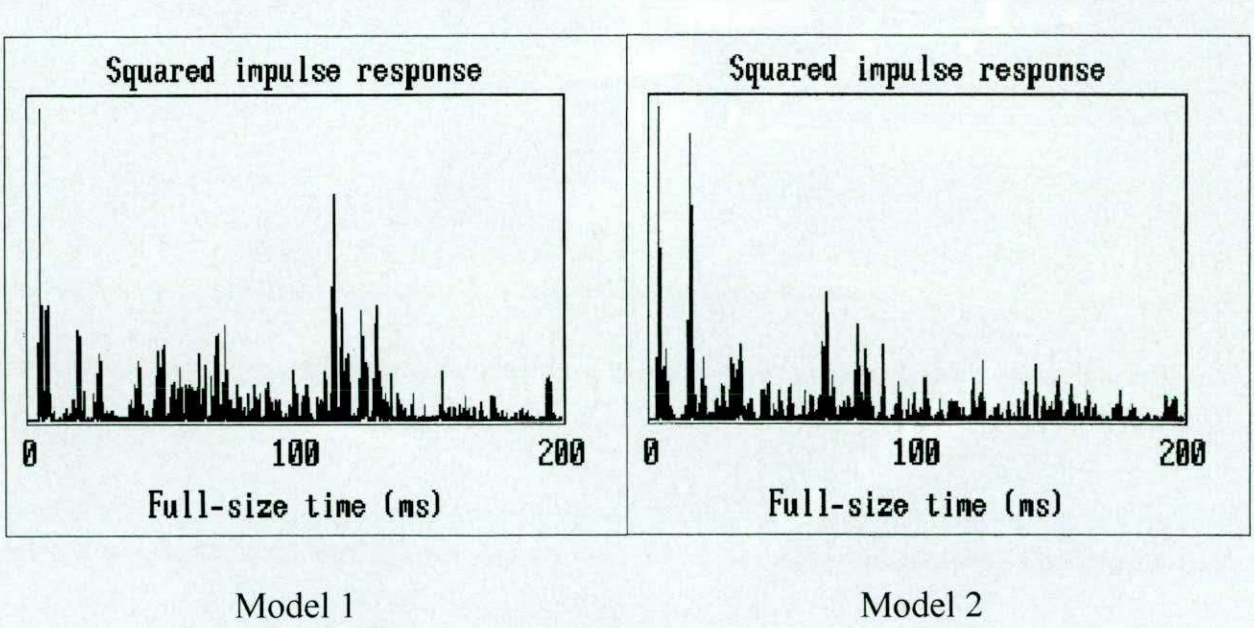


Fig. 6. Impulse responses at the same seat position in models of the Waterfront Hall.

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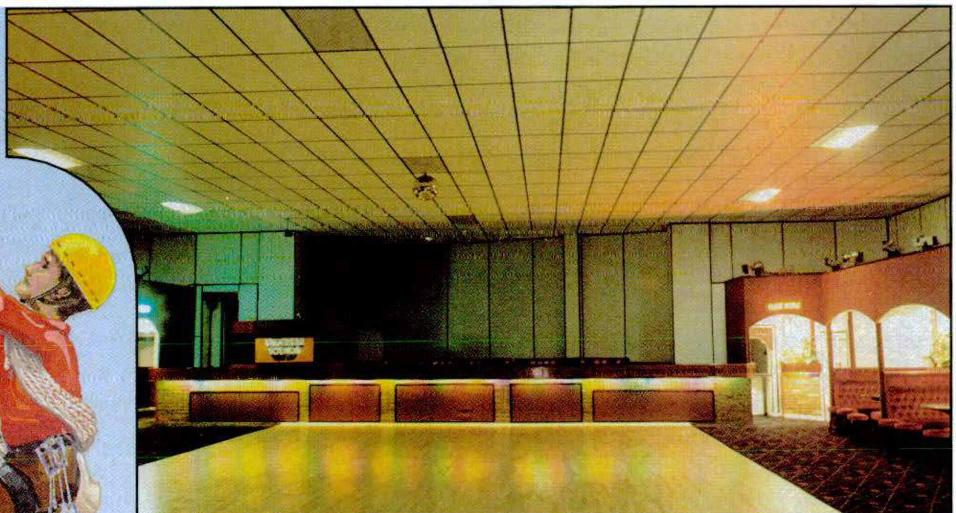

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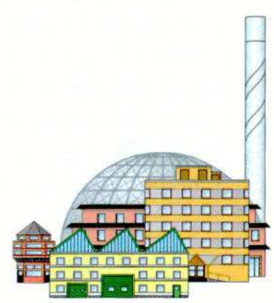

objective measures in the case of concert halls, then the situation for opera 20 years ago was dire. The only available criterion was for reverberation time. And the situation is complicated by there being two sound sources: the singers on stage and the orchestra in the pit. As a result of model tests, objective measurements and subjective survey in full-size opera houses, the principal criteria beyond reverberation are now considered to be intelligibility of the singers and clarity and envelopment for the orchestral sound. But probably most important are the sound levels generated by each sound source and crucially the balance between the singer's level and the orchestra [7].

In 1980 we tested our first model opera house for La Plata in Argentina (consultants Bickerdike Allen Partners); it was also the largest in terms of capacity: 2180 seats with an auditorium volume of 15,500 m³. This model proved to be pivotal for the understanding of the acoustic effects of balcony overhangs. The sound component most influenced by an overhang is the late reverberant sound and this is mainly due to the reduced vertical angle of view of the main auditorium volume from seats under overhangs. In opera houses much of this view is of the proscenium opening which often reflects little sound back into the auditorium. In brief, the effect on the reverberant sound of an overhang is more marked in an opera house than in a space without a proscenium; this leads to a reduced sense of reverberation in these seats.

Other problems met in the model of the La Plata house were possible echoes associated with the high ceiling and focusing by concave surfaces. A diffusing ceiling was proposed as well as replacement of the curved surfaces. The importance of using the splays to the side and above the proscenium opening for acoustic reflections also became clear from the model tests. Construction of the full-size opera house has been rather protracted.

Conclusions

The experience of testing models at various scales has been especially rewarding in reaching an understanding of the behaviour of sound in auditoria and appreciating the acoustic contribution of the various elements in a design. Indeed speaking personally I have probably learnt as much from model testing as other sources of experience combined. Models have provided pointers for what to look for in full-size auditoria. Since most of the modelling relies on objective measures, the testing has stimulated an understanding of acceptable values for the newer measures and what aspects of the design are important. Various publications owe their inception to model results, such as behaviour under balcony overhangs [14].

Testing models demands a range of skills. At the practical level it is important to understand the physical and electronic system being used and know for instance when a microphone is misbehaving. The measurements generate a series of objective results and an understanding of each measure is essential. And based on these results, decisions have to be made when to propose major changes to the design. The roles of technician and engineer have to be combined with that of the acoustic designer.

For our testing at 1:50 scale, it was fortunate that the first two models we tested (St David's Hall, Cardiff and the Theatre Royal, Plymouth) were each good basic designs! With time, we have developed greater understanding and confidence. In the last few years, radical changes have been proposed to several designs we have tested and a second series of tests undertaken on a modified model.

Acoustic scale modelling now has a history of over 60 years, though in the early years it was a case of developing and validating techniques rather than as an active influence on design. Computer models have a clear advantage in terms of convenience and cost, but they have yet to demonstrate that they can cope with the complexities of diffraction and cope with the transition between the early and reverberant sound. Computer models require a good description of the acoustic character of surfaces; this has led recently, for instance, to work on the diffusion coefficient for surfaces. For complex geometries, it is likely that diffusion properties of surfaces may need to be measured at model scale in any case! The position of acoustic scale modelling looks secure for yet a while as a design aid for major concert halls, opera houses and drama theatres.

References

[1] L Cremer & H A Müller (translated by T J Schultz), Principles and Applications of Room Acoustics, Vol. 1, Applied Science, London, (1982)

[2] W C Sabine, Collected Papers on Acoustics, Harvard University Press (Reprinted 1964, Dover, New York), (1922)

[3] M Barron, 'Auditorium Acoustic Modelling Now', Applied Acoustics, 16, 279–290, (1983)

[4] ISO 3382 Measurement of the Reverberation Time of Rooms with Reference to Other Acoustical Parameters

[5] N Xiang & J Blauert, 'A Miniature Dummy Head for Binaural Evaluation of Tenth-scale Acoustic Models', Applied Acoustics, 33, 123–140, (1991)

[6] M Barron and C B Chinoy, '1:50 Scale Acoustic Models for Objective Testing of Auditoria', Applied Acoustics, 12, 361–375, (1979)

[7] M Barron, Auditorium Acoustics and Architectural Design, E & F N Spon, London, (1993)

[8] W Reichardt, O Abdel Alim & W Schmidt, 'Abhängigkeit der Grenzen Zwischen Brauchbarer und Unbrauchbarer Durchsichtigkeit von der Art des Musikmotives, der Nachhallzeit und der Nachhalleinsatzzeit', Applied Acoustics, 7, 243–264, (1974)

[9] M Barron and L-J Lee, 'Energy Relations in Concert Auditoriums, 1', JASA 84, 618–628, (1988)

[10] H D Harwood and K F L Lansdowne 'Acoustic Scaling: Instrumentation', BBC Research Dept Report No 1972/34, (1972)

[11] A N Burd, 'Belfast's Waterfront Hall', Acoustics Bulletin 22, No 2, 21–24, (1997)

[12] Architects' Journal, 6 March 1997, 35–43

[13] R J Orlowski, 'An Eighth-scale Speech Source for Subjective Assessments in Acoustic Models', J Sound Vib 77, 551–559, (1981)

[14] M Barron 'Balcony Overhangs in Concert Auditoria', JASA 98, 2580–2589, (1995)

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BS 7827:1996 CODE OF PRACTICE FOR DESIGNING, SPECIFYING, MAINTAINING AND OPERATING EMERGENCY SOUND SYSTEMS AT SPORTS VENUES

John M Woodgate

Introduction and History

The development of BS 7827 was largely prompted by the Hillsborough and Bradford incidents, although many people in this industry sector were well aware of the need for it long before that was so tragically emphasised.

The history of the standard is very much a game of two halves, to coin a phrase. The initiative was largely due to Steve Jones, under whose chairmanship an Inter-Institutional Working Group (IIWG) was formed, consisting of representatives of the Institute of Sound and Communications Engineers (ISCE), IOA, the Audio Engineering Society (AES), the Institute of Safety and Public Protection and The Noise Council. After much deliberation, the first version of the standard was published by the former Sound and Communications Industry Federation (SCIF) as a Code of Practice. One of the important principles that emerged from these discussions was that if numerical requirements or limits are to be placed on a characteristic of a piece of equipment or a system as a whole, then there MUST be a defined, reproducible method of measurement for that characteristic. It is by no means as easy to ensure that as it might appear, which is why BS 7827 contains some new methods of measurement.

During the later stages of the work, the Football Stadia Advisory Design Council (FSADC) saw the need for a complementary, largely non-technical, document on sound systems in their series of advisory booklets. This was compiled by Peter Barnett, with contributions from Steve Jones, Ken Walker and myself together with several others. The demise of the FSADC means that the document is out of print, but we are exploring the possibility of ISCE taking it over and updating it.

Before disbanding, the IIWG agreed that, after an initial period of using the Code of Practice in the field, it would be presented to the British Standards Institution for adoption as a British Standard Code of Practice. During this time, SCIF distributed some 350 copies of the document.

I have actually managed to find the letter dated 26 August 1992 which advised John Hoile of BSI of what we had in store for him! At first, we thought that we could deal with this project in the same BSI Panel as was dealing with the revision of BS 6259, but this caused confusion, so we set up another Panel, with much the same membership, to deal with the new project separately.

This of course, was the second half of the match. During the half-time interval, an amendment sheet was prepared, and issued by SCIF in April 1992, correcting a few editorial errors in the original text.

The Structure and Content

The structure of standards (in BSI terms, Codes of Practice are one of six sorts of 'standard') is largely laid down in BS 0. A Code of Practice contains recommendations, not mandatory requirements, and any claim of conformity should be in the form: *(This system conforms to the recommendations of BS 7827:1996).*

Section 1 sets out the Scope clause, which says what the standard covers and often, what is specifically excluded. Then there are some 'housekeeping' clauses about references to other standards, followed by Definitions. This is a most important clause, and one which gave us, even after all the IIWG discussions, much difficulty in the BSI Panel.

There are two things to consider in a definitions clause: which terms need to be defined, and what should each definition say. There is a tendency to neglect the first point, which can lead to long strings of unnecessary definitions. Then again, one needs to look at individual descriptive phrases throughout the document and make a specific decision as to whether a definition is required or whether the use of a particular term reacts on other definitions, and if so, how.

Despite the long discussions in the BSI Panel, the changes to the original IIWG text proved to be relatively few. One of the more significant results of this work is a group of three definitions:

- Audibility: that property of a sound which allows it to be heard among other sounds. The sound pressure level must be sufficient to overcome masking effects due to other sounds present at the same time. Because masking is frequency-selective, the spectra of the wanted and unwanted sounds, as well as the relative sound pressure levels, affect audibility.
- Clarity: the property of a sound which allows its information-bearing components to be distinguished by the listener. Much of the information content of speech (in consonants, for example) is transient in nature. Such transients can be adversely affected by limited bandwidth, severe non-linearity and time domain effects such as reverberation. Speech is actually very tolerant of 'limiting' type non-linearity (peak clipping), although much less tolerant of origin distortion (crossover distortion).
- Intelligibility: A measure of the proportion of the content of a speech message that can be correctly understood. Satisfactory intelligibility requires both sufficient audibility and adequate clarity.

While these definitions may now seem fairly self-evident, and they correlate well with the mathematics of the

Speech Transmission Index (STI) approach to the objective measurement of intelligibility, they did not exist before the IIWG work. Note that 'clarity' as defined here includes effects due to the electronic part of an electroacoustic system, and includes the purely acoustic use of the word 'clarity', which relates to the effects of what would in electronics be called multipath propagation.

Section 2 of the standard consists of a treatment of intelligibility, since this is one of the two major functional requirements of a stadium sound system, the other being reliability. In order to prove the achievement of specified requirements, an objective measure of intelligibility is required, and three methods, STI, percentage articulation loss of consonants (%Alcons) and Phonetically (phonemically) Balanced word scores (Pbws) are briefly discussed. (This work led directly to the UK proposal to IEC to revise IEC 849 and IEC 268–16, to provide a more complete treatment of the merits of different methods of assessing intelligibility than appears in ISO TR 4870.)

This Section also contains practically-oriented advice on the definition and achievement of adequate intelligibility. One major difficulty is that intelligibility measurements can rarely be made in a full stadium. However, methods have been developed which allow an experienced person to predict the intelligibility in a full stadium from measurements made under other conditions.

Section 3 deals with system specifications, and begins with a group of recommendations concerning attributes that cannot be assigned numerical values. It recommends that a permanent record be kept of 'what the system was supposed to do when new'. The value of such a record in later years may well be obvious. Other subjects dealt with include zoning and the design of emergency announcement control panels and their environment.

Quantitative (numerical) recommendations are given for sound pressure levels in various types of area, frequency response, coverage, system-inherent noise levels (particularly important in hospitality areas), electrical headroom and intelligibility. Of these, the recommendation for electrical headroom proved the most difficult to determine, and led to a new method of measurement.

Section 4 details the methods of measurement to be used, including sound pressure levels, frequency response, coverage, electrical headroom and intelligibility. Clearly, in a case of dispute, uniform methods of measurement must be used, otherwise no resolution of the conflict is likely.

Both frequency response and electrical headroom do not at first sight appear to present any difficulties in measurement, but this is not so. Frequency response measurement is better carried out using pink noise rather than a swept sine-wave, which is a particularly disturbing sound when unwanted and can cause compressors and limiters to misbehave unpredictably. Any equalization for a particular microphone must be disabled, and third-octave band sound pressure level measurements must be made at a series of places in the coverage area. Because of multipath effects, a flat response is not to be expected from this method, so limits are recommended on a 'deviation from uniformity' basis.

The measurement of electrical headroom is necessary in order to allow a measure of peak clipping of speech signals, but not so great an amount that clarity is compromised. Speech is a very 'peaky' signal: the broadcasters expect a headroom of around 20 dB in order to eliminate clipping entirely, but this represents a sound power 100 times greater than necessary to establish the necessary average sound pressure level. Such an investment in amplifiers and loudspeakers could not possibly be justified unless essential, which it is not. Subjective tests have shown that a headroom of only 6 dB is tolerable if the headroom limit is defined as 17% total harmonic distortion due to clipping of a sine-wave signal.

However, as mentioned, the test signal actually used is preferably noise, in this case noise with a spectrum similar to that of speech, so we have to express that 17% distortion limit in terms applicable to the noise signal. Now when we clip the peaks of a noise signal, its rms level decreases, and this effect is known as 'compression'.

By measurement (and it can be calculated as well), 17% total harmonic distortion due to clipping of a sine wave signal corresponds to approximately 1 dB of compression of the noise signal whose uncompressed rms value is equal to that of the unclipped sine wave. So we apply our noise signal and turn up the wick, plotting electrical output level against input level, and when the output level droops by 1 dB from the straight line, we have reached the end-stop. This is recommended to be at least 6 dB above the output level giving the required sound pressure levels. 6 dB of headroom looks awfully little, but it still means four times the amplifier power and loudspeakers to suit.

Finally in Section 4 are recommendations for commissioning and routine testing.

Section 5 gives recommendations for operation of the system. Many problems are caused by a lack of operator training, leading to misuse if not abuse. The concept of 'responsible person' is used in order to combat the tendency in human nature to suppose that things will continue to work even if no-one is responsible for ensuring that they do. Emphasis is laid on the need for documentation of the system to be readily available where it is needed, in a form that can be understood, yet secured against accidental loss.

Section 6 deals with the need for regular maintenance and re-testing, and in particular the need for a maintenance manual and a log book containing records of all faults, repairs and routine tests. These records are invaluable for convincing accountants that the funding of repairs and maintenance protects the original investment in the system from precipitate and irrecoverable losses, accompanied by smoke.

Section 7 deals with the matter of training in depth, and particularly with the training of announcers. All the intelligibility results will be worthless if the announcer sounds as if he or she is eating a treacle toffee, and if an incident does occur, a 'Private Jones' approach is just what is not wanted, rather a calm, clear, authoritative voice to retain control and restore order.

Section 8 deals with reliability: this is the second of the most important attributes of a system. There are two main aspects: prevention of interference with the system adjustments (however well-intentioned) and preservation of an adequate power supply to the system.

The standard is completed by eleven Annexes, which cover many aspects in greater detail or address specific topics. Models for design statements, fault reports and notification to a certifying authority are included, as well as an inspection check-list and information on the testing and certification of competence of announcers.

This article is based on a paper given to a meeting of The Institute of Sound and Communications Engineers, with whom the Institute of Acoustics enjoys a close relationship, at Tottenham Hotspur Football Club's ground in London on 11 April 1997. Copies of the proceedings of that meeting are available through the ISCE at PO Box 258, St Albans AL1 1QZ, price £10 to members, £15 non-members.

John Woodgate is an independant consultant based at Rayleigh, Essex and is HonSecretary of ISCE.

GOVERNMENT COMMITMENT STRENGTHENS THE VOICE OF THE PROFESSION

Mike Heath

A significant landmark has been reached in the profession's concerted efforts to strengthen its influence, and have its voice heard on matters of national importance, with the recent signing of a Memorandum of Understanding (MoU) between Government and the Engineering Council.

Signature demonstrates a clear Government commitment to the engineering profession and clearly defines its role in ensuring that the UK maintains a world-class, professionally qualified engineering workforce. It represents a ringing endorsement of the direction that the Council and the professional Institutions have taken since unification, and Government approval of the targets we have set ourselves.

Specifically, of course, the Memorandum of Understanding establishes the Engineering Council as the principal voice of the engineering profession and the body recognised by Government to speak on profession-wide issues. Additionally, and of increasing significance, it confirms Government recognition for the Council to represent the UK profession internationally. It is also recognition of the constructive contribution of engineers to the debate on appropriate major issues.

A good deal of our activity over the past twelve months has been focused on strengthening our relationship with Government and persuading it to listen to our views on issues affecting the wider profession. I believe we have achieved considerable progress in that respect.

I hope, however, that Institutions will continue to enhance their own links with Government, Parliament and Whitehall and continue to speak for themselves on issues relating to their particular areas of interest.

The MoU was, of course, signed by a Conservative Government and many people have asked me how its status is affected by the election of the new Government. I am able to report that Margaret Beckett, the new President of the Board of Trade, pledged her support for the agreement prior to the recent election. The arrival of a new Labour administration does not affect its validity in any way.

I do not for a moment see the signing of the MoU as an end in itself. It merely establishes a framework within which the Council and Government can work together to further the cause of professional engineers in the UK, and signals to the rest of the country that Government considers engineering to be important and worthy of its support.

It is an indicator of how far the profession has been transformed in the relatively short time since the new relationship between the Engineering Council and the Institutions was established. The success of the partnership, however, will be gauged on our results. All we have done between us is to create the necessary platform from which we can raise our profile, improve public standing and increase our influence.

During 1997, the Year of Engineering Success (YES) is providing us with the extra stimulus to drive forward a programme that reflects the Council's mission statement: *'To enhance the standing and contribution of the engineering profession in the national interest and to the benefit of society'.*

This statement mirrors what engineers and technicians on the Council's National Register repeatedly tell me they want to see the profession achieve. As the Engineering Council and the Institutions have found to their advantage, working in partnership can be the best way forward. There is potential, therefore, to extend this strategy to the wider engineering community.

One example is the proposed establishment of a National Engineering Group, aimed at drawing not only on the talent and imagination of people from within the profession but also appropriate individuals from outside. We believe that such a pooling of ideas will result in policies which demonstrate the true value of engineering and help convince the brightest young people that it offers exciting, stimulating and well-paid careers.

Nonetheless, I am fully aware that most responsibility for developing the necessary climate of change will continue to fall on the Engineering Council. With this in mind, a decision was taken last October to develop the internal running of the organisation on order to be in the best possible shape to meet the challenge. We are therefore working towards best practice through achievement of the Investors in People (IIP) national standards.

Mike Heath is Director General of the Engineering Council.

NEW CHARTERED AND INCORPORATED ENGINEERS

Chartered Engineers

Martin Newson has been working for twelve years in the field of acoustics, noise and vibration control. A graduate in Engineering Acoustics from the Institute of Sound and Vibration Research at Southampton University, the early part of his career was spent in England, firstly at Trox Brothers Ltd, manufacturers of air conditioning equipment, where he performed acoustic tests on products. He then took up a position with Hann Tucker Associates, a major English acoustic consultancy. In his five years with the company, he project managed many significant buildings from conceptual design to occupancy.

Three years were then spent at Paul Veneklasen and Associates in Santa Monica, California as project manager for many of the company's largest and most complicated projects. In August 1994, he founded Martin Newson and Associates, who are consultants in acoustics and presentation systems.

Frederick Price was educated at King's College Taunton, St Peter's College Oxford and King's College London, where he completed a PhD in ultrasonic acoustic communication prior to joining the Royal Navy in 1984. He has served in a wide variety of appointments at sea and ashore, including the carrier HMS Ark Royal, the MoD and the British Embassy Dubai – where he saw active service during the Iran-Iraq war.

A $2^1/_2$ year appointment as Deputy Commander of the RN's largest Weapons Engineering School at HMS Collingwood was followed by 12 months on the HQ staff of General Sir Michael Rose in Bosnia in 1994. There he was responsible for a number of heavy engineering/ infrastructure repair projects, notably the restoration of water and gas supplies to Sarajevo, for which he was appointed MBE. Currently on the staff of Commander-in-Chief Fleet, he is responsible for the coordination of training policy in a Command of nearly 30,000. Promoted Commander in 1994, he is on a full career commission as a Engineer Officer of the Training Management sub-specialisation.

Steve Sheridan, on leaving the University of Salford's Department of Applied Acoustics, started his career in the noise control equipment manufacturing industry employed as a product applications engineer. This included overseas sales support in the Middle East and the development of acoustic prediction software. During this period Steve successfully completed the Institute of Acoustics' Diploma Course at what is now the Liverpool

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Tel: (0)1727 848195 Fax: (0)1727 850553 email Acoustics@clus1.ulcc.ac.uk
Registered Charity 267026.

Two-day Course

ACOUSTICS FOR SOUND SYSTEM ENGINEERS

Saturday 5 and Sunday 6 July 1997

Institute Offices, St Albans

This course is based on the courses of the same name that have been run until last year as part of the Reproduced Sound series of conferences. The Tutors will again be

Dr Paul Darlington (University of Salford)
Peter Barnett (AMS Acoustics)
Dr Roy Lawrence (Institute of Acoustics)

Full course notes will be provided and the subject areas covered will include

- *The structure of sound waves*
- *How sound is quantified*
- *Aspects of hearing*
- *Sources of sound*
- *Direct and reverberant sound levels*
- *The behaviour of sound in large spaces*
- *The behaviour of sound in small spaces*
- *Room defects*
- *Use of physical and computer models*
- *Microphones*
- *Loudspeakers*
- *Interaction of loudspeakers with spaces*
- *Sound system design*
- *Speech intelligibility*
- *Standards*
- *Aspects of the law*

To derive maximum benefit from the time available, (no prior knowledge in any area will be assumed), on the Saturday teaching is from 09.00 to 20.00 and the course finishes at 17.00 on the Sunday. Course fees include the cost of all written materials and pub lunches on Saturday and Sunday. Course numbers will be limited to a maximum of ten to permit demonstrations. Hotel accommodation for the Friday and Saturday nights will be arranged if required. Attendance Certificates will be issued for CPD purposes.

Attendance on this course satisfies the tuition requirement for the Acoustics Module of the new Diploma of the Institute of Sound and Communications Engineers.

ACOUSTICS FOR SOUND SYSTEM ENGINEERS (No 97/2)
Saturday 5 and Sunday 6 July 1997
Institute of Acoustics Offices, St Albans

Course Fees: Members of the Institute of Acoustics, the Institute of Sound and Communications Engineers, APRS and employees of PLASA companies £300 + £52.50 VAT = £352.50
Non-members £400 + £70.00 VAT = £470.00

Name: **Qualifying Membership:**

Organisation:

Address:

☐ Please register me for the course, I understand that space on the course is limited
☐ Cheque enclosed for the course fees
☐ Please invoice me for the course fees at the above address
☐ I am unable to attend this course, please inform me when it is to be run again.

CALLS FOR PAPERS

1997 Windermere Conferences

Hydro Hotel, Windermere

Reproduced Sound 13

23 – 26 October 1997

Topics • Digital Broadcasting & Internet Audio • Multi-Media Audio • Loudspeakers: Measurement and Developments • Auralisation and Speech Intelligibility • Recording and Listening Environments • Signal Processing • Control of Entertainment Noise • In-Car Audio •

1997 Autumn Conference

Codes of Practice

(their use and abuse in noise or vibration assessment)

27 – 30 November 1997

Topics include • Whether a particular code is used at all • How it is used • Does it need updating /re-writing? • The question of formal adoption under Section 71 of the Control of Pollution Act 1974 •

The sessions at both conferences will be a mixture of formal presentations and workshops. Offers of technical contributions should be sent in the form of a 100-word abstract to the Institute Office.

MEMBERSHIP

The following were elected to the grades shown at the Council meeting on 12 May 1997

Fellow
Goyder, H G
Saunders, D J

Member
Barnes, R
Bickerstaff, C M
Breen, A
Dadkhah, N
Gardiner, R
Gibbs, J L
Hunter, R N
Jephson, L P
Jiggins, M
Mackenzie, R G
Naqvi, A
Nicholl, A
Parker, G F
Rintoul, S
Rogers, I E
Ruttle, J A
Wang, L S
Webb, D J
Willmott, R F
Wright, P

Associate Member
Gosling, S J
Johnson, C D
Morgan, P A
Pennington, C
Scrivener, R M
Smyth, B S
Spencer, J P
Tang, W H

Associate
Cresswell, A P

Student
Ives, D T
Jobling, B
Papanagiotou, K

One-Day Meeting

IEC 1672:

The New International Standard for Sound Level Meters

(Organised by the Measurement and Instrumentation Group)

The Royal Society, London

Wednesday 25 June 1997

The sound level meter is the most commonly used instrument for the measurement of noise levels worldwide. The last twenty years have seen significant changes in the design and features of sound level meters. These changes have prompted the International Electrotechnical Commission to set up a Working Group, IEC/TC29/WG4, to prepare a new International Standard, IEC 1672, covering both integrating and non-integrating sound level meters. A Committee Draft for Voting should be circulated for public comment early in 1997, and this meeting has been arranged to discuss the specification within the new Standard, and the implications for all users of sound level meters.

09.30	*Registration and refreshments*
10.00	The purpose and scope of the new Standard *Alan Marsh, Dytec Engineering, Convenor of IEC/TC29/WG4, USA*
10.15	Requirements for microphones *Gunnar Rasmussen, GRAS Sound and Vibration, Denmark*
10.45	Acoustical frequency responses and accuracies, including testing *Peter Hedegaard, Brüel & Kjær, Denmark*
11.30	*Refreshments*
11.50	Steady and transient measurement capabilities, and verification tests *Ole-Herman Bjor, Norsonic, Norway*
12.30	Electromagnetic compatibility *Richard Tyler, CEL Instruments, UK*
13.00	*Lunch*
14.15	Effects of environmental changes *Gaston Banget, Laboratoire Nationale d'Essais, France*
14.45	The importance of measurement uncertainty during testing *Susan Dowson, National Physical Laboratory, UK*
15.15	*Refreshments*
15.35	The role of the sound calibrator *John Kuehn, IEC/TC29/WG17, UK*
16.05	Implications and implementation time scales *Alan Marsh, Dytec Engineering, Convenor of IEC/TC29/WG4, USA*
16.20	Discussion
16.45	*Close*

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

Meeting Organiser:
Richard Tyler FIOA, CEL Instruments Ltd, 35-37 Bury Mead Road, Hitchin, Herts SG5 1RT
Tel: 01462 422411, Fax: 01462 422511, email richardt@cel.ltd.uk

Registration form available from the Institute office.

Institute of Acoustics, 5 Holywell Hill, St Albans, Herts AL1 1EU
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INSTITUTE DIARY 1997/8

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

13 JUN
IOA Bulletin Management Board
St Albans

18 JUN
Engineering Division – Chartered Engineer Interviews
St Albans

18 JUN
Executive Committee
St Albans

18 JUN
Midlands Branch Evening Mtg – Best Practicable Means as Applied to Acoustic Problems
Coventry

18 JUN
North West Branch Technical Visit to MIRA
Nuneaton

18 JUN
London Branch Evening Mtg – Acoustic Modelling Methods
NESCOT

19/20 JUN
IOA Diploma Exams
Accredited Centres

25 JUN
Instrumentation & Measurement Group One-day Mtg– IEC 1672
London

26 JUN
Yorkshire & Humberside Branch Technical Visit to Health & Safety Laboratories
Buxton

30 JUN
Environmental Noise Group Committee Mtg
St Albans

1 JUL
Acoustics Bulletin Copy Date (July/August)

5/6 JUL
Acoustics for Sound System Engineers Course
St Albans

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

11 JUL
Instrumentation & Measurement Group Committee
St Albans

16 JUL
RS13 Programme Committee Mtg
Peterborough

18 JUL
Engineering Division – Chartered Engineer Interviews
St Albans

31 JUL
North West Branch – Concert at Bridgewater Hall
Manchester

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

2 SEP
Acoustics Bulletin Copy Date (September/October)

8 SEP
Underwater Acoustics Group One-Day Mtg Scattering Problems
Bath

9 SEP
Midlands Branch Evening Mtg
TBA

18 SEP
IOA Publications, Meetings Committee
St Albans

24 SEP
North West Branch AGM and Evening Mtg Application of PPG24
Manchester

25 SEP
IOA Membership, Education Committee
St Albans

26 SEP
CPD Committee & Branch Representatives Mtg
St Albans

SEP
Building Acoustics Group Workshop – Sound Insulation
Salford

2 OCT
IOA Medals & Awards, Council
St Albans

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

23-26 OCT
Conference: Reproduced Sound 13
Windermere

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

OCT
IOA CofC in W'place Refresher Workshop
Birmingham

OCT
Instrumentation & Measurement Group Workshop– Hand/Arm and Whole Body Vibration
TBA

1 NOV
Acoustics Bulletin Copy Date (Nov/December)

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

11 NOV
Instrumentation & Measurement Group One-day Mtg Sound Intensity – Theory and Practice
BRE Watford

12 NOV
Midlands Branch Evening Mtg
TBA

13 NOV
IOA Publications, Meetings Committee
St Albans

19 NOV
North West Branch Technical Visit to Salford University and Presentation on MIDI.
Salford

19 NOV
Engineering Council Conference and Exhibition
London

27-30 NOV
Autumn Conference: Codes of Practice
Windermere

4 DEC
IOA Membership, Education Committee
St Albans

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

11 DEC
IOA Medals & Awards, Council
St Albans

16-17 DEC
Underwater Acoustics Group Conference: Underwater Bio-Sonar Systems and Bioacoustics
Loughborough

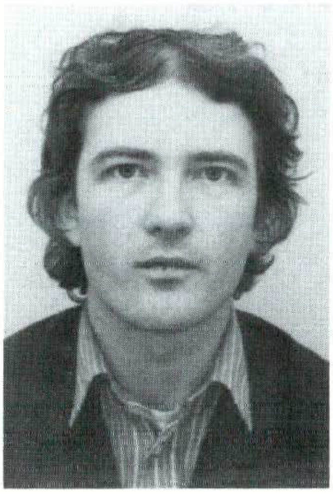
1988

JAN
North West Branch Evening Mtg – Sound Insulation Around Manchester Airport.
Manchester

31 MAR – 2 APR
Acoustics 98. IOA Spring Conference
Cranfield University

1997/98 Register of Members

This is in the final stages of preparation. The entries in the 1996/97 edition will not be automatically included in the new edition. Make sure that a member in your company has returned a form to the IOA office if an entry is requried. Fax for a replacement form if you have lost yours.



John Moores University, including the architectural acoustics and transportation noise specialist modules.

After 5 years in industry he joined Vibronoise Limited, noise & vibration consultants engaged as an engineer. This initial consultancy experience involved a wide variety of projects including environmental, architectural and industrial acoustics, together with vibration engineering. This included generator foundation testing in Libya and the design of a silencer test rig. Between 1986 and 1992 Steve worked for a number of consultancies located in the North West of England. During this period he became a corporate member of the IOA and also returned to the University of Salford where he was awarded an MSc in Acoustics in 1989.

Prior to joining his current employer, WS Atkins Noise & Vibration at their Nottingham office, Steve undertook a PgD/MSc in Computing and Software Engineering at Southampton Institute of Higher Education. He is now engaged as a Senior Consultant with project management responsibility. This role has involved giving expert evidence, conducting industrial noise research and preparing a noise impact assessment for the new Hong Kong Airport at Chek Lap Kok.

Stephen Summers graduated with a BSc in Electroacoustics from the University of Salford in 1987 having spent a year as an industrial trainee at A P Besson working on the development of telephone transducers. On leaving university Stephen went into consultancy with the Acoustical Investigation & Research Organisation Ltd (AIRO). Initial projects included involvement in proposing the methodology for the National Noise Incidence Survey for the DoE and sound insulation testing as part of a research contract for the Building Research Establishment.

In 1991 he gained an MSc in Environmental Acoustics from the then South Bank Polytechnic after part-time study. Since then his work has included field and laboratory testing and a wide variety of consultancy projects including environmental noise measurement and planning assessments, architectural and building acoustics projects. Stephen has also handled the noise assessment of major road schemes for the Highways Agency and acted as an expert witness in noise nuisance and sound insulation disputes. He also takes responsibility for in-house calibration relating to AIRO's status as a NAMAS accredited Testing Laboratory.

Incorporated Engineers

Robert Dolling was awarded his apprenticeship (on completion of four years with Marconi Instruments) and gained his HNC in Electronics with St. Albans College and Hatfield Polytechnic. He subsequently took a position with Modular Technology Ltd, as a Development Engineer, responsible for the development of infrared and laser line of sight communications systems. In 1983, he joined Hadland Photonics Ltd, at Newhouse Laboratories. After studying an Institute of Industrial Managers' course, he held the post of Test Department Supervisor.

In 1990 Robert established and managed Quantum Sound Ltd, installing and commissioning sound systems in sports venues, hotels, council chambers and oil refineries. Uncontrollable circumstances forced the early demise of the Company into liquidation in 1992.

At this point, Robert joined Glantre Engineering who specialise in the design and installation of professional sound, lighting, video and stage rigging systems for theatres and cruise liners.

He was Project Engineer, and had responsibility for the design of the public address systems in a variety of environments such as Tottenham Hotspur FC's ground and Carnival Destiny and Disney Cruise Liners.

Studying at Heriot Watt University, Edinburgh in 1993, he gained The Institute of Acoustics Diploma. From there, he joined AMS Acoustics in London, responsible for sound system design, environmental acoustic measurements and archietectural acoustics. In April 1996, Robert secured a position with TOA Corporation pie, Brentwood. As Manager of the Systems Division, he is responsible for all aspects of electro-acoustic system performance analysis, design and commissioning. He specialises in loudspeaker system design for applications in difficult acoustic spaces, for voice evacuation, public address and entertainment systems.

David Warrington spent several months working as a laboratory assistant at the Department of Applied Acoustics, University of Salford, before attending what was then Coventry Polytechnic.

He graduated in 1988 with a Higher National Diploma in Electrical and Electronic Engineering, having spent the sandwich year at Ferranti Electronics Microwave Division in the Applied Research department, evaluating and implementing improvements to manufacturing technology.

After leaving Coventry, David was offered a post back at Salford University as an acoustics Research Assistant, working on impulsive noise propagation, principally involving field trials at military ranges. This was followed by part-time study for the Institute of Acoustics' Diploma in Acoustics and Noise Control at Liverpool Polytechnic, and he was awarded the Association of Noise Consultants' prize for best Diploma project in 1991.

Following that David began a part-time MSc in Acoustics at Salford University, whilst continuing to develop the field trials capabilities of the department, both in the UK and abroad.

As Trials Laboratory Manager he is currently responsible for co-ordinating and running much of the Department's practical research work and involved in outdoor noise propagation from a wide range of impulsive noise sources, as well as from helicopters and low-flying aircraft. ❖

NUMERICAL MODELLING AT RUPERT TAYLOR LTD

Rupert Thornely-Taylor FIOA

Numerical modelling at Rupert Taylor Ltd has its origins in the late 1970s, when Rupert Taylor began writing 2-dimensional ray-tracing programs on a Hewlett Packard 9845, a cross between a giant programmable calculator and a PC (then unheard of). In the early 1980s, when the Ford Motor Company commissioned a study to find ways of quietening its then new York direct-injection diesel engine, Rupert Taylor's solution, subsequently patented by Ford, was to design a wave filter for insertion in the engine's fuel injector pipes. He began trying to find solutions to the differential equations governing non-linear wave propagation in liquids under very high pressure, and on failing then sought to model wave propagation by finite difference methods. This was all done on a Commodore PET computer with 16 kB of RAM, and was a little limited in scope.

The slightly easier problem of linear wave propagation cropped up later with the design of the Channel Tunnel. Firstly, leaving finite differencing on one side for the time being, Taylor took to numerical modelling using transmission line theory, involving the superposition of forward and backward travelling waves in waveguides after applying reflection and transmission coefficients. This is a very neat technique which converges exactly with algebraic solutions, for example, of equations for the transmission loss of reactive attenuators. He made his first software sale to a French company in the form of a package for modelling low frequency transmission of sound from the tunnel space into the interior of shuttle wagons. This was followed by work carried out to study the likelihood or otherwise of pressure oscillations arising in the draught relief system of the Channel Tunnel itself. Interestingly, while the transmission line model used was intended to study oscillating flow, the results overlapped nicely with those of a simultaneous aerodynamic study carried out using a box model.

Transmission line theory in acoustics can be found succinctly described in the first edition of C M Harris's Handbook of Noise Control, and is a powerful tool. A year or two later, having been impressed by a talk given by Manfred Heckl, Taylor discovered what remains to this day his secular bible, the late Ted Shultz's translation of Cremer and Heckl's book Structure-Borne Sound. In here you will find transmission line theory applied to structure-borne sound. Soon Taylor was adapting the airborne transmission line model to a structural one, and using it for modelling the behaviour of the railway track on the then proposed Tsing Ma bridge, part of Lantau Fixed Crossing in Hong Kong.

The problem with structural transmission line theory is that the phase velocity is dependent on frequency, and the model has to be run separately for each frequency of interest. At the time, a 33 MHz Intel 386 was the state of the art so that full spectrum modelling was slow, and the frequency limitations of transmission line models for structural wave propagation were the driving force behind a change of tack back to finite difference modelling.

Finite difference modelling involves creating a representation of the structure or space to be modelled using a generally rectilinear grid. Each cell in the grid is assigned a shear modulus, mass, loss factor, displacement and velocity. For each time step (which may have to be as little as 20 microseconds to achieve a stable model), the shear and compressive stress, and the damping force are computed, and the cell is accelerated accordingly. Its new displacement and velocity at the end of the time step are computed and the process repeated. For well known structures such as beams, correspondence with Timoshenko beam solutions is achieved, subject to small and quantifiable errors resulting from the finite difference process.

The first finite difference model was ready for the design of railway tunnel vibration isolation systems in the CrossRail project. Validated by retrospective modelling of the Singapore MRT and the London Underground tunnel at Heathrow Terminal 4, the effects of all the design nuances of floating track slab and resilient baseplate track could be predicted.

Further validation was provided through an exercise of a successful 'blind' prediction of levels of ground-borne noise inside an existing theatre affected by an existing underground railway, based on a measured spectrum of rail roughness in the actual tunnel.

Meanwhile the floating track slab and resilient baseplate track of the Jubilee Line Extension had been designed, and the FD model was employed to study their likely behaviour.

Finite difference modelling of this kind is wholly deterministic, and the model can only be as accurate as the material properties supplied to it. Moreover, in a railway tunnel vibration is largely controlled by the magnitude of wheel and rail roughness, something which can only be

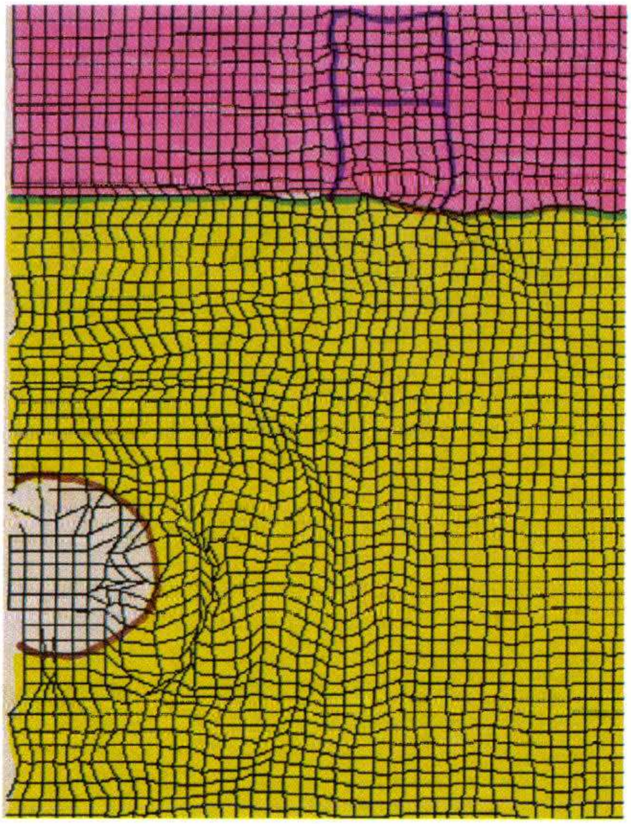


Fig. 1. Finite difference modelling of train, tunnel, surrounding soil, building and air above.

taken as a given piece of input data. Measurements in the Channel Tunnel, where rail roughness measurement results were available and surface vibration measurements possible in a location where the tunnel is under land rather than sea gave added confidence in the level of accuracy achievable when properties such as soil shear modulus and loss factor are only known approximately.

In any case where the future performance of a system such as an underground railway has to be predicted, a deterministic model can at least consider the effect of uncertainties in each of the parameters in the model, so that levels of confidence can be applied to the results.

One of the most useful facilities that models of this kind offer is the ability to study intricate effects such as coincidences between bending wavelength in rails and floating track slabs and vehicle dimensions such as bogie wheelbase, with the train moving at any (not necessarily constant) speed. Many dynamic phenomena which ordinarily tend to take the railway world by surprise when the railway starts operating can be foreseen by operating the FD 'virtual' railway early in the design process.

While modelling underground railways is one of the most valuable applications of FD modelling, in which the dynamic behaviour of the moving rail vehicle and its interaction with the track characteristics are all used to predict not only tunnel wall vibration but also propagation through the surrounding soil, more exotic applications beckon. Propagation of sound in air and modelling the acoustical behaviour of spaces, with audible output via a sound card to headphones is an extreme form of auralisation. Modelling a complete musical instrument even more so.

Unlike the transmission line model which has to be run separately for each frequency when used in structural applications, the finite difference model copes with all frequencies at once, provided that the damping term can be represented as directly proportional to particle velocity. Damping which has a particular frequency dependence means that even the finite difference model has to be run separately for each frequency of interest, unless the damping mechanism can be understood well enough to build it into the FD equation.

While the modelling of structural vibration is by far the most complex application, which requires not only the

Fig. 2. The Class 156 Diesel Multiple Unit enjoyed the benefit of numerical prediction of interior sound levels, followed by East Coast Main Line Coaching Stock, Class 465 Networkers and most recently Class 323 Electric Multiple Units.

Fig. 3. The design of the New Victoria Theatre, Stoke on Trent, was one of the earliest applications of Rupert Taylor's ray tracing software. The geometric shape of the reflectors suspended above the stage area of the theatre-in-the-round was designed to maximise early reflections from each performer around the full 360° auditorium.

handling of compression and shear, modelling of sound waves in air is no less complex when it comes to the behaviour of boundary surfaces. The dynamic behaviour of walls and panels is merely a special case of the structural model, but the resistive absorption of sound absorbent surfaces requires clever representation of the properties of the surface if not only the correct sound absorption coefficient is to be achieved, but also the correct phase relationship between incident and reflected sound is preserved.

Computational speed is obviously of great interest. The original HP calculator on which it all began had only ROM-based interpretive BASIC and ran at about the same speed as a Sinclair Spectrum which was also used for some ray tracing in the early days (subsequently replaced by a QL).

While Z80 machine code is comparatively easy to write, Intel 80386 code is not. The big feature of the model is the size of the arrays used, far bigger than those conveniently handled by DOS compilers. IBM came to the rescue with the operating system they hoped would replace DOS, called OS/2. Version 1.0, which came out in 1986 and gave you no more than a prompt and CGA graphics, nevertheless had the pure joy of a flat memory model, virtual memory through disk swapping and true multitasking.

Version 2.0 followed, and was a 32-bit operating system many years ahead of Windows 95 or NT. So while most people were struggling with DOS, Rupert Taylor was enjoying boundless memory size – bounded only by the capacity of the hardware which doubled each year. The rise of the C++ language, which though totally unforgiving is almost as easy to write as the more advanced forms of BASIC, and very fast if the right compiler is used (Borland, C++ and OS/2 are excellent bedfellows) and the falling price of RAM, mean that complex structures such as the new combined station for the Jubilee Line and District Lines at Westminster, supporting phase 2 of the new parliamentary building over the top, can be modelled for as long as the passage of a complete train, in an overnight run.

Real-time is a long way off (at least on a PC), but the output is printed to file which can then be converted into a .WAV file for replay through a sound card.

Rupert Taylor is a consultancy practice which began life 31 years ago, when only a handfull of present day practices around the world existed in the form of acoustical consultants. He claims to have been the first person to use the term 'noise consultant' in 1968, when it was a strangely off-beat profession. Now that noise consultants seem almost as plentiful as architects, moving into the more obscure corners of acoustical and dynamic modelling is like going back to 1968, into a field occupied by only a handful of people around the world.

Rupert Taylor Ltd is based at Uckfield, East Sussex and is a Member of the Association of Noise Consultants. ❖

SOUND INSULATION: HOW MUCH DO WE NEED AND CAN IT BE ACHIEVED?

Commonwealth Institute, London, 7 April 1997

This first Building Acoustics Group Workshop was attended by 68 people Dr Les Fothergill, from the Department of the Environment, opened the Workshop and stressed the need for the Workshop, in line with recurring problems over sound insulation in homes and the use of the Environmental Protection Act, to promote retrospective remedial measures for poor sound insulation.

Dr Nigel Cogger from Arup Acoustics' Winchester office then discussed Building Regulations Standards. He noted the usefulness of Colin Grimwood's paper on complaints in Acoustics Bulletin July/August 1995, and highlighted that Colin had found a high percentage of complaints were justified where the sound insulation was below the target level of Approved Document E.

Although Colin concluded that the standard was about right, Nigel argued that expectations have now increased and background noise is dropping due to the use of thermal glazing. Additionally, noise sources, especially, domestic sound reproduction equipment, are becoming more powerful.

He highlighted the shortcomings, including the lack of an impact performance test for walls, the lack of post construction testing and the efficacy of the various forms of construction which, although the precise terminology has been deleted, may still be thought of as 'being deemed to satisfy' in respect of the guidances.

Nigel compared standards in some other European countries, for example:

German (multi-occupancy)

53–55 $D_{nT,w}$, 46–53 $L_{nT,w}$

German (semi-detached)

57 $D_{nT,w}$, 48 lateral $L'_{nT,w}$

He then highlighted the work of Brazier and Du Press (JASA September 1994) which showed footfall noise as a problem at low frequencies with timber floors. The only practical method of improvement was to increase the stiffness of a timber floor. Should we measure impact sound over the low frequency range as well?

He concluded,

- A high proportion of constructions do not meet the Building Regulations' target performance in practice.
- Building Regulations deal only with normal domestic activity.
- Higher standards have been adopted in other countries.
- Building Regulations do not deal with low frequencies and suggested:

Improved Criteria

Greater Control During Construction.

Peter Henson from Bickerdike Allen Partners then addressed the Workshop on improvements to timber joist floors. He noted the poor performance of untreated floors and the recommended methods of improvement. The need to deal with flanking transmission was illustrated, with on-site practical details and the problem with services within floors was highlighted. Peter gave the results of actual remedial treatments in several different projects with timber floors. In particular, he illustrated how airborne sound insulation had been improved from around 43 dB $D_{nT,w}$ to 55 dB $D_{nT,w}$ and impact sound transmission reduced from 65 dB $L'_{nT,w}$ to 49 dB $L'_{nT,w}$ using an independent ceiling. He then completed his talk with illustrations of the on-site situations which he had resolved in a prestige flat using a novel isolated ceiling. The need to accommodate site constraints were shown vividly. His practical work had led to an improvement in impact sound insulation from around 51 to 42 $L'_{nT,w}$ for this isolated ceiling.

David O'Neill from the same company then presented a case history of an investigation on the sound insulation of a new estate. Having found airborne sound insulation to be around 45 dB, he reviewed existing literature to define a thin floor treatment and a special ceiling treatment for the beam and block-floored estate. He highlighted the problem of flanking sound transmission and his use of special linings to reduce such transmission. He concluded by showing the final results which indicated a 5 – 6 $D_{nT,w}$ improvement, and sufficient sound insulation obtained.

	Before: dB $D_{nT,w}$	After: dB $D_{nT,w}$
Upwards	48	53
Downwards	46	52

David Watts of Acoustical Investigation & Research Organisation Ltd spoke on the laboratory testing of facade elements, illustrating the difficulties of testing when the original contract specification was inadequately drafted. He highlighted the need to specify accurately the performance actually required, and in the way a test should be carried out.

After lunch, the delegates were separated into three groups, and asked to consider and reach views on specific sound insulation matters. The groups were generally organised to consist of environmental health officers from London, environmental health officers from other authorities (this included Pembroke, N E Lincolnshire, Bournemouth, Birmingham) and acoustic consultants.

After an hour or so of individual group discussion, tea was taken and then the meeting reconvened to hear from the rapporteurs of the groups. In general, it was perhaps surprising that the groups reached generally similar conclusions.

The first series of topics related to how much sound insulation is needed. In general, it was the view that the airborne and impact standard for new building constructions was appropriate for most situations, although it was opined that when residential accommodation was situated against leisure premises a higher standard would probably be necessary. It was felt that there should be one numerical standard for conversions and new build properties, and no different standards dependent on the number of tests.

The proposal made in the morning for an impact test for separating walls was not supported, however a need was seen for design guidance on how to avoid noise intrusion arising from switches, doors, staircases etc.

The methods of testing were generally found acceptable. Concern was expressed over whether the frequency range should be extended to lower frequencies, and also whether a deviation of greater than 8 dB from the reference curve in BS 5821 should be taken into account.

The use of the impact testing machine on resilient materials was held liable to produce confusing results, and so it was suggested some advice should be available on when use of the tapping machine was inappropriate.

There was a view expressed that constructions detailed in Approved Document E appeared not to reliably produce sufficient sound insulation. Concern was specifically raised over the adequacy of the performance of party walls made of solid blockwork with dry lining, and also of floors consisting of beam and block construction without a levelling screed. Similar unease was voiced over timber joist floors with a floating floor with resilient materials placed upon the joists.

The reasons why less sound insulation is achieved than required was discussed, and matters to be addressed were highlighted, specifically:

- Better training for site personnel and building control officers.
- Use of post construction testing.
- Guidance on the completed design of separating walls/floors, not separate documents on fire, thermal and acoustic design.

Jeff Charles FIOA

The Management of Sound from Public Houses, Clubs and Other Indoor Venues

Church House, London, 20 May 1997

This one-day meeting at the Church House Conference Centre was organised by the London Branch and was fully subscribed with 120 delegates. It was opened by an initial address from the Chairman, Jim Griffiths, who outlined the aspects that he hoped would be debated throughout the day, such as suitable criteria and practical engineering solutions.

John Hinton of Birmingham City Council, who is the Chairman of the IOA Working Party preparing a Code of Practice on the control of noise from public houses and clubs, introduced the technical debate. John defined all the potential noise sources that, from experience, have been problematical (music, people arriving or leaving, people at the venue, deliveries, plant and guard dogs). Furthermore the scale of the problem was shown by the growth in the number of complaints related to music which was stated to have grown by over 15% in the past year in the Birmingham area. John outlined tentative noise values for the various entertainment noise sources, which were being considered in the code. A general debate followed with some views being expressed that the code should not be too prescriptive. It was also felt that disposal activities should be included as a potential noise source.

The next paper was presented by Tony White of Liverpool City Council who outlined the policies of the Council to encourage the repopulation of the city centre and its effect on noise issues, in particular with respect to bringing residents close to entertainment venues. Schemes of sound insulation were being considered along with internal design criteria of NR30, requests for acoustic reports and an inaudibility criterion at the boundary of the venue premises.

Nigel Cogger from Arup Acoustics reviewed various commonly adopted criteria and, by the use of two successful case studies for new venues, advocated the need for a flexible approach so that suitable guidelines can be adopted for each particular case.

The next paper, by David Leversedge of Symonds Travers Morgan, outlined noise criteria and noise control strategies adopted at all-night parties held at indoor venues. Various case studies were discussed and a practical guideline for these types of events was proposed.

Remedial measures for reducing the noise impact from existing small venues was highlighted by Andrew Bulmore of Hoare Lea Acoustics. In situ measurement procedures were outlined to identify the problem areas, along with practical control solutions which have been shown to work.

For a balanced debate, the view of the operator was expressed by Paul Ludford of Kitchenware Productions. Paul has had many years experience at producing and promoting many forms of musical events which he outlined in graphic detail. One of his main concerns was the inconsistent approach between local authorities and even by different officers within the same authority. Paul, although welcoming Codes, advocated a degree of flexibility.

The President presents the Institute Prize for the best performance in the 1996 Diploma examinations to Clare Wildfire, a Distance Learning student at the 1997 AGM at Church House.

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A lengthy debate followed the technical presentations which mainly focused on the most appropriate guidelines for the control of music from these venues – the use of NR Curves, allowing marginal (3 dB to 5 dB) increases of the background noise levels at low frequencies and inaudibility – were favoured by various delegates. In summary, the meeting provided a useful forum for delegates to exchange views which will assist in the formulation of a new Code of Practice for the future.

Jim Griffiths ❖

Members and guests at the 1997 Annual Dinner on the River Thames, which followed the meeting and AGM at Church House.

BSI News

New and Revised British Standards

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

BS 5228: Part 1: 1997 Code of practice for basic information and procedures for noise and vibration control. Gives recommendations for basic methods of noise and vibration control relating to construction and open sites generating significant noise and/or vibration levels. The legislative background to noise and vibration control is described and recommendations are given regarding procedures for the establishment of effective liaison between developers, site operators and local authorities. Provides guidance concerning methods of predicting and measuring noise and assessing its impact on those exposed to it. Supersedes BS 5228: Part 1: 1984.

BS 5228: Part 2: 1997 Guide to noise and vibration control legislation for construction and demolition including road construction and maintenance. Supplements BS 5228: Part 1: 1997 with information relevant to construction and demolition work. Supersedes BS 5228: Part 2: 1984.

BS 5228: Part 3: 1997 Code of practice applicable to surface coal extraction by opencast methods. Supplements BS 5228: Part 1:1997 with information enabling extraction to take place with the minimum of noise and vibration disturbance to the community. Supersedes BS 5228: Part 3: 1984.

BS 6259: 1997 Code of practice for the design, planning, installation, testing and maintenance of sound systems. Gives recommendations for sound systems intended for communicating speech, music and other signals primarily for monaural systems. Simultaneous interpretation systems, some aspects for recording studios, broadcasting studios and home entertainment systems are not covered by this standard. This code of practice has been developed in an expanded form at the express wish of industry, as the original code of practice was mainly applicable to small installations. Supersedes BS 6259:1982.

BS 7887: 1997 Ultrasonics – Real time pulse-echo systems – Guide for test procedures to determine performance specifications. Describes methods of measuring the performance of real-time medical ultrasonic imaging equipment in the frequency range 0.5 MHz to 15 MHz including mechanical sector scanner; electronic phased array sector scanner; electronic linear array scanner; electronic curved array scanner; water-bath scanner based on any of the above four scanning mechanisms. No current standard is superseded.

Amendments to British Standards (replacement pages)

BS 848: Fans for general purposes

BS 848: Part 2: 1985 Methods of noise testing. Amendment No: 1 AMD 9374.

BS 2497: 1992 Specification for standard reference zero for the calibration of pure tone air conduction audiometers. Amendment No: 1 AMD 9442. Note: This amendment implements EN ISO 389: 1995 as a British Standard and renumbers BS 2497: 1992 as BS EN ISO 389: 1997.

BS 6840: Sound system equipment

BS 6840: Part 5: 1995 Methods for specifying and measuring the characteristics of loudspeakers [IEC 268-5: 1996] Amendment No: 1 AMD 9409. Note: This amendment implements EN 60268–5: 1996 as a British Standard and renumbers BS 6840: Part 5: 1995 as BS EN 60268–5: 1997.

BS ISO 389: Acoustics – Reference zero for the calibration of audiometric equipment.

BS ISO 389–2: 1994 Reference equivalent threshold sound pressure levels for pure tones and insert earphones. Amendment No: 1 AMD 9427. Note: This amendment implements EN ISO 389–2: 1996 as a British Standard and renumbers BS ISO 389–2: 1994 as BS EN ISO 389–2: 1997.

BS ISO 3743: Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields.

BS ISO 3743–2: 1994 Methods for special reverberant test rooms. Amendment No: 1 AMD 9426. Note: This amendment implements EN ISO 3743–2: 1996 as a British Standard and renumbers BS ISO 3743–2: 1994 as BS EN ISO 3743-2: 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 to 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 8662: Hand held portable power tools – Measurement of vibrations at the handle.

BS EN ISO 8662–9: 1997 Rammers. Specifies a laboratory method of measuring the vibrations at the handles of rammers, backfill rammers, pawing rammers and sand rammers for use in foundries, on building sites etc. No current standard is superseded.

BS EN ISO 8662–14: 1997 Stone working tools and needle scalers. Specifies a laboratory method. No current standard is superseded.
BS EN ISO 10819: 1997 Mechanical vibration and shock – Hand-arm vibration – Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand. No current standard is superseded.
BS EN ISO 11690: Acoustics – Recommended practice for the design of low-noise workplaces containing machinery.
BS EN ISO 11690–1: 1997 Noise control strategies. No current standard is superseded.
BS EN ISO 11690–2: 1997 Noise control measures. No current standard is superseded.
BS EN ISO 11691: 1997 Acoustics – Measurement of insertion loss of ducted silencers without flow – Laboratory survey method. No current standard is superseded.
BS EN ISO 9614: Acoustics – Determination of sound power levels of noise sources using sound intensity.
BS EN ISO 9614–2: 1997 Measurement by scanning. No current standard is superseded.
BS EN 50147: Anechoic chambers.
BS EN 50147–2: 1997 Alternative test site suitability with respect to site attenuation. Specifies requirements for site attenuation which demonstrate the suitability of an enclosed test site when compared with an open area test site. No current standard is superseded.
BS EN 1032: 1997 Mechanical vibration – Testing of mobile machinery in order to determine the whole-body vibration emission value – General. Specifies the evaluation of vibration emission at operator's place during testing and operation of mobile machinery. Intended to be used for defining magnitudes of whole-body vibration transmitted from supporting surfaces to the human body in the frequency range 1 Hz to 80 Hz. Applies to sitting and standing positions; to all mobile machinery producing periodic or random vibration with or without transients. Only rectilinear vibrations are dealt with in this standard. No current standard is superseded.
BS EN 61689: 1997 Ultrasonics – Physiotherapy systems – Performance requirements and methods of measurement in the frequency range 0.5 MHz to 5 MHz. Specifies characteristics, requirements, methods of measurement, performance and acceptance criteria for equipment employing a single plane circular transducer generating continuous wave ultrasonic energy per treatment head. Therapeutic value and methods of use are not included. No current standard is superseded.

DD ENV Publications

The following is a British Standard implementation of the English language version of a European prestandard (ENV). ENVs are issued as Drafts for Development (DDs). DDs series of publications are of a provisional nature because it is considered that further experience is required in application before conversion to a British Standard.
DD ENV 12102: 1997 Air conditioners, heat pumps and dehumidifiers with electrically driven compressors – Measurement of airborne noise – Determination of the sound power level. Three methods are specified; the frequency range used is 125 Hz to 4000 Hz. No current standard is superseded.

Draft British Standards for Public Comment (for information only)

97/560655 DC ISO 10846–3: Acoustics – Laboratory measurement of vibro-acoustic transfer properties of resilient elements – Part 3: Dynamic stiffness of elastic supports for translatory motion – Indirect method (ISO/DIS 10846–3) (prEN ISO 10846–3).
97/704450 DC EN 12736: Specification for electrically propelled road vehicles – Airborne acoustical noise of vehicle during charging with on-board chargers – Determination of sound power level (prEN 12736).
97/102384 DC BS 6262: Code of practice for glazing for buildings – Part 2: Heat, light and sound (Partial revision of BS 6262: 1982).
97/705385 DC Amendment 1 to EN 1032: 1996 Mechanical vibration – Testing of mobile machinery in order to determine the whole-body vibration emission value – General (Possible amendment to BS EN 1032: 1997 (EN 1032: 1996/prA1)).

EN ISOs and ISPs

The following International standards have been adopted as ENs. These documents have been approved by CEN/CENELEC
EN ISO 3822: Acoustics – Laboratory tests on noise emission from appliances and equipment used in water supply installations.
EN ISO 11654: 1997 Acoustics – Sound absorbers for use in buildings – Rating of sound absorption.
EN ISO 11821: 1997 Acoustics – Measurement of the in-situ sound attenuation of a removable screen.

ISO Standards

ISO 266: 1997 (Edition 2) Acoustics – Preferred frequencies. Will be implemented as BS EN ISO 266 when ratified by CEN.
ISO 11200: Acoustics – Noise emitted by machinery and equipment – Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions. Technical Corrigendum 1; 1997 to ISO 11200: 1995. Will be implemented as an amendment to BS EN ISO 11200 1996 (subject to CEN ratification).
ISO 11201: Acoustics – Noise emitted by machinery and equipment – Measurement of emission sound pressure levels at a work station and at other specified positions – Engineering method in an essentially free field over a reflecting plane. Technical Corrigendum 1: 1997 to ISO 11201: 1995. Will be implemented as an amendment to BS EN ISO 11201: 1996 subject to CEN ratification.
ISO 11204: Acoustics – Noise emitted by machinery and equipment – Measurement of emission sound pressure levels at a work station and at other specified positions – Method requiring environmental corrections. Technical Corrigendum 1: 1997 to ISO 11204:1995. Will be implemented as an amendment to BS EN ISO 11204:

1996 subject to CEN ratification.
ISO/TR 11690-3: 1997 Acoustics – Recommended practice for the design of low-noise workplaces containing machinery – Part 3: Sound propagation and noise prediction in workrooms. Will be implemented dual-numbered as a Published Document (PD).
ISO 11654: 1997 Acoustics – Sound absorbers for use in buildings – Rating of sound absorption. Will be implemented as BS EN ISO 11654 when ratified by CEN.
ISO 11821: 1997 Acoustics – Measurement of the in-situ sound attenuation of a removable screen. Will be implemented as BS EN ISO 11821.
ISO 3822: Acoustics – Laboratory tests on noise emission from appliances and equipment used in water supply installations.
ISO 3822-3: 1997 (Edition 2) Mounting and operating conditions for in-line valves and appliances. Will be implemented as BS EN ISO 3822-3 to supersede BS 6864: Part 3: 1987.
ISO 3822-4: 1997 (Edition 2) Mounting and operating conditions for special appliances. Will be implemented as BS EN ISO 3822-4 to supersede BS 6864: part 4: 1987
ISO 5347: Methods for the calibration of vibration and shock pickups. ISO 5347-20: 1997 Primary vibration calibration by the reciprocity method. Will be implemented dual-numbered as BS 6955: Part 20.
ISO 5347-22: 1997 Accelerometer resonance testing – General methods. Will be implemented dual-numbered as BS 6955: Part 22.

European New Work Started

EN 12736: Electrically propelled road vehicles – Air-borne acoustical noise of vehicle during charging with on-board chargers – Determination of sound power level.

International New Work Started

IEC 268: Sound system equipment: Part 5: Loudspeakers; will revise IEC 268 (IEC/SC 100C through EPL/100/3) Part 7: Headphones and earphones; Will amend Sub-clauses 3.2.2.2, 3.6.1.1, 3.6.1.2 (IEC/SC 100C through EPL/100/3: New Part: Loudspeaker components. (IEC/SC 100C through EPL/100/2).

CEN European Standards

The document listed below is now available as an advance warning copy of the BS EN implementation.
EN 1299: 1997 Mechanical vibration and shock – Vibration isolation of machines – Information for the application of source isolation.
This information, provided by John W Tyler FIOA, was announced in the March to May 1997 issues of BSI News.

Book Reviews

Encyclopedia of Acoustics ed Malcolm J. Crocker
John Wiley & Sons 4 Volumes, 2000pp
ISBN: 0471-80465-7
Price £295 (until 30 June 1997)

The Encyclopedia of Acoustics, in four volumes and 2000 nearly A4 size pages, brings together many of today's most eminent writers in acoustics. In the foreword Sir James Lighthill invites comparison in significance between the Encyclopedia and *'The Theory of Sound'* by Lord Rayleigh. Classical acoustics and more recent developments have here been brought together, in what is perhaps more of an eclectic selection of articles than an integrated encyclopedia.

The encyclopedia is divided into 18 parts, each part comprising between 3 and 20 chapters and totalling 166 chapters in all. Some of the subjects are not normally found without access to specialist monographs or the original journal literature, for example 'Propagation in Marine Sediments', or 'Wave Modes in Liquid Helium'.

Volume 1, part 1 deals with general linear acoustics, and covers classical acoustics such as ray acoustics, lumped elements and standing waves. It has an introductory chapter by the Editor-in-chief, Malcolm Crocker, dealing at an intermediate level with wave motion, decibels and other basics. Chapter 2 by Allan Pierce is on the mathematical theory of wave propagation and is pitched at a more advanced level. The first part also includes a piece by Frank Fahy on structural acoustics.

The ten chapters of Part 2 deal with non-linear acoustics and cavitation, ending with a paper on sonochemistry and sonoluminescence containing some well reproduced photographs. Part 3 on aeroacoustics and atmospheric sound has an introductory chapter by Lighthill, and there is an article by Ffowcs Williams entitled 'Interaction of Fluid Motion and Sound'.

Part 4 is the longest section in the encyclopedia, and treats underwater sound in 20 chapters. Amongst the themes discussed are oceanography and fisheries acoustics, underwater noise sources, ship & platform and propeller noise.

The second volume of the encyclopedia opens with part 5 on ultrasonics, quantum acoustics and physical effects of sound. The chapter by Papadakis on non-destructive testing is perhaps of more general interest than some of the specialized contributions in this section.

The Introduction to Part 6 on mechanical vibration and shock is by the sadly missed Manfred Heckl, who also authored the chapter entitled 'Vibrations of 1- and

2- Dimensional Continuous Systems'. Part 6 also includes chapters on active vibration control and machinery condition monitoring.

Part 8 covers noise control, including a technical paper by Nelson and Elliott on active noise control. The 11 chapters encompass areas including surface transportation, airports, hearing protection devices and machinery noise. Coverage is perhaps a little incomplete for an encyclopedia of this nature, with some unaccountable omissions.

Unfortunately Part 9 on architectural acoustics has virtually nothing on concert hall acoustics, although the section does incorporate a chapter by Kuttruff on sound in enclosures.

Part 11 on physiological acoustics includes contributions by S Greenberg on auditory function and E Shaw on acoustical characteristics of the outer ear, and chapters on cochlear mechanics, electrophysiology and biochemistry of the auditory system, but no chapter on cochlear implants – nor is there any specific index reference to this topic.

Part 12 covers psychological acoustics, including a chapter by Brian Moore on frequency analysis and pitch perception. The chapter by Dixon Ward on the effects of high intensity sound, and that by Larry Humes on clinical audiology, might have been better placed in a section on medical aspects of acoustics.

Volume 4 starts with 6 chapters on speech communication, analysis and recognition. These are followed by a section on musical acoustics, with an introduction by Thomas Rossing. The different families of instruments are each covered in their own brief chapters - string, brass, woodwind, pipe and reed etc. The human voice also has a chapter of its own.

Parts 15 and 16 deal with bioacoustics and animal bioacoustics respectively. The articles range in scope from medical diagnosis to bats and echolocation to insect bioacoustics.

Acoustical measurements and instrumentation is dealt with in the short section 17, with inclusion of chapters on sound level meters and on sound intensity. Part 18, on transducers, includes an interesting piece on loudspeakers, and a straightforward introduction to digital audio. The encyclopedia ends with chapter 166 about hearing aids.

It is unclear to what readership the encyclopedia is addressed. The treatment of topics ranges from mathematical to discursive, but the lay person and the practitioner are generally not well catered for. There are certain obvious omissions, such as data tables of acoustic properties, a treatment of sound barriers and general biographical and historical background.

It is regrettable that more care was not taken to produce a comprehensive index which is always important in an encyclopedia. Many items which are in the work will be found only with great difficulty.

There are diagrams throughout, but only a few black and white photographs have been included. Although nearly all the chapters end with a good set of pertinent references, a number of shortcomings let the encyclopedia down as an acoustics reference book. This said, few in academic circles would wish to be without access to a copy. At the introductory price it represents moderate value.

Andrew Silverman MIOA

Speechreading by Humans and Machines, Models, Systems and Applications
D G Stork and M E Hennecke
Springer-Verlag 1996, 690 pages
Price: £116

In recent years the Chateaux de Bonas has become widely known as one of the more delightful and inspiring places in which to hold advanced NATO workshops. Accordingly it seems fitting that this book gathers together not just the technical papers, but some of the ambiance and intellectual debate which took place during a two week workshop devoted to 'Speechreading by Man and Machine'.

A first scan through the 500 pages of diverse papers, 80 pages of bibliography, 40 pages of 'verbatim discussion' and 25 pages of patents hinted that this might be something of a 'challenging' read. However this proved not to be the case, for although it does not quite fall into the category of a 'good bedtime read', the collected papers have a coherent style and sequence which makes for easy reading. As is only to be expected in a book about speechreading it is well, although not lavishly, illustrated with pictures, graphs and diagrams.

The most striking feature is the breadth of basic research covered in the two major sections. The first is concerned with speechreading by humans and covers issues as diverse as the philosophy of speech and language, analysis of the speechreading skills of children and results from psycholinguistic and neuromagnetic response experiments. The second is concerned with speechreading by machines and ranges from 'talking head' technology through to recent advances in processing integrating visual and spoken signals.

Although, in the main, biased towards academic research – unsurprising as only a small number of those taking part were from industrial organisations – several of the papers addressed the applications dimension with particular reference to medical, entertainment and telephony based sectors.

The broad range of contributors means that this book is likely to be of value mainly to those who want to get an appreciation of the state of the art and will be mainly of interest to graduate courses in psycho-linguistics, speech and vision. Industrial users are more likely to focus on a subset of the book to obtain up-to-date information about the performance and value of deploying technologies.

Forty pages of the book are verbatim reports of the panel/discussion sessions. While these certainly help capture the flavour of the discussions they also illustrate the difference between written text and spontaneous speech. Accordingly I found this section of less value then the rest of the book. But perhaps that was the point – how much easier it would have been if I could have seen the participants talking!

D Johnston ❖

Research in Progress

University of Bradford

Department of Civil and Environmental Engineering

Acoustic performance of noise barriers
(with Dept of Mathematics and Statistics, Brunel University)
Mathematical models are being developed for the prediction of noise barriers of complex form and in complex environments, and the performances of existing and new designs of barrier are being investigated.
Duration of project: 1996 – 1999
Supervisors: Dr D C Hothersall, Dr S N Chandler-Wilde, Dr K V Horoshenkov
Researcher: P A Morgan
Funding: £115,000 EPSRC research grant

Poroelastic materials for noise control
(with Dept of Engineering Design & Manufacture, University of Hull)
This project will further develop mathematical models for the acoustic and mechanical properties of porous elastic media and investigate the applications of new materials in outdoor noise abatement schemes.
Duration of project: 1997 – 2000
Supervisors: Dr D C Hothersall, Dr K V Horoshenko, Professor A Cummings
Researcher: to be appointed
Collaborator: Sound Absorption Ltd
Funding: £129,000 EPSRC research grant

Liverpool University

School of Architecture and Building Engineering

Prediction of environmental noise from construction and open site industrial activities
The aim of this project is to develop a simple and reliable method for the prediction of open site industrial noise for use at the planning stage of a project.
Supervisors: Dr B M Gibbs, J Lewis, Professor D J Oldham
Researcher: F Carpenter
Funding: £127,000 EPSRC research grant

Circulation pumps as structure-borne noise sources
To investigate circulation pumps as structure-borne noise sources and lead to a characterisation and rating method of pumps.
Supervisor: Dr B M Gibbs
Researcher: Q Ning
Funding: £148,000 EPSRC research grant

Measurement of structure-borne emission by reciprocity
To identify major mechanisms in the transmission of vibrational energy between machines and supporting structures.
Supervisors Dr B M Gibbs
Researcher: K Yap
Funding: PhD studentship

Rotational actuators and moment excitation
(in collaboration with Shantou University, China)
This project has resulted in the development of three prototype actuators at Liverpool and three at Shantou.
Supervisors: Dr B M Gibbs, Dr Q Shuye
Funding: £23,000 from British Council

Sound insulation of acoustic louvres
(in collaboration with Santa Catarina University, Brazil)
This involves the use of impulse response analysis and intensimetry for the in situ measurement of acoustic louvres.
Supervisors: Dr B M Gibbs, Professor S Gerges
Researcher: E Viveiros

Environmental vibration and noise in buildings
This project involves an investigation of the relationship between field measurement of environmental vibration level and the resultant vibration and noise in nearby buildings.
Supervisors: Dr B M Gibb
Researcher: A White
Funding: PhD studentship from Liverpool City Council

Application of computational fluid dynamics to the prediction of air flow generated noise in ventilation systems
This will use recent developments in computing technology and CFD to predict noise levels from calculated turbulence kinetic energy at the face of a flow spoiler, and will examine effect on noise level of two flow spoilers in close proximity.
Supervisors: Professor D J Oldham, Dr M Johnson
Researchers: Dr D Waddington and M de Salis
Funding: £157,000 research grant from EPSRC

Application of virtual reflectors in open stage auditoria
This project investigates the use of a microphone, amplifier and loudspeaker to solve the problem of poor speech intelligibility in open stage auditoria.
Supervisor: Professor D J Oldham
Researcher: L El Zeky

Expert systems for environmental noise control
This project involves the creation of a knowledge based system for the solution of complex environmental noise problems for use by relatively inexperienced designers.
Supervisor: Professor D J Oldham
Researcher: H Ibrahim

Open University

Engineering Mechanics Discipline, Faculty of Technology

Acoustical monitoring of particulate pollution
Acoustical methods for determining mass concentration and particle size in airborne suspensions of sold particles have been studied, and were found to be inadequate at low concentrations but are currently being investigated for use at higher concentrations.
Duration of project: 1993 –
Supervisors: Professor K Attenborough, Dr R Barratt
Researcher: S Moss
Funding: £41,000 EPSRC research grant plus EPSRC PhD studentship

The prediction of noise arising from moving directional sources in a complex outdoor environment
Previous work on outdoor sound propagation near to the ground will be extended to allow for source motion, directivity and range-dependent conditions.
Duration of project: 1997 – 2000
Supervisors: Dr K Li, Professor K Attenborough
Researcher: Dr S Taherzadeh
Funding: £109,000 EPSRC research grant

Farming processes and noise control
Methods of exploiting ground effects for outdoor noise control through cultivation and landscaping, including effects of tall vegetation, are being investigated.
Duration of project: 1995 – 1998
Supervisors: Professor K Attenborough, Dr K Li
Researchers: Dr P Boulanger, T Waters-Fuller
Collaborator: Silsoe Research Institute
Funding: £177,000 BBSRC research grant

Refraction, curved surface and directivity effects
An acoustic analogy is being used to study the sound field above curved surfaces from monopole and dipole surfaces.
Duration of project: 1994 – 1997
Supervisors: Dr K M Li, Professor K Attenborough
Researcher: Q Wang
Funding: OU Competetive Studentship

Determination of soil properties from measurements of acoustic-to-seismic coupling
Measurements of short range propagation and acoustically-induced seismic signals are being used to determine physical properties of soil.
Duration of project: 1995 – 1998
Supervisor: Professor K Attenborough
Researcher: N Harrop
Funding: EPSRC PhD studentship

Acoustical monitoring of particulate flows
(with University of Greenwich)
Acoustical methods for deducing mass concentration particle shape and size in high concentration pneumatically-conveyed solid particle flows in air will be investigated and the basis for an industrially exploitable system devised.
Duration of project: 1997 – 2000
Supervisors: Professor K Attenborough, Dr S Woodhead
Researcher: to be appointed
Funding: £78,000 EPSRC research grant

Models for sound propagation in concentrated suspensions and emulsions
Duration of project: 1997 – 1999
Supervisors: Professor K Attenborough, Dr K Li
Researchers: Dr J Evans
Funding: £50,000 EPSRC research grant

Software for predicting outdoor sound propagation
Duration of project: 1997 – 1999
Supervisors: Dr K Li, Professor K Attenborough
Researcher: to be appointed
Funding: £20,000 ESDU International plc

The prediction and abatement of high speed train noise
Duration of project: 1997 – 2000
Supervisors: Dr K Li, Professor K Attenborough
Researchers: to be appointed
Funding: £12,000 OU Development Fund

University of Salford

Department of Acoustics and Audio Engineering

The development of a room diffusion coefficient
The project will define, validate and develop a measurement method for a new diffusion coefficient and produce new methods for predicting scattering from surfaces.
Duration of project: 1996 – 1999
Supervisors: Dr T J Cox, Dr Y W Lam
Researcher: T J Hargreave
Collaborator: RPG Diffuser Systems Inc
Funding: £190,000 EPSRC research grant

Techniques for enhancing energy flow - a new sound absorption mechanism
To investigate sound absorbers which exploit a newly discovered energy flow mechanism to promote absorption.
Duration of project: 1997 – 2000
Supervisors: Dr T J Cox, Dr Y W Lam
Researcher: to be appointed
Funding: £100,000 EPSRC research grant

South Bank University

School of Engineeering Systems and Design

The development of a model for the simultaneous prediction of internal and external sound fields
Further computer modelling for the simultaneous prediction of the sound fields inside and outside a building; to develop a database of absorption coefficients for use in prediction.
Duration of project: 1996 – 1999
Supervisor: Dr B M Shield
Researcher: Dr S Dance
Collaborators: ISVR Consultancy Services, Southern Water, HSE
Funding: £126,000 EPSRC research grant

Subjective response to low frequency sound
Laboratory studies of subjective response to noise, particularly noise with a high low frequency component, have been carried out and the effects of factors such as age and hearing acuity on response have been investigated.
Duration of project: 1994 – 1997
Supervisors: Dr B M Shield, Dr K Khirnykh
Researcher: R Adams
Funding: South Bank University Research Scholarship

Speech intelligibilty in underground stations
A computer model for the prediction of speech intelligibility in underground stations has been developed and validated using data from scale models and real stations.
Duration of project: 1994 – 1997
Supervisors: Dr B M Shield, Dr K Khirnykh
Researcher: L Yang
Funding: South Bank University Research Scholarship

Items should be sent to Dr Bridget Shield MIOA, South Bank Unversity, School of Engineering Systems and Design, 103 Borough Road, London SE1 0AA ❖

New Products

CEL INSTRUMENTS LTD

New 'Pocket Sized' Sound Level Meter

CEL Instruments have introduced a new integrating sound level meter which is small enough to slip inside most pockets. The CEL-424, a type 2 meter complying with IEC and BS standards, uses the latest miniaturisation technologies to produce a new shape in sound level meter design for industrial noise measurements.

The familiar conical shape is replaced by a compact, cigarette pack sized instrument that still fulfils all of the requirements of worldwide sound level meter standards.

The CEL-424 provides simultaneous measurement of L_{eq}, L_{Avg} and L_{Peak} as well as selectable A or C weightings and Fast, Slow and Impulse time weightings.

Fitting snugly in the hand, the CEL-424 has an icon based keypad and these icons are replicated on the screen for ease of operation.

The instrument can also be used as a logging noise dosimeter by replacing the stem microphone with a dosimeter microphone. This is an easy operation and converts the meter into a full specification Personal Noise Dosimeter.

For further details please contact CEL Instruments Ltd, 35–37 Bury Mead Road, Hitchin, Herts SG5 1RT Tel: 01462 422411 Fax: 01462 422511 Email: sales@cel.ltd.uk

CEL Instruments is a Key Sponsor of the Institute.

BRÜEL & KJÆR

NEXUS – Signal Conditioning Amplifiers

Brüel & Kjær have introduced NEXUS, a new range of four channel condition amplifiers, which caters for a wide range of uses in sound and vibration measurement.

NEXUS offers a dynamic range of up to 120 dB, advanced overload detection facilities and transducer tests. This provides the flexibility to make different measurements whatever the signal or measurement situation – an essential feature, especially when making measurements in the field. An extensive array of built-in filters make it easy to focus on the signal of interest.

NEXUS can handle a variety of acoustic and vibration transducers. The NEXUS range can interface with five main types of transducers, microphones, a sound intensity probe, charge accelerometers, accelerometers with integral electronics and force transducers. The conditioning channels can be mixed and put in the same NEXUS 4 channel unit. This means a model can be tailored to a customer's specific requirements, eg a triaxial accelerometer plus a microphone and preamplifier.

For further details contact Charles Greene, Brüel & Kjær, Harrow Weald Lodge, 92 Uxbridge Road, Harrow, Middlesex HA3 6BZ Tel: 0181 954 2366 Fax: 0181 954 9504.

Brüel & Kjær is a Key Sponsor of the Institute.

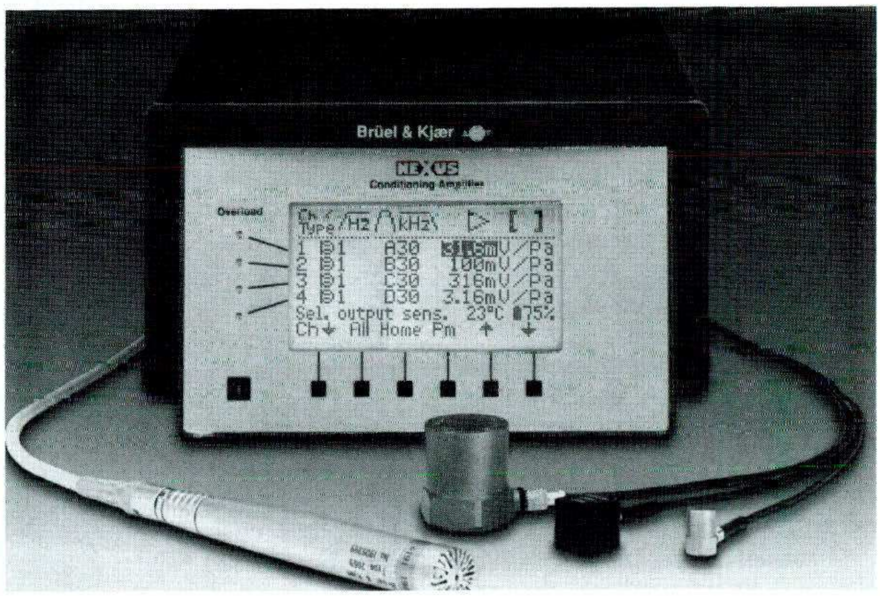
BRAUNSTEIN + BERNDT GMBH

EnviroPLAN module for SoundPLAN

The definition of environmental risk includes the combination of an area's sensitivity and the affects of pollution or other environmental impacts on the area. Designed specifically with this in mind, EnviroPLAN is the ideal new tool for engineers working in the field of environmental analysis, ecology and landscape planning. Even complex environmental impact studies are said to be easy to handle with this new SoundPLAN module. EnviroPLAN allows the user to freely define area sensitivities and to select the environmental impact on an area. The user can define his own rules to convert these impacts and sensitivities into assessments. Assessments can be combined and rank ordered to form an overall evaluation of the quality of the planned variations.

Elements used for evaluation are points, lines and areas. Attributes and values are assigned to these elements. For example, the suitability for retimbering an area may be assigned attribute 1 for very good, 2 for good, 3 for not so good and so on. The number of inhabitants per square mile can be assigned a specific value. New values and attributes can be calculated and/or analyzed using formulas or a linear matrix. Buffer zones around sensitive elements can be defined and evaluated in the assessment. These buffer zones include such items as the radius around a breeding ground (point), the corridor around a deer path (line), or a buffer zone around a biotope (area).

Different algorithms can be assigned different areas allowing for existing values and attributes. Area results are displayed at the push of a function key. Results of an EnviroPLAN assessment can be pre-



sented in numerical or map form. The layout of these thematic maps are user developed. 40 symbols are available in the symbol library and a symbol generator is available for the user to create up to 250 of his own options.

All graphic capabilities included in SoundPLAN and cartography can be used jointly when creating maps. The graphics are readily understood, aesthetically pleasing and easy to reproduce on standard printing equipment.

EnviroPLAN has a distinct advantage for SoundPLAN users in that the user does not have to change programs to include environmental information to an existing map. Users can learn the structures and algorithms of EnviroPLAN more quickly and efficiently than for common geographic information systems (GIS), plus the quality of the results is equal that of a GIS system.

Further details from Braunstein+Berndt GmbH, Robert-Bosch-Strasse 5, D–71397 Leutenbach, Germany. Tel: +49 7195 178828 Fax: +49 7195 63265.

GRACEY & ASSOCIATES

New upgrades for Norsonic NOR-110 Sound Level Analyser

The real time frequency analysis functions of the NOR–110 have now been augmented by the addition of the ability to calculate the L_n value in each octave or third octave in real time. This gives a direct read out of the percentile spectrum, the L_{90} spectrum for example is of considerable use in calculating the masking that the background noise level will afford against a new source that is to be introduced into an environment. The L_{10} spectrum is also specified for the assessment of the intrusiveness of sound transmission in multi-screen cinemas; it allows the sound track to be used as the noise source.

Calculation and display of the percentile spectra is performed in real time and may be viewed along side the conventional power and maximum spectra during the measurement. At the end of a measurement sequence the pre-selected L_n value may be changed and new values calculated based on the stored data. As a result any value of L_n may be calculated in the range $L_{0.1}$ through to $L_{99.9}$. Results may be downloaded to computer in standard formats for direct use in reports or alternatively printed directly from the meter on a standard serial printer.

To meet the requirements of the Noise Act 1996 all the L_n values calculated in the NOR–110 are now to a precision of 0.1 dB. This feature, along with the comprehensive time mode, means all of the measurement requirements associated with the Night Noise Offence are covered by the instrument. The full range of data provided will allow the residual level and the offending noise to be measured with all significant occurrences being indicated on the time trace by use of the marker functions.

All versions of the NOR–110 are equipped with reverberation time and spatial averaging functions and as such they are widely used for building acoustic measurements. A new windows package is now available that allows the data held in the instrument to be transferred to a PC and a wide range of calculations performed as set out in both National and International Standards. For example from a single series of measurements the NOR-SIC package will calculate the $D_{nT,w}$ and produce a report in the format set out in the standards. A free demonstration disk is available on request from Gracey Associates.

All instruments in current service can be upgraded to include these new features; this is in line with the Norsonic policy of continual product improvement and means that even the first NOR–110 produced can be brought into line with the most recent standards and measurement protocols.

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

Gracey & Associates is a Sponsor Member of the Institute.

News Items

THE NOISE CONTROL CENTRE

Open Day

The Noise Control Centre of Melton Mowbray, based at their last factory for the past 23 years, recently held an Open Day to celebrate their relocation to new premises at Crown Business Park, the old MOD Refurbishment Centre at Old Dalby, north of Melton Mowbray. The Company invited long established customers and associates to view their new facilities which provide more than twice the existing factory and office space than their previous factory.

The Acoustic Materials Division of NCC presented many new prod-

ucts. On display were some new generation noise control materials, offering such qualities as high fire resistance and superior acoustic performance. In addition, NCC introduced a range of fibre-free moulded products for use in the OEM market place. These included engine compartment absorbers, manufactured from Basotect melamine based foam. NCC has been licensed for the sale of Basotect, which is manufactured by BASF, for many years and is continually extending its areas of application.

The Industrial Noise Control Division had several acoustic enclosures on display, including a unit to house the new Parsons Trent GT Generator Unit, designed for use in the new combined cycle urban power stations.

The Company is investing heavily in new plant and equipment together with development facilities to ensure that they stay at the forefront of technology and product innovations across all aspects of noise control.

Data sheets and brochures are available by faxing The Noise Control Centre on 01664 821830.

The Noise Control Centre is a Sponsor Member of the Institute.

From the New Products editor: I would like to apologise for a printing error in the telephone number of The Noise Control Centre which was printed in the March – April 1997 issue. The correct number is 01664 821811.

SALEX ACOUSTIC MATERIALS

Plans Announced For Major New Manufacturing Site

Noise control specialists Salex Acoustic Materials (SAM) Ltd have announced plans for a new £2.5 million production facility to be based at Severalls Business Park in Colchester, Essex.

The new factory complex is required due to increased business in SAM's niche automotive business. SAM currently supplies acoustic materials to over 60% of tractors currently built in Western Europe, as well as the majority of the buses manufactured in the UK. The company also serves construction vehicles and heavy trucks.

The new three and a half acre factory site enjoys excellent road and rail links and will be at the heart of Colchester's manufacturing community. Subject to planning consent, the factory is expected to be completed in the Autumn of 1997 and will initially offer some 40,000 sq ft of manufacturing and office facility, with a further 20,000 sq.ft to be added later, subject to permission.

NC55 Application Requires Special Splitters

Noise attenuation specialists, Sound Attenuators Ltd (SAL) have just completed an NC55 level application on a manufacturing clean room the size of a football pitch.

The clean room was to be ventilated by 32 large, variable pitch, axial flow fans with an in-duct SWL each of 124 dB. Each fan had an air volume of 87 m^3/s and had been pre-designed to discharge into 6.0 m x 2.0 m ductwork.

SAL were called in to offer an NC55 level solution to the system. They found themselves faced with a number of initial complications, including 7.25 m/s face velocity on the discharge side and inlet attenuators with a 2000 mm length limitation. Fortunately, the face velocity on the inlets was just 2.5 m/s.

SAL worked in conjunction with the fan manufacturers Howden Varjax and the AHU supplier, AAF McQuay, to plan an economic solution to the challenge posed by the system as designed.

Flow noise caused by conventional attenuation elements would normally prohibit the use of standard splitter configurations, given these face velocities and length restraints.

However, SAL's patented 'TS' splitter design with low resistance and lowflow noise characteristics was able to match the criterion for the discharge elements, and 'TS Reverse' designs were suitable for the inlet elements.

Following a fast-track contract, the SAL TS splitter units were installed, and recent tests have confirmed that the clean room environment now meets the NC55 criterion.

For further information, please contact: Sound Attenuators Ltd, Eastgates, Colchester, Essex CO1 2TW Tel: 01206 866911 Fax: 01206 865987.

Salex Ltd is a Sponsor Member of the Institute.

CEL INSTRUMENTS

Vehicle Noise Testing Systems

On April 1st this year Norway and Italy introduced stationary vehicle noise testing for all cars, vans and trucks and both countries have chosen a CEL Instruments' system to carry out the work. So far Norway have ordered 120 units and Italy 40 units of the system for use in specialist garage outlets. The system includes a Type 1 CEL-414 Impulse Sound Level Meter, a 10 metre preamplifier extension cable, windshield, calibrator and tripod.

The vehicle noise test, complying with IEC 5130 1982 (E), requires a measurement of both the ambient (background or surrounding) noise level and the specific maximum level issuing from the rear of the vehicle.

The system enables the tester to sit in the driver's position to operate the sound level meter and the car's throttle. The preamplifier and microphone unit, connected via the 10 m cable, is positioned 1 m from the vehicle's exhaust at an angle of 45°. When the engine reaches its normal operating temperature the engine is held at 75% of the maximum rpm. The throttle is then released to allow the engine's return to normal tickover speed and the maximum recorded noise level is shown on the instrument's screen. The test is carried out three times for each vehicle. One ambient noise level is also measured with the vehicle's engine switched off. The difference between the ambient and maximum readings is then compared to the vehicle manufacturer's own specifications to determine whether the vehicle has passed the test.

The orders were secured by two of CEL's European agents: Jar Maletekknikk in Norway who will be supplying the systems to Holta and Haland, (a specialist garage supplies

company), and Orione di Bistulfi for the Bosch organisation in Italy.
For details of the system contact: CEL Instruments Ltd, 35–37 Bury Mead Road, Hitchin, Herts SG5 1RT Tel: 01462 422411 Fax: 01462 422511 Email:sales@ cel.ltd.uk
CEL Instruments is a Key Sponsor of the Institute.

ISVR

Making tracks for quiet trains

The Institute of Sound and Vibration Research (ISVR) of the University of Southampton is a partner in two large-scale collaborative research projects on railway noise funded by the European Union within its Brite Euram III programme. Total funding for the University amounts to almost 320,000 ecu (£235,000). Railway noise has been researched at ISVR for the last 25 years beginning with a major national study of community response to railway noise which helped to lay the foundations for the establishment of standards for railway noise in the UK. The new focus is on reducing the noise at source.

The first project, Silent freight, began last year and aims to reduce the noise from goods trains by up to 10 decibels. Its counterpart, Silent track, was launched in January and aims to do the same for the rails and sleepers. The two projects will culminate in a combined demonstration of the technology in the spring of 1999. Both projects are coordinated by ERRI, the research arm of the International Union of Railways, but involve different industrial partners. Heading the University's participation is Dr David Thompson, lecturer in Rail Systems Noise and Vibration, who joined the University last summer. Also involved at the ISVR are Dr Chris Jones, senior research fellow, previously with BR Research and Dr Neil Ferguson, industrial lecturer in Structural Dynamics.

A key tool in this work is a theoretical model for railway rolling noise, TWINS, developed by Dr Thompson and, it is claimed, already in use by more than 10 companies and railway operators in Europe. ISVR will be developing new elements of this model and extending the validation of existing elements. To allow experiments to be carried out without requiring access to an operational railway, a short section of track is to be installed at or near the University. For further information contact Dr David Thompson ISVR Tel. 01703 592510 or Ruth Bowden, Public Affairs, University of Southampton Tel. 01703 595420.

Anthony Best Dynamics

Second ABD kinematics and compliance rig now installed in the US

Anthony Best Dynamics (ABD) of Wiltshire has delivered and commissioned a Suspension Parameter Measurement Machine (SPMM) at a major tyre manufacturer in the United States. This system is similar to the SPMM installed by ABD last year at MIRA in the UK. In a recent press release, ABD claimed that SPPMM is a cost-effective four wheel station machine which can measure the suspension kinematic and compliance characteristics of a wide range of vehicles. The SPMM installed at MIRA has been in almost continuous use since it was commissioned and has provide data on over one hundred vehicles of different types. Like its counterpart at MIRA, the newly commissioned rig in the US is an electro-mechanically operated, fully automated and computer controlled machine, capable of completing a full suite of suspension and steering measurements in hours rather than days.

The four wheel station design of the SPMM enables two axles to be measured simultaneously and provides a fast turnaround for producing a full data set for a vehicle. In addition , the ability of the SPMM to take a wide range of vehicle from the smallest passenger car to the largest vans allows the rig to expand on the tests available from previous systems of this type. ABD explained that the essence of the machine is that it subjects the vehicle suspension and steering system to a variety of forces and displacements applied slowly, so as not to excite any inertia forces from accelerating masses or any damping from shock absorbers or elastomers, whilst recording all the relevant deflections and loads. The SPMM provides the engineer with an important data set relating to vehicle ride and handling performance and is designed to maximise the use of commercially available hardware and software.

For all sales enquiries contact: Tony Best, Anthony Best Dynamics, Holt Road, Bradford on Avon, Wilts BA15 1AJ Tel: 01225 867575

Industrial Noise and Vibration Centre

Hygienic Noise Control

Industrial Noise and Vibration Centre (INVC) have produced a technical note on hygienic noise control technology backed by a selection of case studies covering a wide range of industries and processes and this is available free of charge from the INVC. In a recent press release by the company they note that enclosures and other control techniques used to reduce noise levels often create new problems related to cleaning, access and maintenance. Companies in the food/ pharmaceutical/electronics and other industries where hygiene must be maintained, frequently have to endure high costs and inconvenience to reduce noise levels by conventional means.

The INVC alternative is to make use of the best of current innovative engineering technology to reduce noise at source. INVC claim that this not only has few hygiene implications but is also low cost. Examples of the technology in action include a vibratory feed system where, far from causing problems, the noise control techniques used improved performance, cut down-time and maintenance and reduced the noise level from 99 dB(A) to 77 dB(A) at 10 per cent of the cost of an enclosure.

For further information contact Peter Wilson or David James, Industrial Noise and Vibration Control Centre, Burnham House, 267 Farnham Road, Slough, Berks, SL2 1HA. Tel: 01753 530414/570044, Fax: 01753 570311.

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