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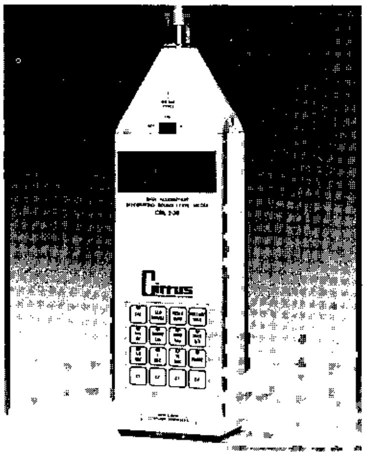

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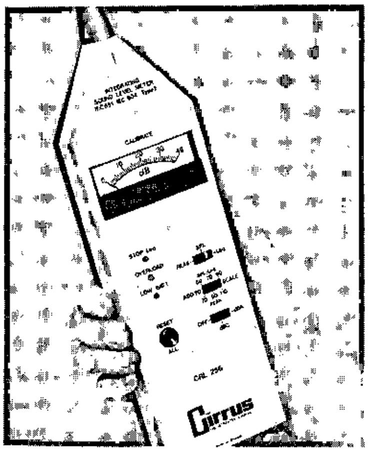

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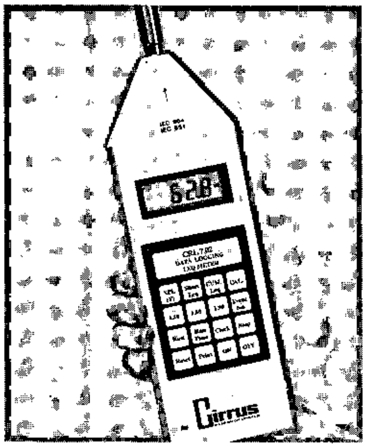

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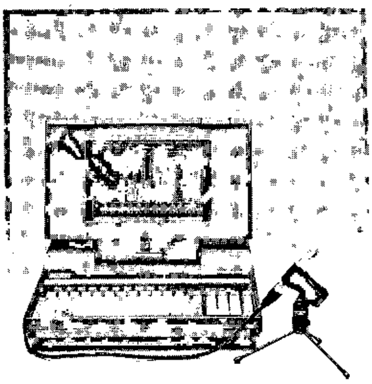

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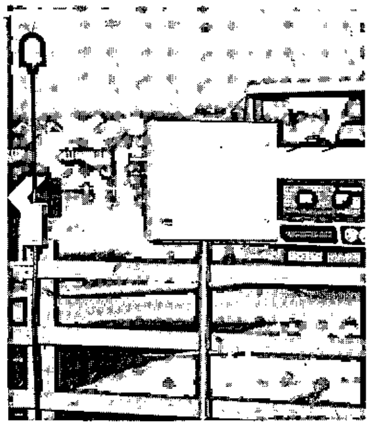

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contents

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Dear Fellow Member

As I write this letter (or should the verb now be 'to doubleyoupee'?) the temperature is rising towards the mid 20s, and I am trying to give thought to the conference season which approaches. The month of September has just commenced and I am due to give a paper at my other Institution's annual congress on the topic 'Noise - the sound of modern living'. I have snatched a few days off from work to polish the words at home and the periods of concentration required have forcibly brought it to my attention just how noisy home life has become during the normal working week.

The barking dog (bought for security but whose warnings are largely ignored), the power mower, the DIY tools, the light aircraft flown solely for the pleasure of a few, the increasing use of helicopters for business and police use, the constant movement of cars used for short journeys by homeworkers, house-husbands and housewives alike, the revving of motorbikes used more to impress than to transport, the cheerful returners from late-opening pubs and clubs, the car alarm which acknowledges the presence of its owner by a few loud chirrups and of a potential new owner by a raucous blare of horn. All these conspire to affect concentration and to disrupt peaceful enjoyment of the home environment.

That leads me to consider also the relatively new phenomenon (to these islands!) of al fresco dining, or barbecue to most, of which I heartily approve. Why, however, is it not regarded as possible to eat, drink and be convivial outside without the addition of some form of music, rarely a string quartet, and never adequately controlled in volume?

Almost all of these give rise to objection, some of which is actually voiced as complaint to police or local authority, but much of which I suspect is merely accepted as an unavoidable consequence of modern living. Many are susceptible of control by acoustical methods, some legislation exists to enable and in some cases to require enforcement officers, such as environmental health officers, to exert control, some can be controlled only by adequate forward planning, but most require a fundamental alteration in social attitude towards the reduction or suppression of environmental noise.

The Institute's Autumn Conference at Windermere in November is devoted, in a much more technical and erudite fashion than this piece, to the subject of 'Noise in the Nineties: a Quieter Britain?' Whatever our area of involvement in the broad church of acoustics, environmental noise affects us all and we should all therefore both be aware of and promote awareness of noise as a pollutant and an undesirable and controllable aspect of modern life.

Best Wishes

Mike Ankers.

DIGITAL SIMULATION OF CONCERT HALL ACOUSTICS AND ITS APPLICATIONS

H Kuttruff

Introduction

In recent years, great progress has been made in computer simulation of concert halls and it can be expected that these techniques will replace the more conventional methods of acoustical design in the near future, on account of their efficiency and flexibility. But even more: computer simulation offers the possibility to give direct, ie aural impressions of the listening conditions expected at the various seats of the hall when it is still in the state of design ('auralisation').

The classical tools of the acoustical consultant are a pencil and a drawing board to trace sound rays and to construct sound reflections. Another well-proven method of acoustical design is a scale model of the hall in which important aspects of the sound propagation can be investigated by experiment. With sufficiently refined equipment, we can even use a model to present aural impressions on how music will sound in the hall when it will be completed. According to the original ideas of F Spandock [1], who has proposed this method as early as in 1934, this can be done as shown in Fig. 1.

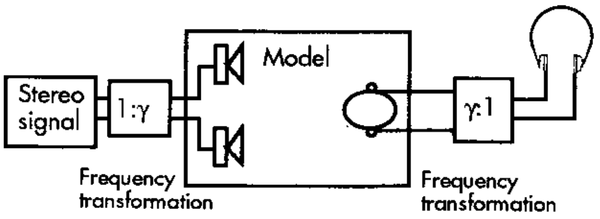

Fig. 1. Principle of auralisation carried out with a physical model

In the scale model, which should be as realistic as possible, 'dry' ie unreverberated sound signals such as speech or music are replayed from a tape recorder and re-recorded with miniaturised transducers. Then the signal processed in this way is presented to the listener through earphones. Of course, this process requires a two-fold frequency transformation since in the model not only the geometrical dimensions, but also the wavelengths of all spectral components must be reduced by the scaling factor, compared with the normal audio frequency range.

Although model techniques have reached a high degree of perfection today, for instance by the work of J Blauert and his co-workers in Bochum [2], or of R Orlowski in Salford [3], this procedure is still plagued with several difficulties. Maybe the most severe of them is the necessity of achieving high fidelity sound reproduction in the ultrasonic frequency range, and to model correctly the absorptive properties of the boundaries and of the air. Therefore it seems more promising to replace the physical scale model in Fig. 1 with a kind of digital filter, the characteristic parameters of which are obtained by computer simulation of the hall. In this case no frequency transformations are needed, of course. The geometrical and acoustical data of the room are just entered into the computer from the input terminal, the absorption of the walls and of the medium can be taken from literature data. Before discussing the process of auralisation, I shall give you a short description of the current methods of sound field simulation in concert and other halls.

Ray Tracing

Probably the first authors who applied digital simulation of sound fields to concert hall acoustics were Krokstad, Strom and Sorsdal [4]. The method they developed is known today as ray tracing. Like all geometrical methods it neglects phase differences between different components of the sound field, therefore neither interference nor diffraction effects can be accounted for. This is probably justified for large halls and for sound signals with a wide frequency bandwidth.

The principle of digital ray tracing is outlined in Fig. 2: A sound source at a given position is imagined to release a number of sound particles into all directions at time t = 0.

Alternatively, we could prescribe a desired directivity to our source. Each sound particle travels along a straight path until it hits a wall which is assumed to be planar. At the intersection point the particle will be reflected, either specularly or diffusely. In the first case, its new direction is calculated from the law of geometrical reflection; if diffuse reflection is assumed to occur, the new direction is calculated from two random numbers distributed in such a way that on the average Lambert's law of diffuse reflection is fulfilled. After its reflection, the particle con-

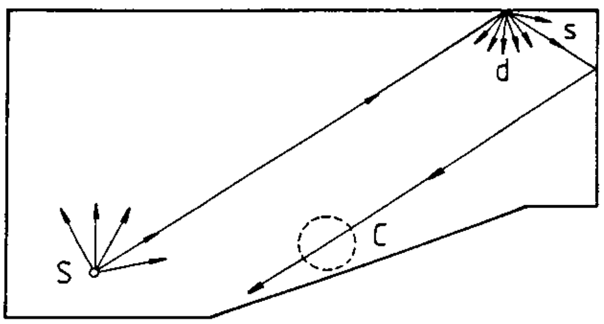

Fig. 2. Principle of ray tracing

tinues its way in the new direction towards the next wall etc. Basically, the absorption of the wall can be accounted for in two ways: either by reducing the energy of the particle according to the absorption coefficient, or by interpreting the absorption coefficient as an 'absorption probability', ie by generating another random number which decides whether the particle will proceed or whether it has been absorbed. In a similar way, the effect of air attenuation can be taken into account. As soon as the energy of the particle has dropped below a prescribed value or the particle has been absorbed, the path of the next particle will be 'traced'. This procedure is repeated until all the particles emitted by the sound source at t = 0 have been followed up.

The results are collected by means of 'counters' ie by counting areas or counting volumes assigned previously. Whenever a particle crosses such counter its energy and arrival time is stored, if desired also the direction from which it arrived. After the process has been finished, ie after the last particle has been followed up, the energies of all particles received in a certain counter within prescribed time intervals are added, the result is a histogram (see Fig. 3) which can be considered as a short-time averaged energetic impulse response. The width of the time intervals determines the achieved resolution; however, if it is too small, the result is degraded by statistical fluctuations unless the number of particles and hence the computation time is not increased.

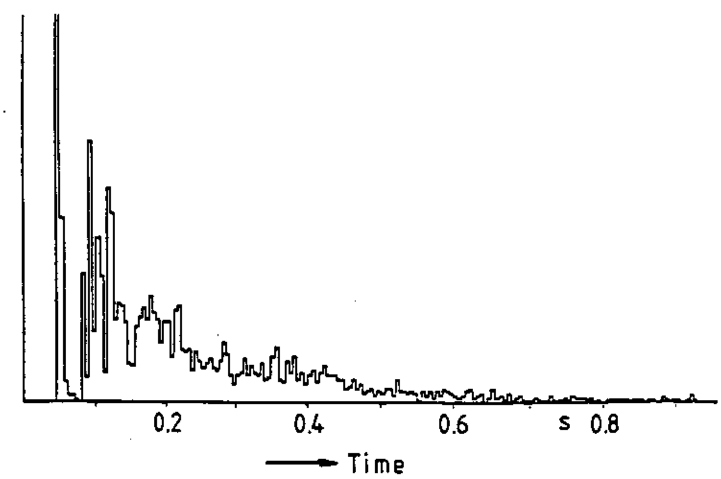

Fig. 3. Histogram obtained by ray tracing.

From the energetic impulse response obtained in this way the usual parameters can be evaluated, which gives at least some indication of whether the sound will be loud enough, for instance, whether music will sound distinct or even dry, or brilliant, full and warm; whether the reverberance of the hall will be sufficient or not and so on. If we evaluate not only the time at which particles are received but also the directions from which they arrive we can predict whether the listener will feel 'enveloped' by the sound field or, on the contrary, he will hear the music strictly from ahead. So this method is quite useful for collecting important objective data on the sound field in the room which are more or less related to subjective impressions. But are its results also suitable for 'auralisation' ie for directly listening to music processed in such a way as if it were transmitted in the hall? At first glance, this is at least doubtful. Therefore we turn to a different method of sound field simulation, based on image sources.

Image Source Model

The image source concept is quite old in room acoustics. It is based on the simple idea that a sound ray which is reflected from a plane wall can be thought of as having been emitted by an image source which can be constructed by mirroring the original sound source with regard to the reflecting wall. Successive reflections from the walls of an enclosure can be accounted for by higher order image sources, which are obtained by constructing mirror images from earlier image sources. Of course, this process of constructing image sources of higher and higher order never ends, resulting in an infinite pattern of image sources. Once this pattern is known, or at least its most significant part, we can forget the enclosure, since we just have to add the energy contributions of these image sources.

However, this method of image source construction requires impractically long computing times. One reason for it is the tremendous number of image sources needed which can easily amount to say 10^9 for realistic conditions. But even worse, only a small fraction of these image sources do really contribute to the sound energy received in one particular point, because most of them turn out to be 'invisible' from that point due to the finite dimensions of the wall planes. So, for each receiver or listener position the visibility of all image sources has to be checked anew and it is this check which requires particularly long computation time.

Fortunately, Vian and van Maercke [5], and independently Vorlander [6] have found a way to determine the locations of just the valid image sources leaving apart the invalid ones. This is achieved by an abbreviated ray tracing process which preceeds the actual simulation: whenever a sound particle released from the original sound source arrives at a counter, it must have passed a certain sequence of image sources, which can be determined by backward tracing its fate. After running the ray tracing for a certain while one can be sure that all significant image sources have been found, including the walls which are involved in their formation, and no visibility check is needed, because all these images are visible.

The result of this procedure is the correct energetic impulse response of the transmission path connecting the sound source with the considered receiving point, in contrast to the crude approximation to it obtained with the ray tracing techniques. An example of such a 'reflectogram' is presented in Fig. 4.

Each vertical line marks the correct moment of its arrival, and its length is proportional to its strength. And we know as well the directions from which each reflection arrives at the observation point. Therefore all nu-

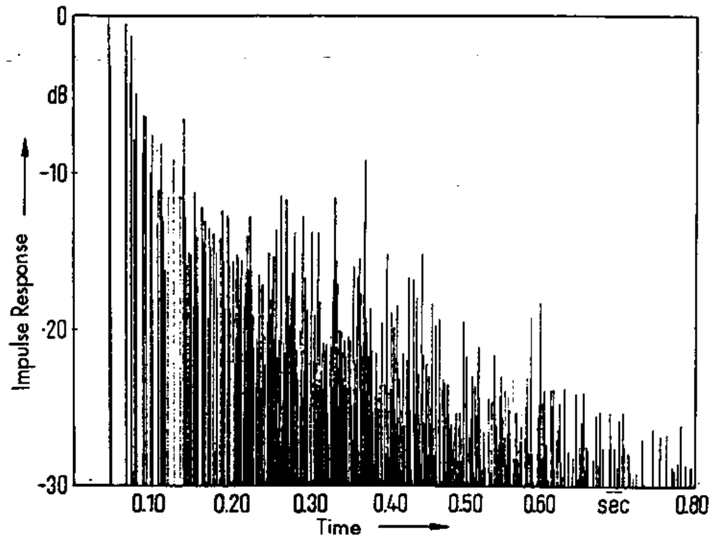

Fig. 4. Energy impulse response (reflectogram) obtained with the image source model.

merical parameters needed for assessing the acoustical quality of the room can be evaluated from the result.

However, to use it for the auralisation of the sound transmission, two things are still missing. The first one is that a reflectogram of this kind does not contain the frequency dependence of the wall and air absorption. Thus we still have to include this important fact in some way. The second is that we usually listen with two ears when attending a concert or opera performance. Therefore we need at least two impulse responses, namely one for each ear, and each of them must account for the sound diffraction around the human head which depends not only on the frequency but also of the direction from which the reflected sound portions hit the head.

Binaural Simulation

If the sound reflective properties of a wall depend on the frequency, as they usually do, the wall's response to an incident Dirac impulse is not just another Dirac impulse, but a more complicated time function which could be named 'reflection response'. It can be calculated from the complex wall impedance (provided it is known). Then, the contribution of one particular image source to the impulse response is obtained by convolving the properly delayed Dirac function with the reflection responses of all walls which are involved in the corresponding ray path. This is the correct method of accounting for the frequency dependence of the wall properties and is being employed by a French group, namely Martin and Vian [7]. Of course it is very expensive in computing time.

A simpler way is to compute the impulse response of a particular transmission path several times, each time with a different set of absorption coefficients and with each of them corresponding to another octave band. The obtained result is passed through the proper octave filter, ie convolved with its impulse response, and finally all output of the octave filters are added to yield the total impulse response [8]. Fig. 5 shows an example which looks quite realistic.

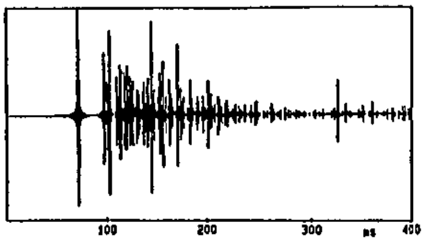

Fig. 5. Reflectogram including frequency dependence of acoustical data.

In order to make it also sound realistic, the impulse response has to be modified in such a way that it conveys the spaciousness of the real sound to the listener, and this requires binaural presentation of the processed sound signals: when we listen to a sound source in the free field, the sounds arriving at both ears of a listener are modified by the head in a way depending on the direction of sound incidence. This modification can be described by the 'outer ear transfer function' or by the Fourier transform of it, the 'outer ear impulse response' $h_r(.,.,t)$ and $h_l(.,.,t)$ - with the subscripts referring to the right and the left ear. To include this modification into our simulation, each component of the room impulse response, ie each of the reflections of which it is made up, must be convolved with the proper ear response. The final result are two impulse responses, one for the right and one for the left ear. They represent the characteristics of the filters we need for the process of auralisation, and they enable us to process 'dry', ie unreverberated music signals in the same way as the concert hall would process them, and to present the result to a listener, by earphones, who now can enjoy the acoustics of a non-existing concert hall in our laboratory. The subjective impression created in this way is surprisingly good [9], particularly if different halls are successively compared in this way. Further improvement can be achieved by replacing the earphones with loudspeakers, which can be done by employing the free field cancellation techniques firstly described by Atal and Schroeder [10]. So far, however, it is not possible to perform all these complicated operations in real time; instead, music samples of finite duration must be prepared.

It should be mentioned, that the outer ear transfer functions show considerable individual differences, and that a perfect satisfactory impression cannot be achieved without taking due account of individual variations. Therefore, strictly speaking, each listener must have measured his personal ear transfer function which is then combined with the impulse response of the hall. The application of maximum length signals in combination with the fast Hadamard transformation permits relatively fast measurement of such transfer functions [11]. It is possible, however, that even this step can be omitted by storing a number of standardised ear transmission functions.

For real time operation, the whole process of auralisation should be simplified. This seems to be possible, since an impulse response as shown in Fig. 4 contains more information than is needed. There are physical reasons for this as well as psychoacoustic ones. Firstly, the components of real impulse responses are certainly not so distinct as shown in Fig. 4; they are blurred by diffuse reflections which are not accounted for by the image model, but which are present in every real hall. Diffraction has a similar effect. Concerning the directional structure of the impulse response, we can benefit from the randomising effect of each real enclosure which makes the reverberant part of the impulse response diffuse; in fact, after the first 150 to 200 ms, the sound field turns out to be diffuse. Hence, it is only the first portion of an impulse response which contains significant directional information, and only this part must be modelled correctly. But even more important are the limited time and directional resolutions of our hearing. It follows that we need not use every detail of the physical impulse response for creating a true and natural sounding listening impression. In fact, it seems that the information contained in a ray tracing histogram as shown in Fig. 3 is sufficient to derive a digital filter from it which can be used for the aural presentation of music.

At any rate, by digital simulation of sound transmission in rooms and by the auralisation of the results, an old dream of acousticians is going to come true. This method will be extremely helpful for the practical design of halls of any kind. Furthermore, it is a valuable tool for more fundamental investigations, for instance in respect of optimum reverberation times, spatial impresssion, optimum ceiling heights, favourable or less favourable room shapes, the arrangement of audience seats and many other interesting questions.

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This article is based upon a paper given in the R W B Stephens Session at the 1991 Institute Spring Conference. Professor Kuttruff is in the Institute of Technical Acoustics, at Aachen University of Technology. ❖

THE USE OF DSP FOR ADAPTIVE NOISE CANCELLATION FOR ROAD VEHICLES

D C Perry, I M Stothers, S J Elliott and P A Nelson

Introduction

The trend for more fuel efficient vehicles, with lighter bodies and smaller engines, is tending to increase low frequency internal noise. This conflicts with the requirements of consumers, who are becoming more critical of high internal noise levels. This low frequency noise has two major contributions, firstly from the firing frequency of the engine (particularly on 4 cylinder vehicles), and secondly from the tyres being driven along the road.

Control of such low frequency noise sources using conventional passive methods would require the addition of considerable weight in the form of either damping materials or body stiffening, thereby negating any weight saving. Adaptive noise cancellation is most suitable at low frequencies due to practical considerations such as the number and location of sensing devices (microphones) and secondary sources (loudspeakers). These factors limit the upper frequency range of global cancellation in vehicles to typically 200 Hz. Above this frequency only limited 'zones of quiet' can be created around the sensing microphones [1].

The control problem which needs addressing is how to independently adjust the input signals to all the secondary sources to minimise the internal noise levels. This problem must be tackled differently for the engine noise and road noise situations. This is primarily because engine noise is essentially deterministic whilst road noise is essentially random. The required speed of adaption must also be considered separately since engine noise changes rapidly (e.g. during gear changes) whilst road noise changes are considerably slower (e.g. changing road surface). Low cost single chip Digital Signal Processor (DSP) devices have made the implementation of these differing forms of multiple channel adaptive cancellation systems an economic reality for road vehicles.

Requirements of Vehicle Noise Cancellation Systems

Several important requirements must be met for any adaptive noise cancellation system intended for use in road vehicles to ensure that its inclusion is both unobtrusive and without unacceptable side effects.Since the majority of road vehicle manufacturers are very concerned with costs, the number of microphones and loudspeakers must be the minimum necessary to provide satisfactory system performance. The positioning and size of the loudspeakers is also constrained to those which are ergonomically acceptable to the interior styling of the vehicle. It is important that the benefits of fitting a noise cancellation system are noticeable in seating positions, and that no adverse effects occur to speech or music from the occupants or the In-Car Entertainment system.

Engine Noise Systems

Cancellation of engine noise requires adjustment of the amplitudes and phases of a set of harmonic reference signals, synchronised to the engine firing frequency, and feeding these signals to the secondary loudspeakers. These reference signals can be generated by measuring the engine speed using a tachometer signal from either the ignition or engine management systems. Under steady state conditions these amplitudes and phases could be taken from a look-up table, unfortunately steady state conditions rarely exist in a road vehicle, thus an adaptive system is essential. The algorithm used to adjust the coefficients of this array of adaptive digital filters is based upon the well-known LMS algorithm [2], which has been adapted to cope with minimising the sum of the squares of many error signals. An important feature of this system is its speed of adaption to sudden changes; this has been shown to occur in less than 100 ms.

Road Noise Systems

Cancellation of road noise within a vehicle is a more complex situation for two reasons, firstly the road noise is largely random in nature, and secondly there is not a single source for such noise, so multiple reference signals must be used. In practice suitable reference signals can be found by measuring the vibration of either the wheel hub or the body. However, the number of reference signals required, and the optimum transducer positions, varies greatly from one vehicle to another.

By contrast with the engine noise cancellation system the reference signals require much more complex filtering before being fed to the loudspeakers. This requires either increased processing power, or a slower coefficient update rate. As has already been discussed, the rate of change of road noise is much slower, so the slower adaption rate is an acceptable solution.

Practical Adaptive Noise Cancellation Systems

Engine Noise Systems

A system for cancellation of engine noise in road vehicles is shown in Fig. 1. This system feeds six loudspeakers with signals synchronised to the engine speed signal which have been adaptively filtered according to the feedback signals from the eight microphones. The loudspeakers are positioned to provide good acoustic coupling, thereby allowing the use of low powers and speakers with a diameter as small as 4.5 inches can achieve good results at frequencies as low as 30 Hz. The low power requirement for cancellation (typically less than 1 watt total for all loudspeakers) allows the loudspeakers and amplifiers to be shared with the ICE system.

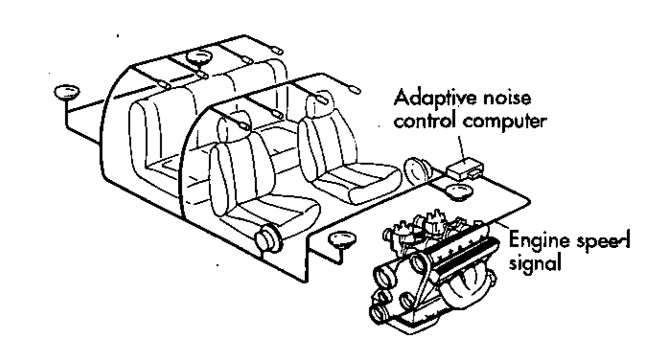


Fig. 1. A 6 loudspeaker, 8 microphone adaptive cancellation system for reducing low frequency engine noise.

The microphones used are small low-cost electret devices, which can conveniently be positioned in the roof lining.

Such systems have been used in over 40 different vehicles, ranging from small sports cars to large vans, over a period of four years. The results of fitting this system in a small car fitted with a 1.1 litre, 4 cylinder engine are shown in Fig. 2. The A-weighted sound pressure level, at engine firing frequency, is shown at the four seat positions in the car. Substantial reductions of 10-15 dB are achieved in the front seat positions above 3000 rpm, whilst in the rear seats significant reductions are also achieved between 2000-3000 rpm (this corresponds to the first longitudinal standing wave in the vehicle interior). The processing required in such a system consists of an array of 6 x 8 adaptive filters each having two coefficients, giving a total of 96 coefficients to be adaptively updated each cycle. These requirements are ideally suited to currently available single chip DSP devices such as the TMS320C25, and leave a significant proportion of the processing power available for other uses. Although this device has been used in all the current implementations of the system, the processing needs of the algorithm used could be achieved using other commercially available devices.

Road Noise Systems

A schematic diagram of a system for cancellation of road noise in vehicles is shown in Fig. 3. This system feeds the loudspeakers with signals derived from the reference accelerometers which have been adaptively filtered according to the error signals from the microphones. The same types of loudspeakers and microphones as the engine noise system are used, and the loudspeakers are also shared with the ICE system.

The results of fitting such an adaptive road noise cancellation system to a large saloon are shown in Fig. 4. The reduction in coherence between the reference accelerometers and the interior noise level can be clearly seen, along with the accompanying reduction in interior noise level. The processing required in such a road noise cancellation system consists of an array of up to 6 x 4 adaptive filters each having perhaps 60 coefficients, giving a maximum of 1440 coefficients to be adaptively updated. These requirements are much more severe than the engine noise cancellation system, but are still achievable using the same devices.

Vehicle Adaptive Vibration Cancellation Systems

Vehicles not only suffer from noise problems which are engine related, but also exhibit engine speed related vibration problems. This vibration is also caused by the out of balance forces created in the engine, and is particularly noticeable on 4 cylinder vehicles.

By replacing the conventional rubber engine mounts with a recently developed active engine mount this vibration can be cancelled using the same controller. An adaptive vibration cancellation system is shown in Fig. 5. This

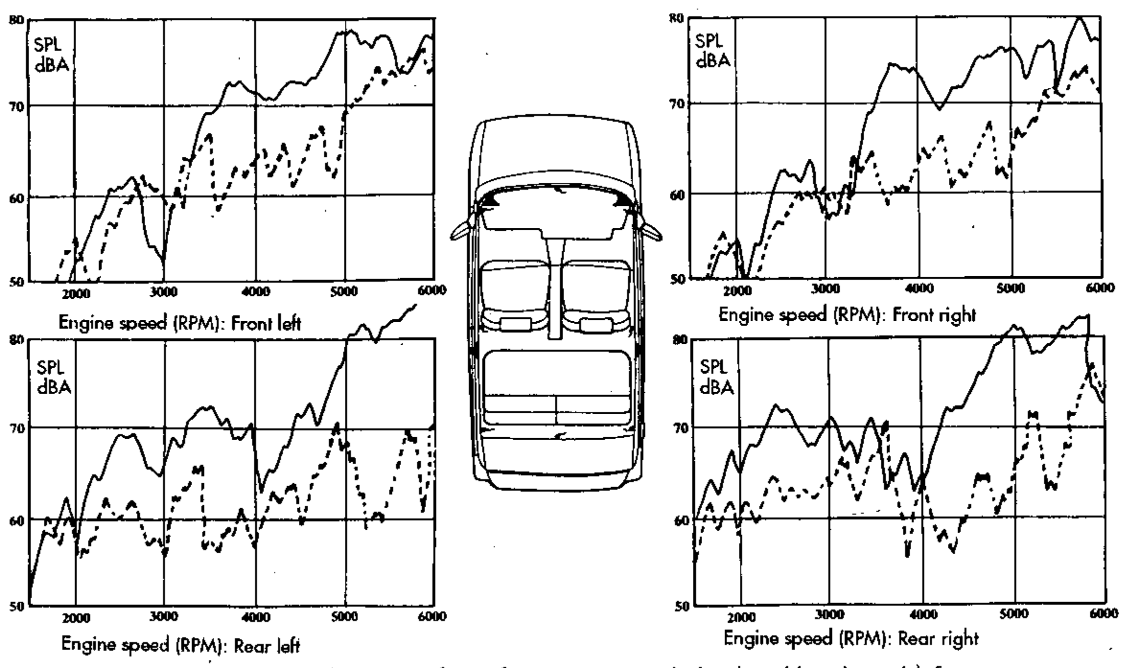


Fig. 2. A-weighted ~~sound~~ pressure level at the engine firing frequency recorded at head height in the four seat positions of a small, lightweight car. The result of using a 4 loudspeaker, 8 microphone adaptive engine noise cancellation system is also shown (----)

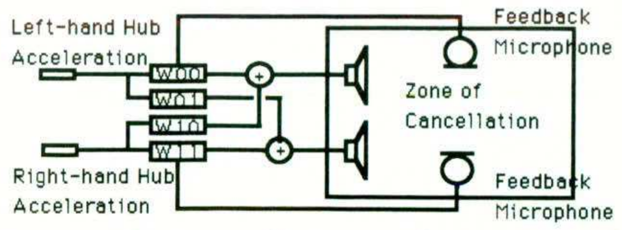


Fig. 3. An adaptive cancellation system for the reduction of low frequency road noise

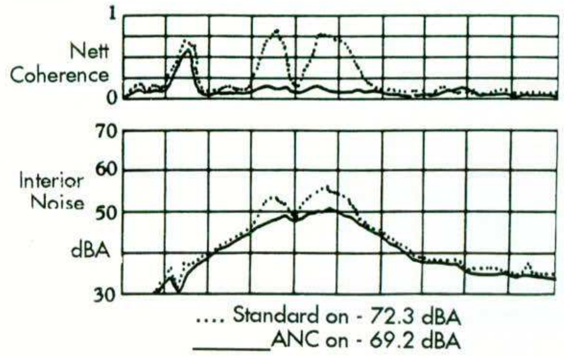


Fig. 4. Coherence between body mounted accelerometers and LA in a large saloon car. (—) is with a 2 accelerometer, 2 loudspeaker adaptive road noise cancellation system.

system feeds the cancellation signals to the three engine mounts, and also to loudspeakers mounted inside the vehicle. The error signals needed to control the adaptive filters are taken from two types of sensor; microphones within the vehicle to sense the noise levels and accelerometers fitted on the active engine mounts to sense the vibration fed through into the vehicle body.

Employing the same modified LMS algorithm gives significant reduction in both the noise and vibration levels perceived by the vehicle occupants. The interior noise is further cancelled by the addition of the vibration cancellation due to the reduction of forced vibrations in the vehicle body. The results of fitting an integrated adaptive noise and vibration system to a family hatchback are shown in Fig. 6. This adaptive vibration control system employs exactly the same controller as the noise cancellation system, so all the factors with regard to processing requirements and DSP device choice are identical.

Future Trends

Development versions of the adaptive noise controllers use readily available components and employ ADC and DAC converters of unnecessary resolution, but by making careful trade-offs between hardware complexity and software processing time it is possible to greatly reduce the component count and costs. By making use of ASIC devices the controller can be reduced to only 4 IC's (DSP, memories and ASIC).

Due to the great degree of commonality between the engine noise cancellation, road noise cancellation and engine vibration cancellation systems it is possible to design a single controller for all these functions. Unfortunately, using DSP devices available today the cost is prohibitive for the automotive industry, but past history of semiconductor device pricing suggests this situation will soon change. Such an integrated adaptive controller will have far reaching consequences for the noise and refinement of future generations of road vehicles. There is also an increasing trend to fully digital ICE systems employing the same type of general purpose DSP devices. Integrating adaptive noise and vibration control into such ICE systems could be as little as extra software!

The previous discussion has concentrated purely on road vehicle applications of adaptive noise and vibration cancellation, but it should be realised that these techniques can be applied to any environment having defined boundaries and experiencing excessive low frequency noise and vibration levels. Typical applications would be engine test cells, recording studios and accommodation areas on oil production rigs.

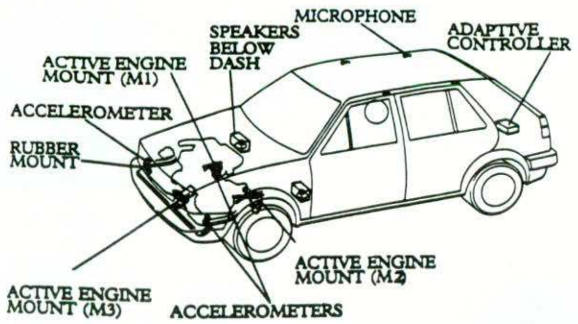


Fig. 5. 3 engine mount, 2 loudspeaker adaptive cancellation system for reducing low frequency engine noise and vibration in road vehicles.

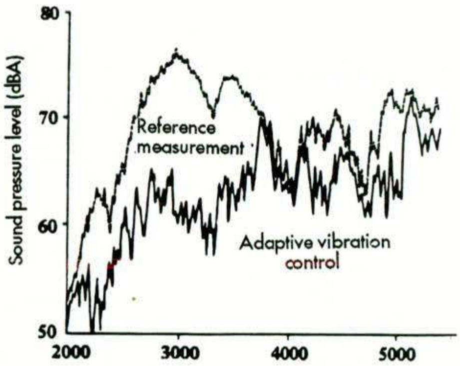


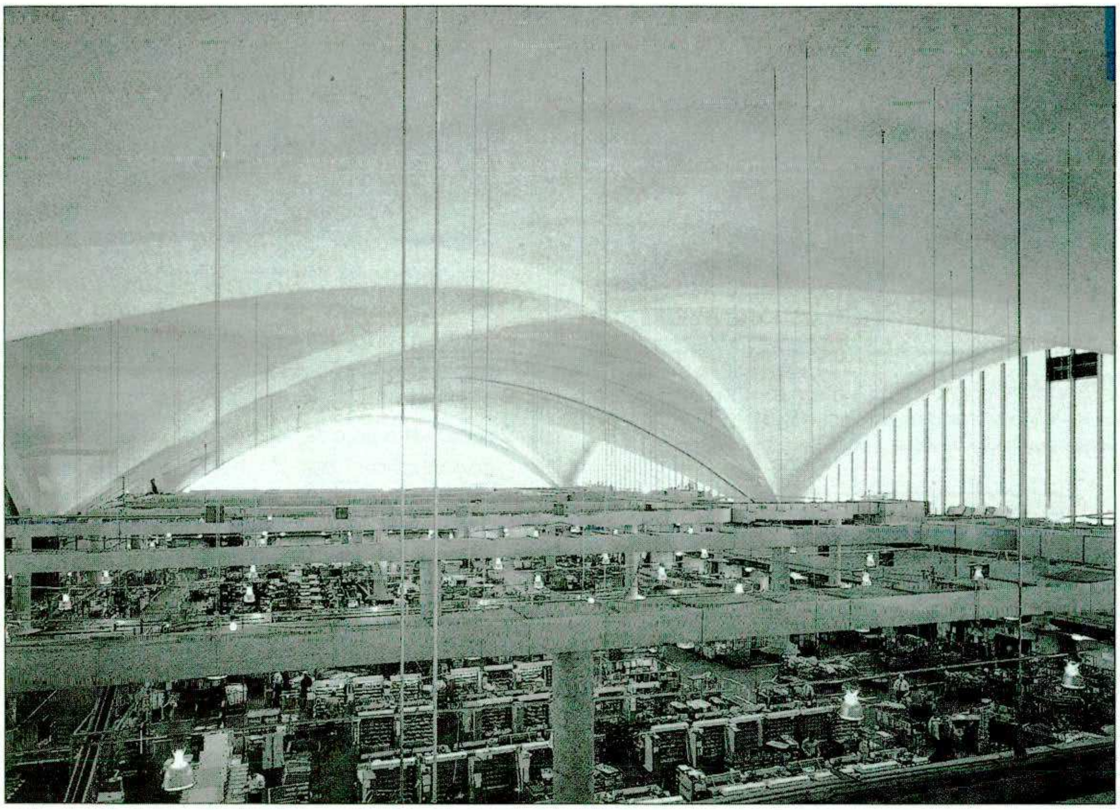
Fig. 6. LA at the engine firing frequency in a family hatchback. (—) is with an integrated adaptive engine noise and vibration cancellation system.

References

[1] S J ELLIOTT et al 'Active cancellation at a point in a pure tone diffuse sound field', J Sound Vib. 120 pp183-189 (1988)

[2] B WIDROW and S D STEARNS 'Adaptive Signal Processing', Prentice Hall (1985)

D C Perry and I M Stothers are at Lotus Engineering. S J Elliott MIOA and P A Nelson MIOA are at ISVR. **Permission is gratefully acknowledged to reprint from Digital Signal Processing: Application Opportunities - Conference Proceedings, London, 17/18 October 1990. ERA Report 90-0471, Leatherhead.** ❖



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NASA Research Centre
Beausejour Sports Complex, Guernsey
Peterborough Regional College
Charles de Gaulle Airport, Paris
London Borough of Hackney
Shell Oil Company, New Orleans
Devon & Cornwall Fire Service
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ELECTROMAGNETIC COMPATIBILITY

John M Bowsher FIOA

What is an article about electromagnetic phenomena doing in Acoustics Bulletin? The answer is that all of us use electrical and electronic devices at home and in our work and the new European Community Directive [1] will affect these devices and the way we use them. At present it is due to come into effect on 1 January 1992, but the relevant UK legislation is not yet out for public comment.

The Directive is extraordinarily wide in its coverage: all environments fall within its sphere; the frequency range is from zero to infinity; both emission and immunity are included. As might be expected, it is not easy for a scientist to read: three of the first four paragraphs begin with 'having', the next thirteen begin with 'whereas'. One feels battered before reaching Article 1. Directives refer to harmonised standards for technical details of their implementation and it is important to remember that, unlike National (e.g. BS) or International (e.g. IEC) standards, European harmonised standards (EN) have the force of law and must be obeyed by manufacturer, agent or user.

We begin with a few definitions; these are taken from the new draft IEC 1000 [2] which will almost certainly be implemented as an EN shortly. As usual in standards work, this document itself refers to other standards before it can be understood. This is why people working on standards may easily be recognised in the crowds around the Park Lane area of London: they are the ones looking harrowed, talking about EAM (the European Acronym Mountain) and carrying enormous brief cases.

Electromagnetic compatability (EMC) is '*the ability of a device, equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in the environment*'. The environment is '*the totality of electromagnetic phenomena existing at a given location*'; disturbance is '*any electromagnetic phenomenon which might degrade the performance of a device, equipment or system, or adversely affect living or inert matter*'. Immunity is '*the ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance*'.

Because of limitations on space, here we shall only consider disturbance and leave immunity for another time; it applies to living organisms as well as to devices. Can portable telephones degrade the performance of the brain? The newer cell-phones radiate just under 1GHz 20 W pulses about 3 or 4 cm from the brain; we don't know yet whether they degrade performance, but once the Directive is in place, legal liabilities may exist.

Any electromagnetic phenomenon is specifically included; there are so many possible forms that a Table is probably the clearest way of indicating the broad areas:

Conducted low-frequency phenomena
Harmonics, Interharmonics
Signalling voltages
Voltage fluctuations
Voltage dips and interruptions
Power frequency variations
Induced low-frequency voltages
DC in AC networks
Radiated low-frequency phenomena
Magnetic fields
Electric fields
Conducted high-frequency phenomena
Induced CW voltages or currents
Unidirectional transients
Oscillatory transients
Radiated high-frequency phenomena
Magnetic fields
Electric fields
Electromagnetic fields
Continuous waves
Transients
Electrostatic discharge phenomena

Table 1 Principal phenomena causing em disturbances

'Conducted low-frequency phenomena' means signals coming along the power line (AC or DC) or along signal and control lines. The limits imposed on the amount of harmonic energy your device can impose upon the mains power are very severe - at present, unless plans to modify the standard [3] (which is to be extended to cover all electronic equipment) are successful, it rather looks that most analogue power supplies will not be allowed because they generate too much harmonic current. Power voltage dips (∂V ranging from 10% to 99% of V_n) and interruptions (∂V = 100% of V_n) may cause some devices problems, especially when we realise that an interruption has to last more than one minute before it is no longer considered an EMC problem. (This may be the definition of the effective low frequency end of the Directive, ≈17 mHz.)

A Panel under the Chairmanship of John Woodgate, on which I sit, is meeting at the BSI with the brief of drawing up proposals for new standards to cover emission and immunity requirements for apparatus used in the professional audio, video and lighting control industries. Our aim is to prepare a proposal for CENELEC (the European standardisation organisation for electrical and electronic phenomena) which would more fairly control the industry and users than would the application of the generic standards already in existence. Our work is extremely far-ranging, some of us are looking at the conducted problem just mentioned; some are considering magnetic field radiation (both mains and AF); some are considering EM radiation of sytems of modular apparatus; still others are looking at the effects of 8 kV sparks applied to casings or leads. I am looking at radiated phenomena in the 300 THz region (infra-red to most of us), as this radiation is used both to control apparatus and also to convey audio signals in conference rooms and theatres. Most problems here come from high frequency ballast fluorescent lamps which radiate a strong infra-red spectrum consisting of lines drifting markedly in response to their rather unstable oscillators and spaced by about 20 to 50 kHz. They effectively block nearly all infra-red transmissions.

One potentially useful product of the Panel is a definition which, if accepted, will enable apparatus handling digital audio and video signals to be tested according to different criteria from Information Technology (IT) apparatus. The IT methods of test may be acceptable for computers and telephone exchanges, but do not suit most audio and video equipment. Our definition of digital apparatus is 'apparatus designed for the purpose of controlling audio, video or lighting characteristics, by means of periodic pulsed electrical waveforms, or of processing audio or video signals in digital form'. The Panel hopes that all using such equipment will benefit from the increased freedom this new definition should impart.

There is an analogy in acoustics to some of this: European Community Directive 89/392/EEC - the 'Machinery Safety Directive' - includes a section on airborne noise emissions which was worked on by CEN Committee TC211. There are standards in place (ISO 11200, 11201 and 11203) which will presumably have EN numbers in due course. This Directive is much more limited in scope than the EMC one, but some readers of Acoustics Bulletin will be aware of the forces behind a Directive.

This account does no more than touch upon one or two aspects of this most important piece of legislation which will profoundly affect all of us in the near future. I hope that this 'tasting' will have served to warn of its existence those who were unaware, and will remind the knowledgeable that there is no time to waste. Tests for your apparatus have to be devised and approved: circuits will probably have to be re-designed; better manufacturing methods capable of withstanding an onslaught by a customs official primed by a competitor must be in place; a new awareness of the global nature of electromagnetic compatibility must be built up within all of us.

Let me end with some good news: it seems very likely that efforts to obtain a derogation will be successful. Originally, the Directive was to come into effect on 1 January 1992, but there have been so many problems over obscurities in the text and lack of applicable standards that the European Commission has agreed to submit an Amending Directive [4] to the Council of Ministers with the effect of delaying implementation until 1 January 1996. The Commission has also produced a draft interpretative document [5] which clarifies many, though not all, of the problems.

The Reproduced Sound 7 Conference at Windermere (31 October to 3 November 1991) reflects the Institute's awareness of the importance of the EMC Directive. Discussions on EMC are to form a major part of the programme.

References

[1] Council Directive of 3 May 1989 (89/336/EEC) on the approximation of the laws of the Member States relating to electromagnetic compatibility. Official Journal of the European Communities No L 139, 23.5.89. pp 19 - 26

[2] Draft IEC 1000 - Electromagnetic compatibility (EMC) Part 2 - Environment. Section X - Classification of electromagnetic environments [77(Secretariat)108]

[3] EN 60555-2:1987 Disturbances in supply systems caused by household appliances and similar electrical equipment - Harmonics.

[4] Proposal for a Council Directive amending Council Directive 89/336/EEC, Com(91) 126 final-SYN 342, Brussels, 31 May 1991.

[5] The most convenient reference is probably: 'EMC Latest Developments', published by the DTI, August 1991.

John Bowsher FIOA was formerly in the Physics Department at the University of Surrey and is the Chief Examiner for the Institute's Diploma in Acoustics and Noise Control.

RAILWAY VIBRATION ISOLATION AT THE BIRMINGHAM INTERNATIONAL CONVENTION CENTRE

Richard Cowell FIOA

Introduction

The siting of the International Convention Centre in Birmingham brings sensitive auditoria close to British Rail's Monument Lane tunnel, which carries Intercity and local services between Birmingham New Street and the North West. Within the Arup Birmingham Office engineering commission for the project, Arup Acoustics became involved in surveys and study of the implications of railway vibration. An American firm, Artec, were already commissioned for the acoustic design, Arup Acoustics' work being restricted to support for Ove Arup and Partners in finalising engineering solutions for railway vibration isolation.

Some years before, the Birmingham Repertory Theatre (an earlier Arup structural project) had been built very close to the tunnel. Although limited measures were taken to attenuate structure-borne noise (in the construction of the auditorium envelope), the passage of trains is clearly audible as a low frequency 'rumble'. For the International Convention Centre, Artec were looking for very low background noise criteria, close to the hearing threshold. The first step was to evaluate whether the Concert Hall should be on the site at all. It is bounded by a major road (Broad Street) to the south and the Worcester and Birmingham Canal to the west, and is formed as fill over conventional Birmingham Rocksand. The railway tunnel is driven entirely within the rock and runs across the site as shown in Figs. 1 and 2.

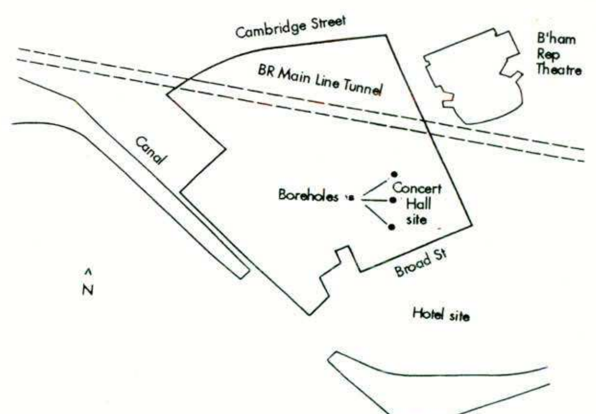


Fig. 1. Site plan showing tunnel line.

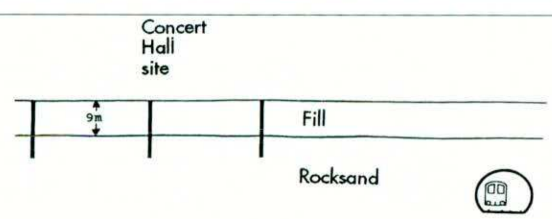


Fig. 2. Section showing boreholes.

A first survey concentrated on vibration velocity measurements on the surface within and close to the Bingley Hall (previously occupying the ICC site), in the Repertory Theatre, and in a number of buildings more remote from the tunnel. At the same time, sound pressure levels were measured in the internal spaces including inside the Birmingham Rep.

One particular feature from the first survey was the concentration of energy in the 63 Hz octave band. This arose because of the spectral emphasis within the train vibration and also because of relatively high radiation efficiency in this frequency at the survey locations. A sound pressure level of 70 dB was measured in the 63 Hz octave in the Birmingham Rep at representative seating positions, but with the theatre unoccupied. Propagation losses in the form of Rayleigh (surface) waves were generally consistent with expectations. Vibration velocity levels (vertical and horizontal) and sound pressure levels were measured around the site (see Fig. 1). Of course, corrections were applied to measured data to allow comparison with likely exposure for a new Concert Hall.

The survey established helpful reference data as a basis for further, more detailed, survey work. It had already become clear that without major vibration attenuation (e.g. at source), construction of the proposed Concert Hall on that site using conventional methods was not compatible with the very exacting target noise limits. Substantial attenuation at source by track isolation could not be expected although some might prove worthwhile if achieved at reasonable expense. Some form of building isolation was already envisaged if this siting were to be pursued.

A second survey was arranged to improve understanding of the specific pattern of vibration propagation from this tunnel. The approach to the further assessment was discussed with Professor Peter Grootenhuis of Imperial College, London, and Dr George Wilson, of the US acoustic consultants Wilson Ihrig of California, who was advising Artec. Arup Acoustics proposed and then developed a methodology for vibration measurements within boreholes. The low water table allowed scope for dropping accelerometers into them to sample ground response arising from compression and shear waves.

The tests were carried out in 250 mm diameter, 9 m deep boreholes at horizontal distances of 33 m, 50 m and 68 m from the tunnel. The vibration measurements were obtained using Bruel & Kjær 8306 and 4370 accelerometers mounted orthogonally in a steel cube by means of magnetic strips. The whole assembly was lowered into a borehole and firmly set in a bed of rapid setting grout to achieve good coupling between boreholes and accelerometers. Once the measurements had been obtained, the accelerometers were retrieved by breaking the magnetic bond.

Examples of vibration velocity from the three boreholes are shown in Fig. 3. Although horizontal vibration levels were significant, the vertical component was found to dominate. From analysis of the data it was agreed that use of 10 Hz isolation bearings (with extensive control over bridging via services, stiff air spaces or at access points) should allow sufficient attenuation to permit siting of the Concert Hall without unreasonable risk. Nevertheless, to achieve inaudibility of the railway, tolerances on estimates would need to be favourable and no certainty of inaudibility could be established. It was therefore agreed that Arup Acoustics would provide input to the design, directed at achieving highest practical standards of isolation. In view of very stringent Artec noise targets, the Concert Hall and seven of the other halls within the Convention Centre were to be isolated as separate constructions. Exhibition Halls sited over the tunnel, foyers and much of the supporting accommodation, were not to be floated, being less sensitive.

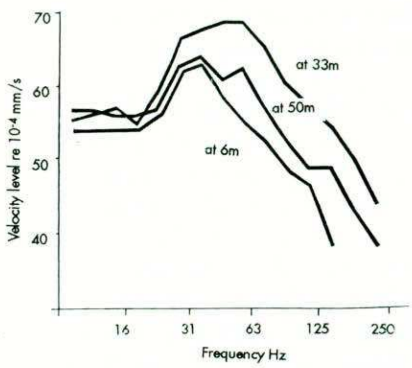


Fig. 3. Borehole vibration data.

Pile Design

At distances from the tunnel greater than 15 m, the vibration transmission was dominated by Rayleigh (surface) waves. It was essential for energy transmission to be limited by using piles bearing on the Rocksand (where mobility was approximately one third of that which would drive a raft at the surface). There was therefore advantage in using large diameter piles and decoupling the top of the piles from the surface waves. Six metres was determined as an appropriate depth for the decoupling. Many materials were considered as sleeves at the top of piles to provide a mismatch against vibration coupling. To achieve the benefit (a few decibels only, but for this project every one counted), sleeving material needed to be highly compliant. It was eventually decided to use a void around the top of the pile. By using a second steel tubular outer case welded to the pile case 6 m below intended ground level a voided pile detail was achieved (see Fig. 4). Close to the railway, piles could not be justified because compression and shear waves dominated the transmission into piles.

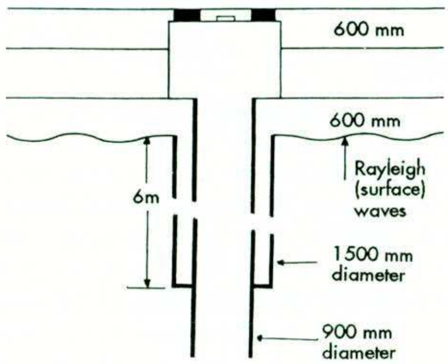


Fig. 4. Pile design (section).

Pile Caps and Tie Beams

A second major influence on the design has been a tight control on the geometry of air spaces surrounding floated structures. In the past, the stiffness of large expanses of shallow air space has lifted the isolation frequency, or the build-up of resonances in the voids has aided transmission sufficiently to have adverse effects on isolation (previous Arup experience of building isolation and research work on isolated studio construction for the unbuilt BBC Langham Project proved useful). A 600 mm airspace has been provided between elements of substantial surface area facing each other across the isolation gap. Pilecaps are tied together by beams which are kept 600 mm above the new ground slab and are also 600 mm below the soffit of the floated structure. The undercroft space allows excellent access to bearings and the complex geometry prevents powerful resonances occurring. The area of pile caps was also limited (i) to avoid excessive local coupling through air across the bearing arrays and (ii) to allow good access to bearings (see Fig. 5).

Bearings

The main support bearings are steel plate-reinforced, natural rubber-based compounds manufactured and sup-


Fig. 5. Undercroft showing the beams.

SECRETARIAT NOTE

This issue of the blue pages carries two meeting notices. The first on 10 October is an event supported by the HSE and has attracted a number of notable speakers including Campbell Christie who is the General Scretary of the Scottish Trades Union Congress. Although the meeting is primarily targeted at senior executives and policy makers in industry north of the border, similar personnel, and of course our members, from the rest of the UK would be equally welcome.

This issue of the Bulletin carries an article by Richard Cowell of Arup Acoustics on railway vibration isolation at the Birmingham International Convention Centre under the general heading of Consultancy Spotlight. This new section offers an opportunity to any member who is either a consultant or a member of a consultancy partnership to submit an account of an individual project or an element of a project in sufficient technical detail, within the constraints of commercial confidentiality, to be of value and interest to other members.

In the same mailing as this Bulletin are included the notices for the two November Windermere Conferences. I hope you will agree the programmes are exceptionally interesting this year and that you are able to come along for what has proved over the years to be an acceptable mixture of work and relaxation. The programme for the Autumn Conference in particular highlights the very high level of activity in terms of reports and legislation that is happening in the UK and Europe in the general areas of industrial and environmental noise.

The results of the 1991 Diploma examinations were to have been published in this Bulletin. However there is an issue that has not yet been completely resolved concerning the standard at which Merit grades will be awarded for the diploma project. Accordingly the publication of the results has been left until the next issue.

May I again ask members who attend non-IOA Conferences to send the Bulletin Editor a report on the proceedings, including attendance statistics where possible.

Cathy Mackenzie

INSTITUTE MEETINGS

October 16
Eastern Branch Meeting
'Speech Technology', Prof M Tatham. Essex University.

October 16
London Branch AGM, 'Mitchell Report', Prof H G Leventhall.

October 16
Joint IOA/IOP meeting. 'Unsteady Combustion and Combustion/Acoustic Interaction'. University of Hull.

October 21
IOA Formal Meeting. 'Railway Noise and Vibration'. English Speaking Union, London.

October 31 - November 3
REPRODUCED SOUND 7
Hydro Hotel, Windermere

November 1
Speech Group meeting. 'Speech Processing by Neural Networks', BT Labs, Martlesham Heath.

November 13
Eastern Branch Meeting and AGM. Salex Group Headquarters, Colchester.

November 13
London Branch Dinner. The National Theatre.

November 21 - 24
AUTUMN CONFERENCE, NOISE IN THE NINETIES - A QUIETER BRITAIN?
Hydro Hotel, Windermere

December 16 - 18
Underwater Group Conference. 'Sonar Signal Procssing'. University of Loughborough.

1992
September 14 - 18
International Conference
EURONOISE 92
Imperial College London

REQUESTS

BSTC GME/21/3/2 - VIBRATION OF STRUCTURES

I represent the Institute on the above committee and we shall shortly be considering the drafting of Part 2 of BS7385: Vibration in Buildings - Guide to Levels of Concern. In order that the guidance is based on the best available database we are seeking to obtain documentary evidence of measured vibration levels from such sources as blasting, demolition, piling, road and rail transport and their effect on structures. Of particular interest would be any cases where measured vibration levels have been correlated with structural or architectural damage and details of building type and condition, ground conditions, etc.

I have offered to collate any data sent in by Institute members and pass this on to those concerned with the detailed drafting of the standard. Please send any contributions to me at the address below:

Chris Manning, Arup Acoustics, Parkin House, 8 St ThomasStreet, Winchester, Hampshire SO23 9HE

Consultation on Environmental Policy for the Building Services Industry

The Building Services Research and Information Association (BSRIA) has obtained DoE funding for a research project to develop a draft environmental code of practice for the industry.

BSRIA aims to improve the availability of information on such issues as selection of materials, health impacts, opportunities for recycling and life-cycle costs.

The project will establish an information database, review practical experience and oommercial opportunities and draw up a draft code of practice.

BSRIA are inviting comments from interested parties, especially organisations who have already developed environmental policies, or have experience of policy implementation and policing.

The Association's address is BSRIA, Old Bracknell Lane West, Bracknell, Berks., RG12 4AH.

MEETING NOTICE

RAILWAY NOISE AND VIBRATION

21 October 1991

English Speaking Union, Dartmouth House, London

09.45 Registration & coffee

10.30 PREDICTION AND ASSESSMENT OF GROUNDBORNE NOISE FROM UNDERGROUND RAILWAYS
J G Walker (1) & S A Ridler (2), (1) ISVR, Southampton, (2) Arup Acoustics

11.00 DEVELOPMENT OF A NOISE SPECIFICATION FOR DIESEL LOCOMOTIVES
A E J Hardy, British Railways Board

11.30 NOISE AND VIBRATION FROM LUDGATE RAILWAY WORKS
C J Manning, Arup Acoustics

12.00 COMMUNITY RESPONSE TO NOISE FROM THE DOCKLANDS LIGHT RAILWAY
B Shields, L Matthews & A Zhukov, South Bank Polytechnic

12.30 lunch

14.00 RAILWAY NOISE - CALCULATION AND MEASUREMENT
G Rock, Somerset Scientific Services

14.30 VIBRATIONS AND NOISE FROM TRAINS IN TUNNELS
R Hood & R Greer, Ashdown Environmental

15.00 tea

15.30 A STUDY OF RAIL NOISE AFFECTING NEARBY RESIDENCES
R Heng, Sheffield City Polytechnic

16.00 PLANNING AND DESIGN OF NEW RAILWAYS - NOISE AND VIBRATION CONTROL
R M Taylor, Consultant

RAILWAY NOISE AND VIBRATION
Please register me as a delegate
Name:

Organisation:

Address:

Tel no. for contact

Cheque enclosed for ☐ £75 + £13.12 VAT= £88.12 (members) or ☐ £90 + £15.75 VAT= £105.75
Invoice me for ☐ £75 + £13.12 VAT= £88.12 (members) or ☐ £90 + £15.75 VAT= £105.75

I shall not attend; send a copy of the Proceedings: a cheque is enclosed for ☐ £20 (members) or ☐ £27

MEETING NOTICE

Scottish Branch One-day Conference

NOISE AND VIBRATION AT WORK - europe 1992

Strathclyde Fire Brigade Headquarters, Hamilton
10 October 1991
In collaboration with the Health and Safety Executive

OPENING ADDRESS by the Chairman, David C T Eves, *Deputy Director General, Health and Safety Executive*

PROTECTION AGAINST NOISE AND VIBRATION AT WORK - THE IDEAS OF THE EUROPEAN COMMUNITY Dr Marcel van der Venne, *Principal Administrator, Commission of the European Communities Health and Safety Directorate*

THE MACHINERY DIRECTIVE AND THE PROPOSED USED MACHINERY DIRECTIVES - PROGRESS WITH NEGOTIATIONS AND IMPLEMENTATION Stephen Kennett, *Manufacturing Technology Directorate, Department of Trade and Industry*

NOISE MEASUREMENT IMPLICATIONS OF THE MACHINERY SAFETY DIRECTIVE and NOISE CONTROL BY ENGINEERING MEANS Michael F Russell, *Professor of Automotive Engineering, Institute of Sound and Vibration Research, University of Southampton*

EFFECTS OF VIBRATION ON PEOPLE AT WORK Michael J Griffin, *Professor of Human Factors, Institute of Sound and Vibration Research, University of Southampton*

INDUSTRIAL INVOLVEMENT IN THE EUROPEAN LEGISLATIVE PROCESS Alasdair N MacCallum, *Chief Executive, Don & Low Holdings Ltd and Chairman, CBI Scotland*

EMPLOYEE PARTICIPATION IN OCCUPATIONAL HEALTH - A EUROPEAN OVERVIEW Campbell Christie, *General Secretary, Scottish Trades Union Congress*

INDUSTRIAL NOISE THROUGH THE INSURER'S EYES David Hughes, *Regional Claims Manager, Iron Trades Insurance Company Ltd*

TRAINING IMPLICATIONS OF THE NEW LEGISLATION Dr Robert J Peters, *Chairman, Examination Board for the Institute of Acoustics Certificate of Competence in Workplace Noise Assessment*

DISCUSSION AND QUESTION PERIOD

General Information The conference will commence with coffee and registration at 9.30 am and the programme will start at 10.00 am. The Conference Fee is £125 + VAT; this includes the cost of lunch and refreshments and conference papers. Attendance is limited so early application for registration as a delegate is advised. Delegates will receive a detailed programme and joining instructions prior to the event. There is ample parking at the venue.

Application Form
Please enrol me as a delegate to
NOISE AND VIBRATION AT WORK - europe 1992

Name:

Position:

Organisation:

Address:

Telephone no for daytime contact:

- ☐ I enclose a cheque payable to the Institute of Acoustics for £125 + £21.88 VAT at 17.5% = £146.88
- ☐ Please invoice me at the above address for the conference fee
- ☐ Please arrange for a vegetarian lunch

Call for Papers

PC PROGRAMMES IN ACOUSTICS

London, January 1992

Topics include

Data Collection and Manipulation
Prediction for Road Traffic, Railway and Aircraft Noise
Sound Insulation and Sound Power Measurement
Environment Noise Monitoring
General Utilities for Acousticians

Offers of contributions with 100 word abstracts to the Meeting Organiser: John Seller MIOA, Institute of Environmental Engineering, South Bank Polytechnic, Borough Road, London SE1 0AA

LETTER TO THE MEMBERSHIP FROM NPL

Industrial noise complaints: Study of the application of British Standard BS 4142: 1990

Dear IOA members,
As readers may be aware from my letter published in the Jan-Feb edition of the Bulletin, the National Physical Laboratory, on behalf of the DoE, is currently conducting a study on the application of the revised British Standard BS 4142:1990 "Method for Rating industrial noise affecting mixed residential and industrial areas".

As described previously, although the revision has a broadly unchanged scope, it uses the equivalent continuous sound pressure level, LAeq , to describe the noise and tightens up the requirements on equipment, traceable calibration and measurement procedures. However in the absence of new data on noise complaints, major changes were not made to the actual assessment procedure.

A need was therefore recognised to collate information on the application of the new standard in order to investigate how the assessments compare with the actual investigated noise complaints.

A data sheet was developed in consultation with the Building Research Establishment to be used to collate information on investigations into complaints in accordance with the revised standard and therefore to improve our knowledge and understanding of industrial noise disturbance.

In the last letter, we asked those people who would like to assist us in the collection of data about this important source of noise disturbance and its assessment, to contact us to obtain data sheets. I would like to thank the large number of volunteers who offered to participate in this stage of our work. We received many calls and letters and have sent out numerous data sheets.

However, the actual number of returned data sheets at present is lower than we had anticipated at this stage. Therefore I would like to encourage all participants to return any completed data sheets as soon as possible for analysis.

It is intended that preliminary results from this investigation will be presented at the IOA Autumn Conference "Noise in the Nineties" and we would therefore like to obtain as much valuable information as we can before November. However, we should point out that this will be an interim report only and therefore would ask that completed data sheets be sent to us at least until the end of July 1992.

We are fully aware that BS 4142 is used for purposes which are outside the scope of the standard, and for a thorough study of its application we would welcome information on all its uses. We would therefore ask that the data sheets are completed as far as possible for any use of the standard making it clear for what purpose the standard is being applied. We would stress that we do not wish in any way to police the use of the standard.

For your information, from the initial data sheets that we have received, there have been a large variety of noise sources including many which are tonal and impulsive in nature. At this stage over 90% of those completed give the opinion that the BS 4142:1990 assessment of the likelihood of complaints corresponds fairly well with the actual investigated noise complaints.

We will, of course, keep members of the Institute informed about the results of our investigation through the Bulletin. All volunteers will be sent a preview version of the final report.

If you require further information on this study, please contact me at the address below.

Thank you again to all those people who have shown interest.

Yours sincerely

Nicole Porter

Miss Nicole Porter, Acoustics Branch, National Physical Laboratory, Teddington, Middlesex TW11 0LW
Tel: 081 943 6705 Fax: 081 943 6161.

plied by the Andre division of BTR Silvertown. They are generally 125 mm deep and 250 mm square, carrying approximately 300 kN per pad, with static deflection close to 9 mm excluding a few millimetres of creep. Dynamic stiffness is close to 1.5 x static stiffness. A full programme of static and dynamic testing has been carried out including tests at Malaysian Rubber Products Research Association in Hertford.

All bearings are numbered with individual static test certificates. Creep, ozonization, shear and durability assessments have followed the guidelines of BS 6177:1982.

Bearings are set onto levelled epoxy grout beds around a steel failsafe block. Lateral restraint of floated elements was achieved using bearings which perform primarily in vertical shear but offer resistance to wind loads. However, a special case was the need for the Broad Street retaining wall to be propped by the bearings. This has been achieved in the design of the Concert Hall lower slabs (to transfer the load) and use of precompressed bearings being set in to replace temporary wedges.

Perimeter Detailing

Where slabs meet floated structures, generally a 50 mm airspace has been allowed. A theoretical ±12 mm lateral movement under 50-year wind load is expected and relative vertical settlement of as much as 12 mm has been allowed across railway vibration isolation joints (RVJs). The elevational area facing the floated structure has been limited and slabs are generally chamfered to a 75 mm deep nosing (see Fig. 6). A series of special bridging details deals with the need to carry people over the joint, achieve fire separation, and account for settlement and bearing creep without vibration bridging. Folded foam or ceramic blanket is used to achieve fire ratings within

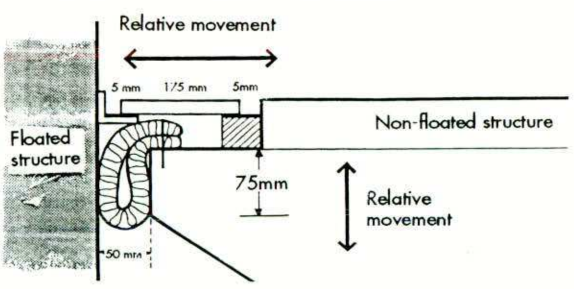


Fig. 6. Nosing and joint detail.

isolation joints. For waterproofing or facing, low modulus sealants or dry resilient seals have been included. At roof level, and at pavement junctions, cover pieces have been fixed to one side of the joint and bear on resilient material on the other side. Flexible weatherproofing material avoids bridging at high level.

Services

The high standards of isolation sought presented a challenge to conventional flexible links in services connections, and research found little definitive work covering attenuation across such flexible links. The City of Birmingham, with the Arup Development Fund, provided money for laboratory research into their performance in various pipes from 50 mm to 150 mm under a variety of pressures, as single flexible links, or as two units separated by a loaded bend, with changes to patterns of local support. As a result, flexible connections were selected for maximum practical performance. In the case of groups of smaller pipes, some loaded bends have been arranged at RVJs by strapping bends to steel plate suspended on spring hangers with flexible connections either side. Electrical trunking was broken and large cables suspended on springs for designated distances beyond the joint, subject to cable stiffness.

Isolation at Source

At a late stage it was found that BR's plans to re-lay one of the tracks in the tunnel (as part of their maintenance programme) offered a chance for under-sleeper isolation to be added. A material manufactured by James Walker Ltd., which had been on trial in North Wales, had provided close to 10 dB attenuation in the 63 Hz octave band (see Fig. 7) and it was felt that perhaps 6 dB could be achieved in the tunnel. In view of the wish to minimize transmission to the site, it was agreed that the 'up' track should be isolated and the 'down' track could then be isolated in a second maintenance programme planned for 1991. The 'up' track is now isolated. Arup Acoustics'

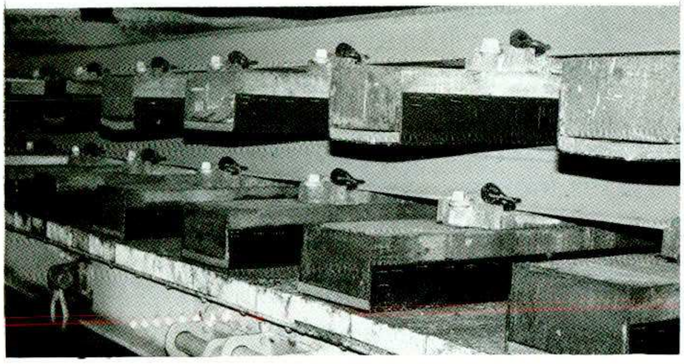


Fig. 7. Under-sleeper isolators stacked.

measurements indicate that useful benefit has been achieved. More extensive tests are proceeding.

Quality Control

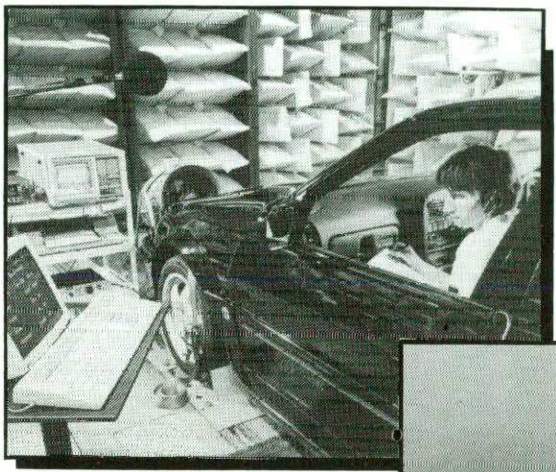
At the time of writing, surveys of residual vibration within the floated structures are becoming possible. As the project developed, isolation measures called for the highest standards of quality control. Although building planning has resulted in the pattern of isolation lines becoming more elaborate than proposed by Arup Acoustics, a strong awareness of the critical nature of the isolation process has developed amongst the site team, supported by Arup teach-ins to site staff.

Richard Cowell FIOA is with Arup Acoustics

Editor's note: Since this article was written in summer 1990, the Centre has opened and we are advised that the isolation exercise has been a complete success. A project update will appear in a later issue. ❖

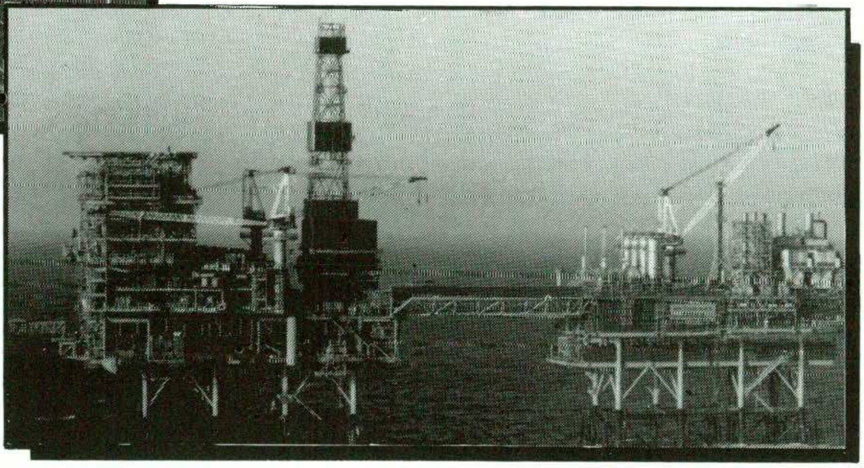
LOTUS

Awareness of the hazards of noise and vibration is growing. The 1990 EC Noise at Work regulations limit, for the first time, the exposure levels of individual employees.



Lotus Engineering solves noise and vibration problems throughout the automotive world. It uses both traditional and modern methods of analysis and solution, having the courage to innovate where necessary.

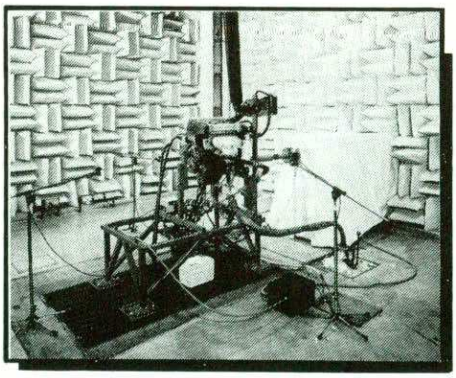
It has pioneered Active suspension and Active noise and vibration control in cars.



It now also applies this expertise in other areas. For example it has recently joined with Aberdeen based Gerard Engineering to tackle problems in the oil and gas industry.

Problem Identification

- Noise/Vibration surveys
- Personal dosimetry
- Two semi anechoic test chambers
  (one with rolling road, one with engine dynamometer)
- Extensive range of data acquisition and analysis equipment
- Modal analysis



Solution

- Enclosure and damping specification
- Silencer and mount design
- Active noise and vibration control
- CAE/CAD
- Management of implementation for one-off solutions
- Technology transfer for production solutions
- Noise and vibration training

For further information contact:

Malcolm McDonald
Lotus Engineering
Potash Lane
Hethel
NORFOLK NR14 8EZ

Tel: 0953 608000
Fax: 0953 606884

Acoustics '91
1991 Spring Conference
University of Keele 15/18 April 1991

Overview
Acoustics '91, the Spring Meeting of the Institute, was held this year on the rural campus of Keele University which provided the ideal forum for a relaxed and friendly conference. As in 1990 the weather enabled delegates to enjoy pleasant strolls to the technical sessions through the University grounds.

A particular highlight of the Conference this year was the RWB Stephens Memorial session which comprised five presentations from distinguished acousticians together with this year's Stephens lecture, delivered by Bob Chivers and reported in the previous issue of the Bulletin. Technical sessions were arranged on physical acoustics, underwater acoustics, speech, building and duct acoustics and there was an open session.

With only 118 delegates attending support was somewhat lower than in previous years and almost certainly reflected the general economic climate and in particular the cutbacks within the defence industry. Nevertheless those who attended were seemingly of one voice that they heard a range of interesting presentations and enjoyed some lively discussions.

The conference dinner was held in the magnificent surroundings of the Old Library within Keele Hall and the delegates and honoured guests were entertained during the meal by members of the Keele University Chamber Orchestra arranged by Professor Richard Challis of that University. The Meetings Committee is very indebted to Richard Challis for his energy in heading the local organisation.

On Thursday after the close of the conference members of the Speech Group and other delegates to the conference visited the laboratories of the Departments of Communication and Neuroscience and Physics to inspect the research work in progress.

R W B Stephens Memorial Session

There is no doubt that the highlight of this year's Spring Conference was the session dedicated to the memory of Dr Raymond Stephens. No less than five past Stephens lecturers together with this year's, Dr Robert Chivers, gave presentations to the session which included in addition to the technical content, many warm references to Dr Stephens as teacher, host, colleague and friend.

The papers in order of presentation were:

The 1991 Stephens Lecture entitled R W B Stephens - Master of Cymatics, by Dr Bob Chivers of the University of Surrey.
As the title suggests, this excellent lecture was based on Ray Stephens' life but with the theme of symmetry and cymatics, defined by Dr Hans Jenny as the simple study of waves, which Dr Chivers cleverly integrated with details of the work and interests in acoustic waves of Dr Stephens.

Bob Chivers has the enviable, or unenviable depending upon one's point of view, task of sorting out for posterity the accumulated mass of uncollated papers, books and memorabilia piled high in Ray's home.

From his efforts so far, Bob was able to present us with a fascinating insight into Ray Stephens the person as well as his more well known achievements as 'the greatest acoustician since Lord Rayleigh'. The talk was illustrated with impressive and sometimes amusing pictures of some of the physics apparatus used by Ray in his schooldays, and also some superb colour slides of the lattice structure of crystalline matter which Ray Stephens had marked particularly in his copy of Dr Hans Jenny's second book on cymatics.

From Dr Stephens' contributions to acoustics and vibration research the inference was made that the man was indeed a 'Master of Cymatics'.

Marine sediment non-linearity, by Professor Leif Bjørno
This paper, prefaced by the dedication - 'to the memory of my teacher and friend Dr R W B Stephens', dealt with the use of high intensity sound sources to study the materials and profiles of the seabed.

The penetration of high power signals into the sea bed leads to second order nonlinear acoustics effects which can be measured and compared with theoretical models used to predict the properties of seabed materials.

Digital simulation of concert hall acoustics and its applications, by Professor H Kuttruff
After expressing his personal gratitude for the life of Ray Stephens, Dr Kuttruff presented an interesting review of the progress made in the simulation of concert hall performance using digital techniques.

He explained that computer simulation offers the opportunity to experience the listening conditions in a proposed concert hall when it is still in the design stage; 'auralisation'.

The method can be used to investigate optimum reverberation times, spatial impression, optimum ceiling heights and arrangement of audience seats. The written paper is reproduced elsewhere in this issue of the Bulletin.

Photoacoustic examination of selected materials, by A Slawinski
Mentioning that R W B Stephens gave the invited paper on the photoacoustic effect in Gdansk in 1980, Dr Slawinski gave an illuminating review of the latest results of research on this subject by his group of co-workers at the University of Gdansk, Poland.

Photoacoustic spectra were presented and discussed in comparison with absorption and excitation spectra obtained by spectroscopic methods. Comparisons were made

using chemical compounds, dyes and plant matter.

Cavity resonance, acoustical networks and violin acoustics, by Edgar Shaw

This interesting paper was presented by Dr Shaw 'in memory of Dr R W B Stephens and in gratitude for his extensive contributions to the advancement of acoustics in his own and many other countries, especially as a research supervisor who taught, inspired, guided and encouraged a generation of students'.

Dr Shaw dealt with wave motion in a cavity interacting with lumped acoustical elements such as resistances and inertances. He illustrated the concepts with a description of the acoustics of violins, describing an experimental instrument with acoustical characteristics which could be modified by opening varying numbers of holes in the ribs, 65 holes in total which could be plugged by corks. The instrument was known as 'Le Gruyere'!

Heat conduction, fish and ocean sound absorption, by David Weston

Some fascinating research was described by Dr Weston, on the attenuation of acoustic waves by fish, due to heat transfer within the fish causing the absorption of propagating sound (from echosounders). The results are of use to the fisheries in their study of fish behaviour, population, sizing and species identification, but Dr Weston pleads the case for acknowledging the contribution of this effect in explaining discrepancies in results of studies of ocean sound propagation.

He dedicated his paper to the memory of Dr R W B Stephens whom he first met in 1947 as an undergraduate at Imperial College. To the undergraduates 'at first he appeared to be our stern taskmaster, but soon metamorphosed into the kind and gentle Ray Stephens or Steve, always helpful and mindful of our interests. He was a man who always took on far too many tasks, and then managed to cope with them all working at a tiny cleared corner of the desk in his cluttered office. There was one disgraceful occasion when members of his research group, in his absence, decided to help by sorting out the cupboards in this office. Empty date boxes were removed, those with a few dates remaining were kept, single slippers without a partner were discarded, conceivably some items were thrown out that should not have been. The next morning a worried Steve was sighted as he checked through the contents of the college dustbin!'.

Thus ended a memorable session in the '91 Spring Conference in which the gratitude of the acoustics world for the life of Ray Stephens was truly declared. A group photograph of the contributors to the session together with our president Mike Ankers, can be seen on this page.

R W B Stephens Memorial Session Lecturers with the President.
Left to right L Bjørno, A Slawinski, D E Weston, R C Chivers, H Kuttruff, E A Shaw & M S Ankers.

Physical Acoustics

The physical acoustics sessions were organised by Professor Richard Challis, of the home team at Keele. Some twenty papers were presented, grouped into four principal themes.

The first session covered scattering in dispersed systems, solid-in-liquid and emulsions, and included work on novel spectrometric methods, characterisation of foodstuffs during processing, slip cast ceramics, and scattering from whole fish. This was followed by a group of papers giving impressive formulations on scattering from imperfections in solids and from within inhomogeneous and composite materials.

The third session included a critical analysis of the use of an interferometer for velocity measurements in liquids and a much awaited interim report from the National Physical Laboratory on a UK interlaboratory comparison of ultrasonic attenuation and velocity measurements. It was pleasing to note the level of agreement between different laboratories and techniques.

The session ended with an invited paper from Professor T J Mason of Coventry Polytechnic who gave a colourful review and demonstration of the art of sonochemistry. The need for theoretical input from physicists to improve our understanding of sonochemical phenomena and to support the development of sonochemical technology evolved as a clear and exciting challenge to the audience. The first part of the final session presented two papers on Lamb wave excitation, propagation and measurement, with applications to NDT of sheet structures. This was followed by a report of new composite ultrasonic sensors, papers on the problem of feature extraction from concrete media, ultrasonic interferometry and hole burning, and finally, experiments on an harmonic drum.

The sessions were stimulating and the discussions lively, but perhaps most important of all, and despite the vagaries of science funding in the UK, the small but active community of UK scientists involved in physical acoustics showed itself as still producing research which is exciting in its novelty, and of high scientific quality.

Underwater Acoustics

Although, in terms of both the number of authors and the number of delegates, this meeting was smaller than the Underwater Acoustics Group has been used to in the past, an interesting selection of papers was presented. These covered the general topic of 'Arrays, Beamforming and Related Signal Processing', and ranged from the most abstract signal processing to descriptions of real hardware. There was some lively discussion throughout, yet all presenters are to be congratulated on their precise timekeeping.

The first session on the Wednesday afternoon, was chaired by Peter Dobbins of British Aerospace and opened with an interesting tutorial by J W R Griffiths on sensor array processing. He began with an overview of beamforming theory and then proceeded to describe the conventional beamformer and various of the adaptive methods that are currently under investigation.

This was followed by A B Baggeroer, who reported on a 'true' maximum likelihood method for estimating frequency wavenumber spectra which takes advantage of the physical constraints of the propagation medium in an algorithm which converges relatively quickly, and yet has modest computing requirements.

A W Kuperman then discussed source localisatation in a waveguide with unknown acoustic properties using a technique which he called focalisation, a simulation search for the source direction and the acoustic parameters of the medium. In the final paper of this session, T A Rafik presented some practical results on a high resolution sonar system which compared the merits of some of the algorithms described by Professor Griffiths in his tutorial.

The Thursday morning session was chaired by David Weston of YARD Ltd. The first paper was by P F Dobbins, who outlined a method for finding shading coefficients that produce an arbitrary beampattern from an arbitrary array.

R McHugh then discussed digital holographic sonar imaging. In this technique, sensor data is digitised and stored in a memory. Look-up tables containing the geometry of the array and the field of view are then used to map these data directly onto pixels in the image.

This was followed by W A Kuperman who, in his second paper, explained optimal time-domain beamforming with simulated annealing, including noise cancellation.

After coffee, B J Uscinski introduced the problems of fluctuations in the sound field, drawing the analogy between the scintillation in a sonar signal and the twinkling of stars, and described the effect of internal waves on the directional pattern of a towed array.

A G Riley then considered the effects of sensor positional errors on the ESPRIT algorithm. This referred to the flexing of a towed array in response to tow-ship motion and ocean currents, which results in a difference between the assumed locations of the hydrophones and their actual positions.

The concluding presentation in the underwater sessions was provided by C Flewellen, who described a deep submergence parametric array intended for penetrating the sea bed sediment.

Speech Research

There were two sessions on speech research: one on Wednesday afternoon on speech processing and recognition (chaired by Marcel Tatham) and the other on Thursday morning on speech synthesis and perception (chaired by Bill Ainsworth).

The first session began with a paper by Dave Miller and Peter Roach (University of Leeds) on the recognition of sub-word units by HMMs. They presented part of their contribution to the SYLK project. Next A I Tew and P D Stringer (University of York) described an adaptive binaural beamformer which could be useful for separating speech signals from interfering noise.

Co-operation between the University of Keele and ICP, Grenoble has led to the development of a computational model of the cochlear nerve and nucleus. Georg Meyer, Bill Ainsworth (Keele) Andy Morris and Jean-Luc Schwartz (Grenoble) showed how plosives may be processed by such a model and how it could be used as the front-end of a speech recogniser.

This was followed by a theoretical paper by Nick Sifakis (University of Essex) attempting to bridge the gap between phonetics and phonology. The session ended with an additional paper by Abdul Mobin, visiting Leeds from CEERI, Delhi, on the recognition of Hindi digits.

The second session was marred by the absence, through illness, of two of the authors: Kate Morton from the University of Essex and Pete Howell from UCL. However, Marcel Tatham gave Kate's paper on assessment techniques applied to speech synthesis followed by his own on units of representation in speech synthesis. The latter was enhanced by numerous recorded demonstrations of synthetic speech.

The theme of speech synthesis continued with a description of a version of the JSRU text-to-speech system by Eric Lewis and R. Sampson (University of Bristol). Finally Pat Wilson (University of Keele) reported on some perception experiments on directional adaptation to formant-like frequency sweeps.

Duct Acoustics

Four papers on silencers and air-conditioning elements were given in this short session on duct acoustics.

N J Pittams investigated the differences between in-service insertion loss of silencers with values obtained from laboratory testing to BS 4718. The shortcomings of the manner of generation of the incident sound field in BS 4718 were identified.

In discussion, Alan Fry commented that evaluation of non-plane wave (cross) mode effects had to be via in-duct measurements. Although BS 4718 just assesses the plane wave contribution and is therefore not necessarily correct, it is at least a repeatable procedure.

Nick Sormaz presented a theoretical study of attenuation in dissipative splitter silencers with mean flow. Practical measurements using glass fibre splitters agreed well with predictions and indicated that the fundamental mode is not necessarily the least attenuated mode.

The paper from Keith Peat from Loughborough continued a series analysing discontinuing impedances in cylindrical ducts - this time where the ducts at a sudden area change are not coaxial. The results are applicable to engine intake and exhaust silencers.

David Oldham studied regenerated noise due to closely spaced duct elements in air-conditioning systems. It was shown that for two duct elements, re-generated noise increased if they were close together and that the increase is frequency dependent - enhanced where the separation is similar to the acoustic wavelength.

Building Acoustics

The Building Acoustics session commenced with an interesting paper on the in-situ measurement of the acoustic reflection coefficient by J Kaminski of the Polish Academy of Sciences. The technique employed was based upon the measurement of complex sound intensity and the objective of the work was to obtain data for use in computer simulation modes for room acoustic studies. This was followed by a paper by Norman Pittams and S Simpson of Bristol Polytechnic comparing the proposed test procedure for acoustic louvres with in-duct insertion loss measurement.

Mark Rowell of the Acoustics Research Unit of Liverpool then presented a paper co-authored by David Oldham on the determination of the directivity of a planar noise source by means of near field acoustical holography. This technique would appear to be capable of giving all the information required by the proposed louvre test procedure described by Norman Pittams without making the compromises that the proposed system is forced to make.

R S Ming and Barry Gibbs, again of Liverpool University, presented a paper describing an experimental study of rotational mobilities of concrete floors in which the limitations of a number of techniques were identified. Sue Ridler of Arup Acoustics then presented a paper based upon data obtained in the field on the design aims regarding structure-borne noise in mixed development.

Finally Murray Hodgson of the National Research Council of Canada presented a paper on evidence of diffuse surface reflection in rooms. His results appeared to show that even surfaces which are essentially smooth act as if they reflect a high proportion of sound in non-specular manner. This effect had also been observed by the Chairman when modelling traffic noise propagation down city streets.

Open Session

The open session provided a fascinating range of acoustic subjects, from psycho-acoustics to office machine noise.

Steve Benton's paper studied the extent to which an individual's ability to habituate to acoustic signals is influenced by an interaction between personality and the acoustic signal's frequency. Intermittent tones and low frequency tones posed more difficulties for the habituation process, in particular for introverted people.

Mo Tokhi and K Mamour from Sheffield presented two papers on active noise control the first of which was an investigation of noise cancellation in a 3-dimensional propagational medium based on a single-input multi-output ANC structure. The extent to which cancellation is dependent on both the frequency of the noise and the separation between primary and secondary sources was demonstrated. Due to interference of the primary and secondary waves noise is cancelled in particular regions and reinforced in others. The second paper explored the merits of self tuning, rather than fixed, ANC systems.

Murray Hodgson's talk provided further information on the propagation of sound within industrial buildings. A range of measurements showed an interesting 'cut-off' point at approximately 20 metres and peak attenuations at a frequency of 1 kHz.

There were three papers allied to the subject of traffic noise. Greg Watts of TRRL described the successful design and validation of listening rooms via which realistic, repeatable traffic noise surveys could be simulated.

David Tobutt presented a most comprehensive description of a semi-empirical model constructed at TRRL for the prediction of traffic noise (LA10) in complex highways situations. Data from 18 separate sites with distinctly varying cross-sections were studied. The prediction model, which utilises ray tracing and image source theory to account for reflection, absorption and diffraction associated with barriers and cuttings, gave highly satisfactory accuracy.

Andrew Peplow presented a complementary theoretical paper studying a method for the prediction of cutting noise using a wave model.

Nalgi Kozula's paper described the development of a simulator to represent a Ricoh photocopier. An eight channel simulator was used with close microphone recordings and a specially developed loudspeaker array, to give a good impression of the spatial separation of the various sources on a real machine. Subsequent studies will assess each of the major sources with respect to overall perceived noisiness of the photocopier. ❖

New Products

SCITECH MICROSYSTEMS

SIGNALCALC 'C' Library

SciTech MicroSystems, specialists in unique signal processing solutions, have announced a 'C' version of SignalCalc that supports Microsoft Quick C and Borland Turbo C. SignalCalc is a powerful library of digital analysis and graphics routines that is used in conjunction with a DP310 FFT Card and any PC/AT compatible computer, including laptops.

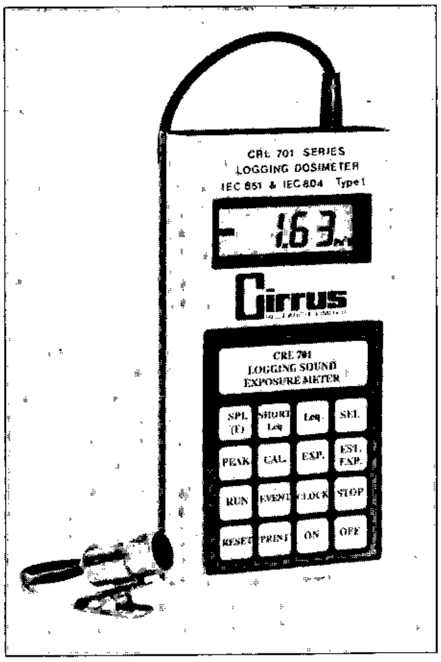
This combination allows the engineer to acquire data from any plug-in accessory card or external instrument and then undertake high speed signal analysis with real-time graphics and interactive cursors. The addition of a DP340 Analogue I/O card, which includes 16 bit converters and on-board programmable anti-alias filters, allows the engineer to develop a system offering all the capabilities of dedicated instrumentation,at a greatly reduced price.

For further information contact SciTech Microsystems Ltd, 11 Ashton Rd, Wokingham, Berks RG11 1HL. Tel: 0734 772595.

CIRRUS RESEARCH

CRL 701 Dosimeter

The Cirrus CRL 701 Noise Dosimeter is a programmable instrument which combines the features of older style dosimeters with those of Integrating Sound Level Meters and Data Loggers. This instrument has been designed for the international market and accommodates exchange rates of 3, 4 and 5 dB, without modification, to provide a unit applicable to any standard for Sound Exposure so far proposed. This includes the U.K's Noise at Work Regulations and the unit also provides simultaneous measurement of true peak as defined by the latest revision of IEC specification 651. Whilst the CRL 701 is designed to comply with Type 1 requirements of all requisite standards, it utilises Cirrus' concept of grade convertibility to allow a grade 2 microphone to be fitted and hence a considerable cost reduction can be achieved.



The CRL 701 provides a direct printout of the stored data in a summary report onto a printer or directly into proprietary software, such as databases, allowing comprehensive worker monitoring programmes to be undertaken. It can also provide direct readout of any of the parameters via the unit's own display.

The CRL 701 can acquire up to 18,000 'Short Leq' elements allowing 8 hours continual use. This data can be transfered to an MS-DOS computer for analysis using Cirrus' Acoustic Editor software which will allow detailed investigation of the logged noise environment. The CRL 701 can be supplied with a software program, 700SETUP, which allows any key on the dosimeter to be redefined.

700SETUP is supplied as a self-installed program with only modest computer requirements: MS-DOS or PC-DOS operating systems and a serial RS232 interface. 700SETUP is a windows driven software program with both on-line helpfiles and an on-line manual.

01dB

ARIA

Cirrus Research's associate company 01dB have developed a powerful alternative to the traditional range of acoustic analysers. This alternative, named ARIA, uses the power of modern software with the portability of laptop computers to provide a modular acoustic measurement system. ARIA requires a processor card to receive the acoustic signal and then software modules are added as required to build a customised acoustic analyser. Each software module fulfills a dedicated task and these include: architectural acoustics, building control acoustics, real time dual channel narrow band FFT analysis, environmental monitoring and event recording, real time sound intensity analysis, acoustic power determination and time domain spectrometry.

As each module is software based then addition or upgrading of the system is simply achieved by installing extra software. The performance of ARIA has been verified by an international standards laboratory. ARIA generates all of its tables and graphic displays for easy incorporation into reports. This data can be stored on hard or floppy disk and copies can be sent anywhere for analysis using data-base programs or subsequent reanalysis.

Further details from Duncan Brown, Cirrus Research Ltd, Acoustic House, Bridlington Road, Hunmanby North Yorkshire, Y014 0PH Tel: 0723 891655. Fax: 0723 891742. Telex: 527579 LINAS G.

Cirrus Research is a Key Sponsor of the Institute

LMS

Multi-mode Control

In 1989 at the IES Conference in Los Angeles LMS introduced its first UNIX based closed-loop vibration control package: LMS CADA-X Random Control. This year the IES conference in San Diego saw not only the completed Sine, Random and Shock control modules but also the announcement of a sophisticated Sine-on-Random package. Sine-on-Random control is used to emulate a real-life vibration environment in which the spectrum combines several discrete sweeping sine tones superimposed upon a random background signal. It incorporates many innovative features from both LMS

International and Hewlett-Packard, and illustrates the close collaboration between the two companies on the project. Up to 10 independently sweeping sine tones can be generated by the firmware within the HP 35656 DAC. These tones are generated digitally using a phase continuous algorithm that allows pseudo-analog sweeps of up to 10 octaves per minute. The random signal is provided by a second DAC module. Extraction of the sine tones is performed using a unique least squares identification time domain technique.

Further details from LMS UK Ltd., Cheddar Industrial Park, Wedmore Road, Cheddar, Somerset BS27 3EB. Tel: 0934 744222 Fax: 0934 744461.

GENRAD

Vibration Control System

GenRad has announced a SINE software enhancement for its recently introduced GR2530 Vibration Control System. The SINE test facility provides capability for conducting swept sine tests over a range 1 Hz to 10 kHz, with a comprehensive set of test definition and control parameters including up to eight-channel control. For RANDOM testing, the GR2530 offers nine control frequency ranges from 50 Hz to 20 kHz, a choice of resolution from 100 to 800 lines and up to 40 breakpoints. The GR2530 is suitable for use with both electrodynamic and electrohydraulic shakers. A high-resolution colour monitor enables the operator to pinpoint complex problems at a glance and a colour print-out is also available.

Contact Jan Poole, GenRad Limited, 3 Roxborough Way, Foundation Park, Maidenhead, Berks SL6 3UD. Tel: 0628 826941 Telex: 848321 Fax: 0628 822332.

BRUEL & KJÆR

Type 3550 Multichannel Analysis System

Bruel & Kjær have announced a new modular analyser which grows from dual-channel to 16-channel as the user's requirements grow. Furthermore, unlike most analysis systems with multichannel capability, which rely on external computing power, the Type 3550 Analysis System includes all the computational flexibility of a PC or workstation, to make it a complete standalone analysis solution.

The hub of the system is a dual-channel analyser performing FFT analysis, a choice of input modules giving 25 kHz or 100 kHz operation, and optional signal generator. Two levels of software provide capability for handling the toughest sound and vibration problems, as well as test and analysis of machinery, structures, servos and electro-acoustic systems in design and production environments.

The addition of up to 16 rack-mounted expansion units enables the analyser to cope with most structural, multichannel acoustic and electro-acoustic applications. The full potential of the system is realised by running the advanced software package concurrently with multi-channel software.

Whatever the configuration, operation is simple. A few keystrokes recall complete measurement and display setups, user-defined functions, auto-sequences and calibration inputs, and control the analysis. Automated operation and clear pass/fail indication allow untrained personnel to perform quality control testing at a rate which supports high-throughput manufacturing.

For further information, contact Les Minikin, Bruel & Kjær (UK) Ltd, 92 Uxbridge Road, Harrow HA3 6BZ. Tel: 081 954 2366 Telex: 934150 BK UK G, Fax: 081 954 9504.

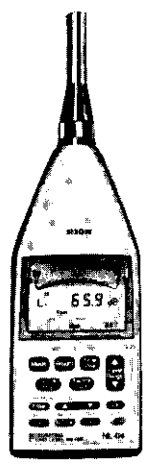
Bruel & Kjær (UK) is a Key Sponsor of the Institute

QUANTITECH

Type 1 Hand-held Sound Level Meter

A new, next generation, hand-held, precision, impulse, integrating Sound Level Meter is now available from Quantitech Ltd., the environmental monitoring specialists.

Utilising the very latest advances in state-of-the-art technology and microprocessor techniques, the RION NL-14 has all the features expected of a Type 1 field or laboratory instrument. It is ideal for assessing industrial noise deafness risk, as well as conducting environmental and community noise assessment programmes.



The instrument incorporates optional integral one and one-third octave filters.

With an on-board, non-volatile, memory facility plus five time constants (S, F, I, P, 10 mS) and Lp, Leq, Lx, Lmax, with a peak measurement range of up to 142 dB, this new instrument is ideal for identifying potential action levels and assessing environmental noise pollution.

Further information contact: Quantitech Ltd, 75 Garamonde Drive, Wymbush, Milton Keynes, Buckinghamshire MK8 8DD Tel: 0908 564141 Fax: 0908 260554 Telex: 827560.

VIBAC (NOISE CONTROL)

Electric Motor Acoustic Hoods.

Vibac (Noise Control) Ltd announce a new design for Electric Motor Acoustic Hoods.

Motor noise is due mainly to the cooling fan at the air inlet end of the motor and can be reduced by fitting a VIBAC VMH Motor Hood designed to use the body of the motor itself as one surface of the attenuating air outlet path eliminating the need for total enclosure. This gives two further advantages: the drive end of the hood is left open and so does not interfere with the drive shaft and coupling and secondly the air flow pattern across the motor is not unduly affected - so that any resultant temperature rise is not normally significant.

The hoods have a mild steel casing lined with sound absorbent fire retardent acoustic foam. The hood is a simple 'drop-over' unit which can be fitted to the motor plinth/baseframe and located by means of angle brackets or similar. Various alternative foams/facings are available for different environments as are alternative linings such as mineral wool and perforated steel.

Cooling is one critical feature of electric motors. The VMH motor hood addresses this problem by incorporating an air inlet acoustic baffle which allows air entry to the motor fan grille. Air discharge is between the motor casing and hood open end, allowing the natural airflow path to be maintained, without undue risk of air recirculation.

The close fitting design and attenuation around the motor fan mean that reductions of 10-15 dBA are readily achievable.

Further information from: J Savidge, Vibac (Noise Control Ltd), Brookhill Road, Brookhill Industrial Estate, Pinxton, Notts NG16 6NT Tel: 0773 812321.

Personnel

BRUEL & KJÆR (UK)

Mark Appleyard has been appointed managing director of Bruel & Kjær (UK) Ltd after four years as managing director of the company's Belgian operation. He previously worked for three years at Bruel & Kjær Denmark where he ultimately headed up a marketing services group, specialising in vibration technology, structural test and modal analysis.

Appleyard assumes responsibility for a restructuring exercise which focuses attention on new market areas, bringing important new products to the UK marketplace, and enhancing cust-omer support through a 'total system' approach to measurement problems.

QUANTITECH

Roberto Lorenzetto has joined Quantitech Ltd. as Product Support Specialist - Sound and Vibration, following the company's appointment as the sole UK representative for RION of Japan. Mr Lorenzetto strengthens the Company's sound and vibration monitoring expertise with many years experience in the field gained with Lucas and Plessey.

News Items

CIRRUS RESEARCH LTD

Cirrus Research Ltd, based in North Yorkshire, manufacturers of airport noise monitoring sytems announce they have been awarded the contract to provide the aircraft noise monitoring equipment for the newly expanded Humberside International Airport. Cirrus will provide the main airport extension contractor, Laing Civil Engineering, with a system using a combination of portable and permanently located noise monitoring terminals which are linked into a central computer. The central computer operates the system completely automatically, checking the calibration and the service state of the units every second. Users can check the noise of any flight as it is happening and compare data of any flights they choose.

Whilst the permanently sited noise monitoring terminals will monitor aviation activity at pre-defined locations, a portable unit will be used to assess noise disturbance at varying locations providing a powerful respone to local environmental concerns.

The computer will then generate user defined noise activity reports and all the data required for accurate noise control including noise maps of the surrounding area. This system will be the most modern installed at any United Kingdom airport and has been developed in Hunmanby.

Development of the new system was made possible by a Small Firms Merit Award for Research and Technology from the UK Department of Trade and Industry.

For further details please contact: Duncan Brown on 0723 891655

ECOMAX ACOUSTICS

Alpha dBk Ltd of High Wycombe and Hedemora Engineering Ltd of Corby have been combined into a single company: Ecomax Acoustics Ltd, now owned by Partek OY, Scandinavia's largest producer of building materials.

Ecomax Acoustics will provide noise control solutions for architectural, commercial and industrial applications. The company will also be able to offer specialist advice together with an appropriate range of products for environments in which the presentation of music and speech demand the highest standards of acoustic integrity.

Head office of Ecomax Acoustics will be located at High Wycombe which will also carry stocks of acoustic products. The Corby plant will handle acoustic flooring, noise-insulated control room cabins and enclosures as well as acoustic doors.

Brand names carried by Ecomax Acoustics include: Reduc and Soundfloor acoustic flooring, Sportspanel, Hi-Clinic, Cleansound, Graphiti, Logo and Overture acoustic ceilings; Softsound acoustic wall panels; Tufsound and 1379 acoustic panelling and Soundslab acoustic insulation.

Further information from Ecomax Acoustics Ltd, Gomm Road, High Wycombe, Bucks HP13 7DJ. Tel: 0494 436345

TRAVERS MORGAN

The Travers Morgan Consulting Group has recently been appointed by the Health and Safety Executive to help draft the noise guidelines for the new Code of Practice for Pop Concerts.

The commission is being handled by the Group's Acoustics team led by Jim Griffiths, who will be looking at environmental noise, audience and employee noise exposure and other noise control procedures.

The commission from the HSE follows the revolutionary sound system designed by Travers Morgan and installed at Wembley Stadium last year.

Further information may be obtained from Jim Griffiths, Travers Morgan Consulting Group, Mead House, Cantelupe Road, East Grinstead, West Sussex RH19 3DG. Tel: 0342 327161.

SOUND ABSORPTION

Sound Absorption Ltd of Haslingden, Lancashire, makers of 'COUSTONE' acoustic panels have appointed a new team of agents to work in a nationwide network, concentrating their efforts into helping Works Managers and Plant Operators meet the UK noise at work regulations.

Further information from Unit 6, Bentwood Road, Carrs Industrial Estate, Haslingden, Lancs BB4 5HH. Tel: 0706 213477. Fax: 0706 214147.

Items for the New Products section should be sent to J Sargent, BRE, Garston, Watford WD2 7JR ❖

News from BSI

New and Revised British Standards

BS 4196 Sound power levels of noise sources. This describes methods for determining the sound power levels of machines and equipment.
BS 4196 Part 1:1991 (≡ **ISO 3741**) Precision methods for the determination of sound power levels for broad-band sources in reverberation rooms. Supersedes BS 4196: Part 1:1981.
BS 4196 Part 2:1991 (≡ **ISO 3742**) Precision methods for determination of sound power levels for discrete-frequency and narrow-band sources in reverberation rooms. Supersedes BS 4196: Part 2:1981.
BS 4196 Part 3:1991 (≡ **ISO 3743**) Engineering methods for the determination of sound power levels for sources in special reverberation test rooms. Supersedes BS 4196: Part 3:1981.
BS 6686 Methods for the determination of airborne acoustical noise emitted by household and similar electrical appliances.
BS 6686: Part 2: Particular requirements.
BS 6686: Section 2.5: 1991 (≡ IEC 704-2-5) Room heaters of the storage type.
BS 5108 Sound attenuation of hearing protectors.
Part 1:1991 (≡ ISO 4869-1) Subjective method of assessment. This give a method for measuring the sound attenuation at the threshold of hearing. Supersedes BS 5108:1983.
BS 7445 Description and measurement of environmental noise (≡ ISO 1996).
Part 1: Guide to quantities and procedures. Gives guidance on the basic quantities for use in describing noise in community environments and on basic procedures for determining them.
Part 2: Guide to the acquisition of data pertinent to land use. Gives guidance on methods for acquiring data to give descriptions for environmental noise relating to land use.
Part 3: Guide to the application to noise limits. Gives guidance on the way noise limits should be specified and on methods to verify whether or not specific noise limits have been complied with.
BS 7458: Test code for the measurement of airborne noise emitted by rotating electrical machinery. (≡ISO 1680).
Part 1: Engineering method for the free-field conditions over a reflecting plane. This gives a method, of engineering grade accuracy, for measuring sound pressure levels around a machine, for calculating band power levels and determining A-weighted sound power level.
Part 2: Survey method. This gives a method, of survey grade accuracy, for measuring sound pressure levels around a machine and for determining the A-weighted sound power level.

Amendments to British Standards

BS 6083: Hearing aids.
BS 6083: Part 3: 1991 Methods for measurement of electroacoustical characteristics of hearing aid equipment not entirely worn by the listener.
BS 6083: Part 4: 1991 Specification for magnetic field strength in audio-frequency induction loops for hearing aid purposes. Implements CENELEC HD 450.4 S1.
BS 6698: 1986: Specification for integrating averaging sound level meters.

Draft British Standards for Public Comment

91/22890 DC IEC XXXX Standard method of measuring and labelling for ultrasonic Doppler foetal heart beat detector (IEC 87 (Central Office) 15)
91/28273 DC Test code for the determination of airborne acoustical noise emitted by household and similar electrical appliances. Part 3: Procedures for determining and verifying declared noise emission values.

International Publications

IEC 862-2:1991 Surface acoustic wave (SAW) filters. Part 2: Guide to the use of surface acoustic wave filters (Chapter III). This will be implemented as a dual-numbered British Standard.
IEC 1019-1-1 1990 Surface acoustic wave (SAW) resonators. Part 1: General information, standard values and test conditions. Section 1: general information and standard values. This will be implemented as a dual-numbered British Standard.
ISO 7235: 1991 Acoustics - Measurement procedures for ducted silencers - Insertion loss, flow noise and total pressure loss. This will not be implemented as a BS because it is technically unacceptable to the UK.
ISO 389:1991 (Edition 3) Acoustics - Standard reference zero for the calibration of pure tone air conduction audiometers. This will be implemented as a dual numbered British Standard.

CEN European Standards

The following European Standard has been approved by CEN:
EN 27 182:1991 Acoustics - Measurement at the operator's position of airborne noise emitted by chain saws (ISO 7182-1984). This will be implemented as an amendment, triple-numbering BS 6916: Part 6:1988.

BSI announced international new work has started on the following

ISO 4871 Noise labelling of machinery and equipment This will revise ISO 4871: 1984 to make the standard more suitable to support directive 89/392 EEC.
ISO 6081 Noise emitted by machinery and equipment - Guidelines for the preparation of test codes of engineering grade requiring noise measurements at the operator's or bystander's position.
ISO 5129 Acoustics - Type Measurements of airplane interior sound pressure level during cruise. Revises ISO 5129:1987.

Noise reduction
Methods for the determination of the acoustical performance of noise attenuating devices (excluding personal protective equipment). This will give methods of determining attenuation of noise by acoustic screens, enclosures and silencers.
Guidelines regarding reduction of noise emission from machines and equipment. This will give guidelines for identifying the origins of noise from machines and recommendation on how to reduce it.
Guidelines regarding reduction of noise at the workplace including planning and prediction methods. This will recommend procedures for identifying the cause of noise in workshops and methods of preventing it, or protecting workers from its effects.
IEC 704-2-11 Test code for the determination of airborne acoustical noise. Part 2 Belt sanders. Noise measurements under working conditions.
ISO 2923 Measurement of noise on board vessels. This will revise ISO 2923: 1975 to take account of more recent standards on instrumentation, measurement procedures and the use of ear protectors.
Measuring method for comparing noise in different road surfaces. This will give a method for the comparison of noise emitted by vehicles travelling on different road surfaces, taking into account the effects of different vehicle types and speeds.
Ergonomic assessment of speech communication - Part 1: Speech interference level and communication distances for persons with normal hearing capacity in direct communication. This will provide a method of assessing the effectiveness of speech communication in noisy environments.
The information was provided by Miss Nicole Porter of NPL from the May to August 1991 issues of BSI News.

Information

Department of the Environment Newsletter on New Environmental Protection Research Projects for 1991/92

The Department of the Environment has decided to bring out an Annual Newsletter to publicise the new items of environmental protection research approved by Ministers before the beginning of the financial year. A brief summary of the Department's environmental protection research programme for 1991/92 is given below as background for the new areas of work covered in the newsletter. The newsletter gives details on the new work, project by project, giving brief descriptions of these projects which remain to be put out to tender. The new items amount to £17 million in total representing about 41 per cent of the programme expenditure of £41.75 million on environmental protection research planned for 1991/92.

Air Quality
A major feature of this programme is the development of the critical loads approach to acid pollutants initially, and to nitrogen compounds and photooxidants latterly, which provides a unifying theme for the programme. The programme is intended to support the Department's responsibilities for the majority of its statutory environmental monitoring activities, where substantial new efforts on urban monitoring and on emissions of organic compounds can be anticipated in 1991/92.

Global Atmosphere
The contract for the Centre for Climate Prediction at the Hadley Centre is the main item of research in this rapidly expanded Programme. Liaison and co-operation with basic research on the atmospheric ocean and terrestrial processes that together govern climate and climate change is an integral part of the contract, as is forging a direct link between climate modelling and climate change impacts researches. In 1991/92 new activities will include support for the European Arctic Stratospheric Ozone Experiment, relevant aspects of remote sensing and data handling, monitoring and assessment of effects of UV radiation, and socioeconomic aspects of climate change response strategies.

Toxic Substances
This programme is primarily intended to support the Department's statutory responsibilities for the control of new and existing chemicals and of genetically modified organisms in the environment. There is an accelerated effort being devoted to new work on existing problem chemicals. The growing programme of research into the risk assessment of releasing genetically modified organisms to the environment supports the Department's inputs to the DE/HSE Advisory Committee on Releases to the Environment (ACRE).

Controlled Waste Management
This programme covers projects on land-filling and associated waste treatment and disposal facilities, and monitoring their effectiveness. It includes work on the control and use of methane gas from landfill sites. The main areas of work are the development of a landfill gas potential test, other methods of determining landfill stabilisation and a risk assessment framework for landfilling; the transfer of materials expertise from combustion research to materials recovery prior to landfilling and the provision of data for the revision of key waste management papers.

Contaminated Land
The need for work on problems of contaminated land and its rehabilitation, is emphasised in the Government's response to a House of Commons Select Committee enquiry, published as Cmnd 1161 (1990). The programme covers the preparation of profiles of industries and activities with the potential to contaminate land; the investigation of risk assessment methods for contaminated land and develop assessment criteria to assist clean-up; the evaluation of measures to protect buildings, structures and services from the effects of contaminants, including landfill gas, in soil and the evaluation and investigation of remedial technologies for site clean-up (1992/93).

Noise
This programme provides and maintains baseline data for establishing trends in environmental noise and information for the formulation of any future legislation. It evalu-

ates and assesses: the efficacy of noise control legislation; the technical feasibility and economic implications of controlling noise pollution; and public perception of noise pollution whilst aiming to identify changes in sensitivity. The programme involves the development of predictive modelling methods for assessing the effectiveness of noise control options.

Radioactive Substances Policy

This programme of research is intended to support the Department's policy responsibilities for radioactive substances in anticipation of HMIP becoming an Executive Agency. The programme includes projects in direct support of policy on radioactive waste management, radioactivity in the natural environment, and long term monitoring of environmental radioactivity and health related projects (e.g. radon in houses and its effects).

Her Majesty's Inspectorate of Pollution Research Programme

The main sub-programme of HMIP covers projects on the underground disposal of radioactive wastes, the main focus being evaluation studies of the facility for low and intermediate level wastes expected to be proposed by NIREX plc. The Department's support is being steadily reduced reflecting the move from generic studies to assessment of specific protocols. However, this will be counterbalanced by a steadily increasing sub-programme of work on environmental and monitoring studies directed at supporting HMIP assessments of operators' activities and the environmental and other risks associated with releases of radioactive and nonradioactive polluting substances from scheduled processes and works.

Marine

The North Sea sub-programme was commissioned by the Department as part of the UK follow-up to the Second North Sea Conference and covers some 35 physical, chemical and biological projects as the DOE effort to complement work funded by MAFF, DAFS, and NERC. The overall aim is to underpin the UK position at North Sea Conferences. A new feature in 1991/92 will be the initiation of steps to develop a complementary UK R&D and policy position on the Irish Sea. Several new projects are designed to enhance and exploit basic work completed under the Natural Environment's Research Council's North Sea project, in order to meet UK commitments to the North Sea Task Force and Conferences.

Environmental Protection Economics and Statistics

This programme addresses a number of undertakings set out in the Government White Paper on the Environment, Cmnd 1200, notably to enhance the publication of regular statistical reports on the environment, to examine the scope for applying market-based instruments, as a means of pollution control, and to establish wider use of cost benefit analysis to establish environmental priorities.

Water

The research programme has two large elements: (i) an expanding programme of research on drinking water quality and health where research is aimed at improving methods for measuring quality, and investigating changes in quality brought about by particular treatment processes and distribution systems; and (ii) freshwater, estuarine and marine water quality where studies support the Department's policies for setting UK and meeting EC water quality objectives, and for meeting associated commitments in the Oslo and Paris Commissions and the North Sea Conferences. The North Sea work is co-ordinated with that of EPC. Health aspects of bathing and recreational water quality are also receiving attention in co-operation with DH and Public Health Laboratory Service. Small sub-programmes provide policy support on reservoir safety, water conservation including implications of climate change, and sewage disposal.

Long Term Monitoring

A new feature of the 1991/92 environment protection programme is the specific identification and financial accounting of long term monitoring projects, over 70% of which covers the monitoring of the main air pollutants occurring and some of their effects (e.g. acidification of headwaters) in the UK. The DOE work is complemented by programmes of other bodies such as MAFF, DAFS, NRA, NRPB and NERC.

In connection with the above item, notification has been received that the following new projects on noise will be let during the current financial year

1. National Noise Attitude Survey A National Noise Attitude Survey will be undertaken using a questionnaire designed by BRE. The survey will involve conducting 2000 interviews at locations throughout England and Wales.

2. Disturbance caused by industrial noise This follows the recommendation of the 'Report of the Noise Review Working Party 1990', to carry out further research into community response to various types of industrial noise. This research has the objective of establishing relationships between noise-dose and disturbance caused by industrial noise in residential areas.

3. Detection and assessment of low frequency noise The study will include (i) an investigation of complaints about low frequency noise to gain a better undestanding of the nature and scale of the problem and (ii) the development of techniques for locating low frequency noise sources.

4. Unified model for human response to transportation noise Following the recommedation in the 'Report of the noise Review Working Party l990' that 'Research should be put in hand to formulate a common measure for the assessment of noise from the main forms of transportation', this project will review current knowledge and devise the structure of the model. The work is also expected to include the framework for the survey(s) required to provide data for the model, including the sampling strategy and objective measurement requirements.

5. Noise prediction over long distances The purpose of this work is to produce a model of noise propagation for use at distances greater than 120 metres. The initial work is likely to include a literature review and the formulation of the framework for the model with an assessment of the further research required to provide new information to complete and validate the model.

The DOE contact for the above programme is Roy Strapp, Room A227, Romney House, 43 Marsham Street, London SW1P 3PY ❖