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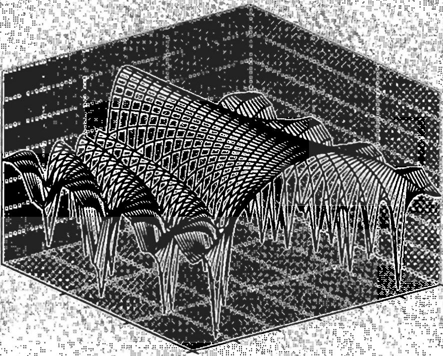

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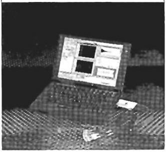

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From the President

At the 60th Meeting of Council, in December last year, I had the privilege of being elected President of the Society for the next year. Unfortunately, it's a position which doesn't come with an instruction manual (perhaps we'll work on one) so, although I have a number of ideas about what I'd like to achieve, I would like to turn to you, the membership of the Australian Acoustical Society, to tell me what you want. I suppose it's almost a cliché now, for every new President to appeal to the membership for ideas and feedback, but it happens to be important, even crucial, to the future development of the AAS. Membership is stable and we are in a healthy financial position, but every organisation such as ours depends upon feedback from its members, brickbats or bouquets, to guide it towards accomplishing the things its constituents want it to achieve, so please feed your ideas to your divisional councillors.

In the meantime, Council has made progress in the past two years and for that I'd very much like to thank retiring President, Charles Don. In addition to attending to the many duties of running the AAS, he has presided over a major overhaul of our Memorandum and Articles of Association, the book of rules which guides and controls the activities of the AAS. The new Articles, which you have all seen and had the opportunity to comment on, was approved by the Annual General Meeting in December and will soon be in effect. Your division will tell you exactly what has been accomplished by the changes, but I would like to thank Charles Don, David Watkins and Geoff Barnes for a sustained effort over the past year in driving the revision process towards its successful conclusion. Copies of the new Articles will soon be posted to all members.

Looking forward, Council has started several new initiatives. First, the AAS web site. It seems mandatory for all organisations such as ours to have a presence on the Internet in order to advertise its existence, to inform the public of its activities, as a public source of information on matters acoustic, as a service to its members and as an administrative tool for divisions and Council. Acoustics Australia has maintained a site for both the society and the journal for several years now and the South Australian Division has recently put up the first divisional site as well as improving the presentation for the society site. Before things went too far and all five divisions started their own, inconsistent sites, Council thought it sensible to form a consensus policy across all states, Council and Acoustics Australia so that we could appear to the electronic world as a single entity with a state-based structure rather than as a collection of anarchic groups. When completed, the policy will ensure that the Australian Acoustical Society presents a single, professional front while still permitting divisions to reflect their own priorities and character.

The Society has a policy of holding an annual conference in each divisional state on a rotating basis, but last year was exceptional in that the conference was held in Adelaide as part of the 5th International Congress on Acoustics and Vibration. 1998 will also be an exception because of the close proximity, temporally as well as geographically, of two major, international conferences. AAS has strongly supported the 1998 International Congress on the Biological Effects of Noise (ICBEN), a prestigious gathering of international experts in Sydney, November 22-26. This is shortly after Internoise 98 in Auckland, November 16-18 and the symposium in Queenstown, November 20, and we expect many of our members to attend. Council therefore felt it would be unlikely that an AAS conference would be a success, resulting in a disappointment for the organising state. To make up for this, however, Council established a new, provisional calendar for future conferences.

Council also requested the Queensland Division to investigate the possibility of making a bid for Internoise 2003, possibly at a venue on or just off the north Queensland coast somewhere. Although an international conference is a major responsibility and a great deal of work for the Society, it also offers great benefits to us in the form of enhanced contacts with practitioners of acoustics from all over the world. It would also provide our members with access to a major international conference at minimal expense. The Queensland Division will report back to Council which will then decide whether to proceed with the bid.

I am looking forward to the next year and I have great confidence that the Society will continue to succeed in its charter of bringing practitioners of acoustics together and sharing their skills and expertise. I personally feel it is time we took the Society into a more public role, advising and lobbying governments on acoustical matters and I'd like to hear your opinions on that.

Graeme Yates

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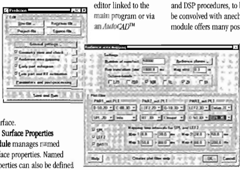

The Surface Properties Module manages named surface properties. Named properties can also be defined directly in geometry files.

The Multiple Source Addition Module creates new echograms based on results from the prediction module. Source directivity, aim, eq and delay can be varied without need for a full re-calculation. The module optionally creates data for multiple source auralization.

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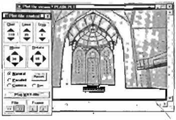

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NON-DESTRUCTIVE TESTING OF COMPOSITES USING LONG WAVES

S. Thwaites and N.H. Clark

CSIRO National Measurement Laboratory,
P.O. Box 218 Lindfield NSW Australia

This paper was awarded the 1997 PRESIDENT'S PRIZE. This prize, established in 1990 by the Australian Acoustical Society, is awarded to the best technical paper presented at the Australian Acoustical Society Conference.

ABSTRACT: A new technique for detecting faults in composite panels has been developed based on measurements of the local phase velocity of low frequency flexural waves. Broadband excitation is used so the method includes source configurations and software to reduce the effect of the reverberant field. An X-Y scanning version has been built employing non-contact methods and a handheld version based on a note book computer has also been constructed. The method has been used on multi-ply panels to determine stiffness matrix elements and lay-up errors. Delaminations and core damage in honeycomb sandwich panels have also been detected via scattering of the waves.

1. INTRODUCTION

Composite materials are rapidly replacing metals in many applications, because of their superior performance and reduced weight. In the aerospace industry in particular, carbon fibre composites are becoming more common. All aerospace structures must be tested at manufacture, and most at regular intervals during service. It has become essential to develop methods of testing which are both cost-effective and practical to implement.

A method has been devised using low frequency acoustic waves, which can detect many typical defects in composite structures. The method supplements manual ultrasonic pulse-echo methods, and the automated "Through Transmission Ultrasound" (TTU) scanners. Unlike the latter, the new method is not limited to structures accessible from both sides, and is also suitable for structures which may be harmed by the water jet couplants of TTU.

2. PHASE VELOCITY

The new method is based on measurement of the phase velocity of acoustic waves travelling in the structure being tested, typically some sort of panel. Continuous broadband vibration is introduced into the panel, and as the resulting waves propagate out from the point of excitation, they are detected by two transducers which are spaced apart by a distance d. In principle, the velocity c of the wave component of frequency f Hz is simply

$$c(f) = 2\pi f d / \phi \qquad (1)$$

where ϕ is the phase difference measured by the two transducers. Any structural anomalies will change the Local Phase Velocity (LPV) of propagation.

In practice it is not that easy. Reflections from boundaries and from structural discontinuities result in a reverberant field which can completely swamp the propagating wave which we are trying to measure. A major feature of the new method is the development of techniques to overcome the reverberant field.

3. THE REVERBERANT FIELD

It has been shown [1] that a propagating wave in a plate is relatively unaffected by a diffuse field, ie a field such as would be created by a large set of uncorrelated random noise sources arranged around the edge of the plate. The present authors [2] have shown that the reverberant field can be made to resemble a diffuse field if the point source of broad-band excitation is either (a) moved along a line, or (b) replaced by a set of uncorrelated point sources arranged along a line. In either case it is advantageous to arrange the line of excitation to be collinear with the LPV measuring points.

4. WAVE PROPAGATION IN COMPOSITE PLATES

The LPV method uses waves which propagate parallel to the plate surface, but with displacements normal to the surface. The type of propagation depends on the plate thickness h. For isotropic plates in which $h < \lambda/5$, where λ = wavelength of the propagating wave, through-thickness shear strain is negligible and the waves are classic bending waves. Propagation is dispersive in this case, ie the phase velocity varies as the square root of the frequency [3].

For thicker isotropic plates, with $h > \lambda/5$, shear strain tends to dominate, and the waves propagate at a velocity which is constant with frequency.

Both types of propagation have been encountered and utilised in developing the LPV method. As composite plates are not generally isotropic, the velocity of propagation varies with direction in a plate, and the condition for transition between dispersive and non-dispersive propagation may differ from the above.

5. MEASURING LOCAL PHASE VELOCITY

An X-Y scanner has been built to implement the LPV method. The required broad-band excitation is by a row of jets supplied with compressed air from a standard workshop compressor. The vibration measuring sensors are two Doppler-laser velocity transducers (Polytec OFV352), which are mounted on the armature of the scanner together with the array of jets. Also on the armature are steering mirrors to direct the laser beams to be approximately normal to the panel, and to direct the returning light into the detectors. The scanner can accommodate panels up to 1.5m wide.

The laser beams impinge on the test panel at points separated by a distance *d*, usually about 30 to 50 mm. The signals from each detector are simultaneously sampled with a fast A/D converter. Both signals are Fourier transformed with a programmable FFT analyzer (hp3567A) which then computes the complex frequency response function (FRF) between the two transformed signals.

To get clear phase information from the measurements, a number of stratagems have been adopted. The first of these is the use of a line array of excitation sources, which makes the reverberant field resemble a diffuse field. A second involves taking an average, in the frequency domain, of several sets of readings taken in quick succession.

For the case of "thin" plates (see **4** above), the program plots the phase of the FRF against $\sqrt{f}$, and thence the phase velocity at frequency *f* is computed as

$$c(f) = 2\pi d\sqrt{f} / S \qquad (2)$$

where S is the slope of a line fitted by least squares to the plot of phase ϕ against $\sqrt{f}$. For "thick" plates, $d\phi/df$ is nominally constant, so ϕ plotted against f instead, and the phase velocity is

$$c = 2\pi d / S \qquad (3)$$

where S is the slope of a line fitted in this case to a plot of ϕ against f.

The phase at each point is computed as the inverse tangent of I/R, where R and I are the real and imaginary parts of the FRF. A further stratagem is to apply a smoothing function, in the frequency domain, separately to the real and imaginary parts of the FRF. This eliminates most of the remaining reverberant effect. Without this step, it is almost impossible to unwrap the propagant phase needed for Eqs (2) and (3).

6. AN APPLICATION TO THIN COMPOSITE PLATES

The local phase velocity was measured and plotted as a function of direction, in 10° steps, on a sample of 3-ply plate 1.2mm thick. Each ply was of carbon fibres woven at 90° to each other (see Figure 3(a)). Excitation and analysis were for the frequency range 5.0 to 17.8kHz, within which the phase varied as ÷f as expected, and the phase velocity for f = 20kHz was calculated from equation (2). An interactive program was developed to fit a 3x3 matrix to stiffness values calculated from these results, shown plotted in Fig 1 (a) and (b). The continuous curve is for the fitted model. Stiffness along each of the principal in-plane axes was found within approximately 5%, and shear stiffness within 10%. A small asymmetry between the x and y directions was clearly distinguishable.

The same technique was applied to a sample of composite plate, approximately 4mm thick, built up from 12 plies of unidirectional fibres. Relative to the principal in-plane axes, successive layers were oriented at angles +45°, 90°, -45°, 0° etc as shown in Fig 3. Velocity measurements were made as before in 10° steps. At angles between 35° and 55°, velocities were found to vary considerably at different locations on the plate; this has been attributed mostly to very small variations in the distance between outer plies and the neutral plane of the plate. For this reason, the points in Fig 2 are averages over several positions on the plate. Even with such averaging, to achieve the fit of the curve in Fig 2 it was necessary to rotate the angle of plies 3 and 10 in the model from –45° to –49°. These results show the localization capability of the technique.

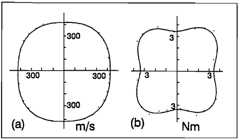

Figure 1. 3-ply carbon fibre composite panel
(a) Phase Velocity versus direction,
(b) Stiffness along fibres versus direction

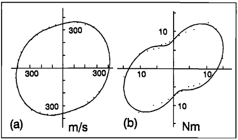

Figure 2. 12-ply carbon fibre composite panel
(a) Phase Velocity versus direction,
(b) Stiffness along fibres versus direction.

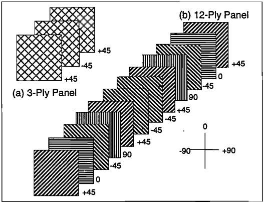

Figure 3. Lay-up of plies in 3-ply and 12-ply panels

7. APPLICATION TO NOMEX HONEYCOMB SANDWICH PANELS

A typical structure in aerospace components is a composite panel with outer skins of 3 to 10 plies of carbon fibre, sandwiching a core of epoxy coated paper in an hexagonal arrangement ("nomex") as shown in Fig 4. The most common defects in such "honeycomb sandwich" structures, also shown in the figure, can occur either in manufacture or in service. Crazed or crushed core, in particular, can be produced by an impact which may leave little visible external damage.

LPV measurements were made on samples of panel which had 10mm nomex cores with skins of 3-ply and 4-ply woven carbon fibre. It can be shown [4] that, for panels such as these, the waves are dominantly shear for frequencies greater than about 1 kHz, thus non-dispersive propagation can be expected and the appropriate equation is (3).

Excitation and analysis was for the frequency range 5 kHz – 30 kHz. Fig 5 shows (outer points) velocity data from a set of measurements at 10° steps. The form of the obvious orthotropic symmetry is due to the double thickness of the honeycomb core walls in the direction of the bond lines, shown in Fig 4. This can be contrasted with the symmetry for the skin alone, also shown for two different frequencies in the two inner sets of points.

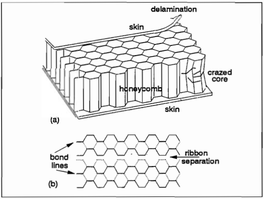

Figure 4. "Honeycomb Sandwich" panel, showing typical defects.

Core damage in panels such as these decreases the core shear stiffness, thus reducing the phase velocity locally. LPV measurements from either face of these panels were able to unambiguously locate artificially produced core damage, as in Fig 6.

Artificially produced delaminations were also detected using the LPV scanner. They could be distinguished from other forms of damage by characteristic patterns of variation in the apparent LPV, as the scan approached and passed over the defect. Fig 7 shows this for a scan collinear with the exciter jets and the detectors: the central dip locates the defect. For the dotted trace, the characteristic peaks and troughs either side of the fault show that the delamination is under the skin on the face being measured. The solid line shows the same delamination measured from the opposite face of the panel; the asymmetry is characteristic. These features have been shown [4] to be due to scattering from the defect, producing distortions of the otherwise rectilinear phase/frequency plot. Fitting a line to such a plot does not give the true LPV, but it clearly distinguishes this type of defect.

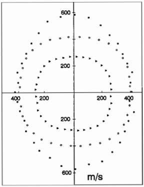

Figure 5. Phase velocity versus direction, honeycomb sandwich panel (outer set of points)

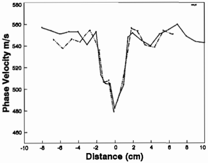

Figure 6. LPV scan across a crushed core defect, measured on the two sides of the panel.

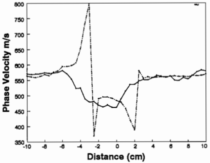

Figure 7. LPV scan across a delamination - - - - - - on same face, ——— on opposite face of panel.

8. A PORTABLE LPV DEVICE

A portable instrument has been developed to enable the LPV technique to be used in the field (or on the tarmac). The main physical components are a laptop computer, a PCMCIA DAQ card, and a measuring probe, which has become known as a "ferret" (Fig 8)

The ferret is a light, hand-held device which incorporates a row of air-jet exciters; these are fed by a hose from a compressor or a cylinder of compressed air. In the front half of the ferret are two ultra-light accelerometers (Endevco 2250-10), attached to self-aligning tips which contact the surface of the test object. The accelerometers are supported in nylon mounts designed to minimize unwanted transmission of waves between the accelerometers, through the ferret body. Behind the accelerometers is surface-mount conditioning electronics. The mounted accelerometers and electronics are matched for phase for frequencies up to 25 kHz. A thumb-operated start button turns on the compressed air, which in turn activates a switch to trigger the data collection and processing.

The data acquisition card (INES DAQi148) incorporates two 14-bit A/D converters synchronized for simultaneous data collection from the two accelerometers. The card can run at up to 330 kS/s per channel, but for this application it is run at 60 kS/s.

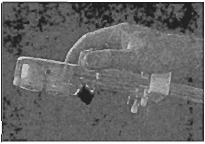

Figure 8. Hand-held LPV probe.

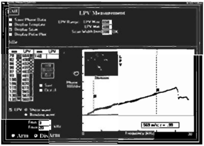

Figure 9. Screen display of portable LPV instrument for rectilinear scan of a composite panel.

All the data processing is carried out by routines in a Visual Basic program developed as an essential part of this instrument. The processes include Fourier transforms, frequency response, averaging, smoothing, phase unwrapping, line fitting, velocity calculation, plotting and screen displays. LPV analysis is generally carried out within the range 2 to 25 kHz, but these limits can be adjusted if necessary.

Fig 9 is a typical screen display. The main section shows a phase/frequency plot for the most recent measurement on a panel. Inset shows results, as velocity/distance, at several points stored from a scan across a core defect. A phase/frequency plot can be stored as a template, from a measurement on a supposedly fault-free section of the panel. This template can be displayed in the main section for rapid comparison with the latest measurement. Fig 10 is similar, but the inset shows results of LPV versus angular direction in a panel.

The computer used for the prototype was a "Fieldworks" ruggedized laptop, but many other laptop or notebook computers would be suitable, provided that they can accommodate a type II PCMCIA card and supply sufficient current to drive the electronics.

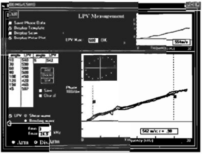

Figure 10. Screen display for a scan of LPV versus direction in a composite panel

9. CONCLUSION

A new method, Local Phase Velocity (LPV), has been developed for non-destructive testing of composite panels using plate waves at frequencies less than 50 kHz. The method complements existing ultrasonic techniques for detecting defects. An X-Y scanner has been constructed to perform automated non-contact scans over panels up to 1.5 m wide. A portable device has also been developed to implement the method.

ACKNOWLEDGEMENTS

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REFERENCES

1. J.S.Bendat & A.G. Piersol, *Engineering Applications of Correlation and Spectral Analysis.*(Wiley), 1980, pp170-173.
2. N.H.Clark & S.Thwaites, 1995 *Journal of Sound and Vibration* **187**, 241-252. Local Phase Velocity Measurements in Plates.
3. L.Cremer, M.Heckl & E.E.Ungar, 1973 *Structure-borne Sound.* Berlin: Springer-Verlag. pp87-115.
4. S.Thwaites & N.H.Clark, 1995 *Journal of Sound and Vibration* **187**, 253-269. Non-Destructive Testing of Honeycomb Sandwich Structures using Elastic Waves.

NOISE REDUCTION FOR FRICTION SAWS

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Friction saws are used extensively in industry to cut steel and aluminium pipes and structural sections. In many cases they may be the only type of saw which is suitable for the task or because of their speed. The noise levels from friction sawing are such that there is a high potential for hearing damage for the operator and for others in the area. The findings from an investigation of methods for noise reduction for a friction saw are presented. The potential for noise reduction by changing various parameters associated with the sawing process and by the application of damping to the saw and to the product is discussed.

1. INTRODUCTION

A friction saw is a type of circular saw which is commonly used in the metal manufacturing industry in situations where other sawing techniques are not suitable. Friction saws have fine teeth and operate at high speeds. They produce a cut via a friction action which causes localised heating and a softening of the metal in the workpiece. The cut surface is generally rougher than for other metal sawing operations. Friction saws are used to cut thin materials because of their fast cutting speeds and reduced tendency to jam or grab the workpiece. Friction sawing often produces excessive noise levels for the operators so that it is often necessary to use the highest grade of personal hearing protection. When it is not practical to isolate the friction sawing operation to a separate area, its use may also lead to a high noise exposure for workers nearby. In many cases there are no suitable alternatives to the friction saw for cutting the product. While there has been considerable research into noise generation and subsequently noise reduction measures, for other types of saws, there has been little investigation of the noise from friction saws [1].

In this paper, the findings of a research project with the goal to reduce the noise exposure for the operators of a friction saw used to cut thin walled metal pipes are discussed. The effects on the cutting noise of saw blade parameters, such as diameter, material, thickness, tooth profile and tooth number, and of product parameters, such as production speed, pipe diameter, material and thickness, were investigated. Then experiments concentrated on various noise reduction techniques which apply damping or restraint to the saw blade or the pipe. Limited laboratory testing was also conducted to investigate variable saw speeds and feed rates which were not available in the factory environment. Despite the case study nature of much of this project, general conclusions can be drawn about the nature of noise from friction sawing and about practical noise reduction methods.

2. CASE STUDY - HELCOR SAW

Figure 2.1 Helcor machine. Flat sheet enters formers on the left then is spiral wound and seamed. The completed pipe emerges on right. An operator is standing near the saw assembly.

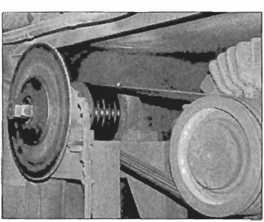

Figure 2.2: Friction saw and pulley assembly used in Helcor machine

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The friction saw selected for this case study is used to cut-to-length 'Helcor pipe' which are manufactured by roll forming sheet steel or aluminium and then forming a pipe by spiral winding and seaming. The Helcor production machine, shown in Figure 2.1, is used to produce a range of products with diameter varying from 300 to 3600 mm and wall thickness from 1.5 to 3.5 mm which are cut to the length required by the customers. The chrome-vanadium friction saw blade normally used, shown in Figure 2.2, is 400 mm diameter and 6 mm thick with 240 v-type teeth. The normal rotational speed is 4350 rpm. The pipe is cut 'on the fly' while the production process continues. The saw assembly moves along with the product and is mounted on rails below the pipe. When the cut is complete the saw retracts into the assembly which then moves back ready to cut the next pipe.

3. MEASUREMENT PROCEDURES

The majority of the noise measurements were made during the production of steel pipes with a metal wall thickness of 1.6 mm and with 68 mm x 13 mm corrugations (i.e. corrugations which have a 13 mm peak to trough wave height and a 68 mm wave length). Although the operator was actually closer to the saw, it was impractical to locate the sound level meter (SLM) at a point closer than 2 m to the side of the saw table. This position avoided interference with the operator and damage to the microphone from sparks and debris.

Both noise and vibration measurements were undertaken during production. The noise level of each cut was characterised by measuring the L_{eq} over the full duration of the cutting of a pipe. The data presented in the following sections are the averaged results for a number of such tests for each condition. The repeatability was good, within ± 1 dB(A).

A milling machine was used to conduct some tests under laboratory conditions. Although the milling machine allowed better control of rotational speed and product feed rate than with the Helcor production facilities, the milling machine had limited power and a low maximum spindle (saw) speed. Actual noise levels in laboratory tests were lower due, *inter alia*, to differences in workpiece geometry and clamping arrangements. Hence noise levels in laboratory tests are not directly comparable to noise levels in production conditions, however the effects of parameter changes are comparable.

4. SUMMARY OF FINDINGS

4.1 Product Parameters

The first investigations involved determination of the effect of product parameters on the noise output. It was found that increasing the pipe diameter and increasing the thickness of the pipe material both led to an increase of up to 5 dB(A) in the noise level. This indicates that different modes of vibration were excited and that there was difference coupling between the pipe and the saw blade but it was not possible to examine this in detail within the framework of this project. The effects of changes to the various parameters related to the production process are summarised in Table 1.

DESCRIPTION OF ACTION	EFFECT on CUTTING NOISE
CHANGES TO SAW BLADE	
Metal spray one side: low carbon steel	Decrease 4 dBA
Damping sheet on blade	Decrease 2 dBA
Damping collars on blade	No change
Different tooth profiles	Increase 3 to 7 dBA
CHANGES RELATED TO SAW OPERATION	
Saw rotation clockwise vs anticlockwise	Increase 1 dBA
Saw speed increase: 2060 to 4350 rpm with pulleys	Decrease 7 dBA
Tip speed increase: 375 to 400 mm diameter blade	Increase 4 dBA
Production speed increase: 2.41 to 4.68 m/min, gear 2 to 3	Increase 1 dBA
Production speed increase: 4.68 to 11.31m/min, gear 3 to 5	Increase 4 dBA
MAINTENANCE	
New bearing, replace worn bearing on saw shaft	Decrease 3 dBA
Sharpened saw teeth	Decrease 3 dBA
DAMPING OF PRODUCT	
Flat metal bands wrapped on pipe at 50 mm from saw	Decrease 2 dBA
Profiled metal bands wrapped on pipe at 25 mm from saw	Decrease 3 dBA
Loaded vinyl over pipe at 200 mm from saw	Decrease 2 dBA
Damping of guide rollers	Decrease 1 dBA
CUMULATIVE EFFECTS	
Damping sheet on blade plus minimum production speed	Decrease 5 dBA
Above plus product damping	Decrease 6 dBA
Metal spray on blade plus minimum production speed	Decrease 7 dBA
Above plus product damping	Decrease 10 dBA

Table 1: Effect on noise level in terms of L_{Aeq} for changes in various parameters.

4.2 Changes to Saw Blade

Three different methods for damping the blade were investigated. Two of these were conventional approaches to damping by the application of damping sheet to the blade and by the use of damping collars. However greater reduction was achieved with the use of a blade treated with a low carbon steel metal spray. An annulus 100 mm wide (145 mm inner diameter, 245 mm outer diameter) and 1 mm thick was machined in one surface of the blade. This annulus was then overfilled with metal spray. The blade was remachined in the region of the metal spray so that a smooth surface resulted. The natural frequencies and their damping factors for the normal blade and the blade with the metal spray treatment were investigated with the aid of modal analysis. The resonant frequencies for the modes were found to be very close for the two blades and the differences between the damping factors are shown in Figure 4.1.

Helcor pipes are currently cut using v - type profiles. Other profiles tested were pendulum profile (inverted v), brobo style (one side bevel alternately) and Hi-lo profile (alternate square/trapezoidal). It was clear that the currently used v - type produced lower noise level and the reasons for this need further investigation.

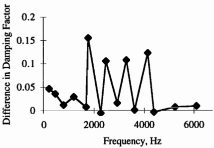

Figure 4.1: Increase in damping factor (%) for the blade with metal spray as compared with the normal blade.

4.3 Changes to Saw Operation

Increases in the production speed, ie the rate at which the product passes the blade, and the blade tip speed led to increases in the noise level. It was only by increasing the saw speed that a reduction in the noise level was achieved. From the laboratory tests it was found that noise levels depended on both feed rate and saw speed in a non-linear manner. However the practical limitations associated with the operation of the Helcor saw restricted the number of options that could be investigated.

4.4 Maintenance

These findings showed that maintenance is important in minimising noise output. The regular sharpening of the teeth and the replacement of worn bearings can assist to reduce the noise level for the operation of the saw and while it is idling.

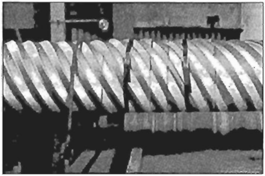

Figure 4.2: Profiled bands on both sides of the cutting line.

4.5 Product Damping

From the analysis of the noise and the vibration data, it was clear that vibrations induced in the product by the sawing process were a major source of radiated noise. As the Helcor pipe production process requires pipe rotation during cutting, this does not allow the simple methods of clamping to improve damping and restraint on the workpiece. However several techniques were investigated with the primary aim was to determine the effectiveness and with the recognition that considerable development would be required for the production environment.

Greater reduction was achieved with the use of metal bands having the same profile as the product so that the damping was applied to the full circumference of the pipe. Figure 4.2 shows the set up with the profiled bands, secured with metal straps on the pipe at 25 mm from the saw cutting line for which a reduction of 3 dB(A) was achieved. This result indicates that dampening the pipe close to the saw cutting line could reduce the radiated noise.

4.6 Combinations

After the effects of individual parameters and some noise reduction techniques were determined, the cumulative effects of both optimising various parameters and applying control techniques were investigated. An overall noise reduction of 10 dBA was achieved from the optimised operation of the saw plus noise control measures, including blade damping, minimum production speed and product damping. Blade damping and minimum production speed, leading to a reduction of 7 dBA, can readily be immediately applied to the Helcor production process. The pipe damping needs considerable development for use in normal production.

It would appear from the tests on the Helcor saw that the normal operating conditions are close to an optimum as, with the exception of the replacement of the bearing, all the changes to the operation of the saw led to increased noise levels. The greatest potential for the reduction of the overall noise level appears to be from changes to the saw blade and with the application of damping to the product.

4.7 Operator Noise Exposure

The use of minimum production speed effects the time duration for the cutting noise. This consideration, combined with the very high noise from the friction sawing, means that a reduction of 10 dBA is not sufficient for the operator of this particular machine to dispense with personal hearing protection. However such a reduction would enable the use of lower grade hearing protectors. In addition, the improvement would assist in reducing the noise exposure for the other workers in the factory.

In this case an enclosure for the machine is not practical so the remaining option is an enclosure for the operator. The demands on such an enclosure would be reduced following the reduction of the noise at the source.

5. CONCLUSION

This study has shown that significant reductions in noise from friction sawing can be achieved through the following types of measures.

- Optimising Sawing Parameters. In particular optimising the saw rotational speed, the product feed rate, the blade thickness and the tooth profile can reduce noise.

- Blade Damping. Blade damping through the application of metal sprays or damping materials was found to be an effective noise reduction technique.
- Product Damping or Restraint. Product vibration was shown to be a major source of noise in friction sawing which could be reduced by providing improved damping or restraint for the product.

For a particular application of friction sawing, the amount of noise reduction which can be achieved will need to be explored on a case by case basis. However, in the case study reported here, a 7 dBA reduction was readily achieved by practical measures. Combined with product damping, where practical, the reduction could be increased to 10 dBA. Such a reduction can be worthwhile even if it is insufficient to allow the operator to dispense with personal hearing protection. This reduction can enable the use of lower grade hearing protectors, can greatly improve working conditions for personnel in other parts of a factory and reduce the extent of noise reduction required by an enclosure.

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REFERENCES

1. Williamson, H. and Burgess, M. (1994) "Sawing Noise from a Helcor Pipe Production Machine - Strategy Study", *Report No. AVC 9405*, Acoustics and Vibration Centre, University College, University of New South Wales, Australian Defence Force Academy.
2. Kanapathipillai, S., Williamson, H. and Burgess, M. (1996). "Helcor Noise Control Project - Final Report", *Report No. AVU 9618*, Acoustics and Vibration Unit, University College, University of New South Wales, Australian Defence Force Academy.

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SOFTWARE FOR NOISE AND AIR POLLUTION MODELING

WORKERS COMPENSATION FOR INDUSTRIAL DEAFNESS

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ABSTRACT: In 1997, the final report of the Heads of Workers Compensation Authorities made the following recommendations: a percentage loss of hearing (PLH) threshold of 10% will apply for compensability but a PLH of 5% or greater will trigger rehabilitation for the worker and workplace assessment as a preventive initiative; where the threshold for compensability is attained, the full PLH will be compensated; and subsequent claims must demonstrate at least a further 5% deterioration from the previous PLH. The relationship between PLH and requirement for hearing aids and the retest variability of PLH were investigated in order to obtain information that could be used to assess these recommendations. Requirement for hearing aids begins at a PLH of about 5% for some clients and approximately 16% of claimants with a PLH between 5 and 9.9% will require hearing aids. It seems more reasonable, therefore, to set a PLH threshold for compensation of 5% rather than 10%. The standard deviation of the retest variability of PLH was found to be 1.94%. This means that a change in PLH of 4.5%, or 5% when rounded to the nearest whole percentage point, is significant at the 1% level. The recommendation that an increase in PLH of 5% must occur before any subsequent claim can be made therefore seems reasonable.

1. INTRODUCTION

The term "hearing loss" is ambiguous: it can mean impairment of the threshold sensitivity of the ear (threshold impairment) or it can mean loss of the ability to hear in everyday life (hearing disability). Threshold impairment and hearing disability must be distinguished from one another. The common use of the the term "hearing loss" refers to hearing disability, i.e., loss of the ability to hear the sounds of everyday life.The results of research that has been carried out so far indicates that threshold impairment in a person with initially normal hearing must reach about 20 dB before hearing disability begins to occur. This conclusion has been based mainly on reports of hearing disability by people with threshold impairment. However, it should be realised that people with impaired hearing tend to underestimate the extent of their impairment and that continuing research into subtle hearing abilities, such as the localisation of sources of sound, is likely to reveal that there are disabilities associated with lesser degrees of threshold impairment than 20 dB. It seems likely, therefore, that further research will result in tables of hearing disability which begin at threshold impairments less than 20 dB. However, current trends in compensation for industrial deafness are moving in the opposite direction.

Throughout Australia, hearing disability is assessed for compensation purposes in terms of percentage loss of hearing (PLH), determined from the hearing threshold levels of the compensation claimant [1]. The cost of compensation for industrial deafness in Australia has escalated in recent years. Figure 1 shows that the cost of compensation claims for industrial deafness in New South Wales grew from about 12 million dollars in 1988 to about 101 million dollars in 1996. Faced with increasing costs of this kind, the response of some statutory authorities and legislators has been to introduce thresholds of PLH, of the order of 5 - 10%, that must be exceeded in order for claimants to be eligible for compensation. In South Australia and Northern Territory, the threshold is currently 5%, in New South Wales 6%, in Victoria 7% and in Western Australia 10%.

Since a large proportion of compensation claims for industrial deafness are for a PLH of 5% or less, a threshold for compensation of this order means that the costs of many claims and the associated administrative costs are avoided. This is illustrated in Table 1 which shows, for New South Wales, the number of industrial deafness claims from 1995/96 in various payment categories. With an approximate relationship of $1000 compensation for each percentage point of PLH, it can be calculated that introduction of a compensation threshold of 6% reduces claims to less than 40% of the original number. In the case of a compensation threshold of 10%, claims would be reduced to about 20% of the original number.

In 1994, the Industry Commission Report on Workers Compensation in Australia [2] recommended that a common Table of Injuries be developed to apply across all Australian jurisdictions. As a result, the Heads of Workers Compensation Authorities included this as a part of the national harmonisation process. Review of PLH thresholds has formed part of the review under the Standardised Measurement of Impairment Project. In 1997, the final report of the Heads of Workers Compensation Authorities [3] recommended that:

a PLH threshold of 10% apply for compensability; but

a PLH of 5% or greater will trigger rehabilitation for the worker and workplace assessment as a preventive initiative;

where the threshold for compensability is attained, the full PLH is compensated; and subsequent claims must demonstrate at least a further 5% deterioration from the previous PLH.

The following work was carried out in order to provide information that can be used in assessing these proposals. Two relevant matters were investigated: first, the relationship between PLH and requirement for hearing aids; second, the retest variability of PLH.

TABLE 1

HEARING LOSS CLAIMS IN NSW IN 1995/96

Payment in Dollars	Number of Claims
0-999	3286
1000-1999	761
2000-2999	729
3000-3999	637
4000-4999	565
5000-5999	504
6000-6999	489
7000-7999	493
8000-8999	433
9000-9999	365
10000-14999	1214
15000-19999	364
20000+	593
TOTAL	10413

2. RELATIONSHIP BETWEEN PERCENTAGE LOSS OF HEARING AND REQUIREMENT FOR HEARING AIDS

The relationship between PLH and requirement for hearing aids was investigated in two ways. In the first approach, a sample of the hearing thresholds of 436 child and age pensioner clients provided with hearing aids by Australian Hearing Services was drawn at random from files and the binaural PLHs of the clients were calculated from their thresholds. The results are shown in Table 2. The one client in the category 0-4.9% had a PLH of 4.9%. This result indicates that some clients with a PLH of about 5% require hearing aids.

In the second approach, the associated binaural PLH was calculated from the hearing thresholds of 282 war veterans whose threshold impairments were mainly due to noise exposure and whose requirements for hearing aids were known. The results are shown in Table 3. No veterans with a PLH in the range 0-4.9% required hearing aids. All of the veterans with a PLH of 20% or greater required hearing aids. In the intermediate ranges, the percentage of veterans requiring hearing aids gradually increased. A graph of the findings with a straight line fitted to the data is given in Figure 2. The real function underlying the relationship apparent in the data is probably sigmoidal but the straight line is a satisfactory approximation for practical purposes. Given the illustrated linear relationship and an even distribution of the number of claimants through the range of PLH from 5 to 9.9%, it can be calculated that approximately 16% of claimants with a PLH between 5 and 9.9% will require hearing aids. The results of this approach also indicate that the requirement for hearing aids begins at a PLH of about 5%. This conclusion is supported by findings in a study of hearing impairment in the Western Australian noise-exposed population. Monley et al. [4] reported that examination of the associated group mean audiogram suggests that a noise-induced PLH of 5% would require consideration of hearing aids and rehabilitation.

These findings do not mean that hearing disability begins to occur at a PLH of 5%. Hearing disability exists if the PLH is 0.1% or greater. The requirement to use a hearing aid does not begin at the point at which hearing disability begins. Hearing disability must reach a certain degree (for some people, a PLH of 5%) before the advantages of hearing aid use outweigh the associated disadvantages.

TABLE 2

PERCENTAGE LOSS OF HEARING OF CHILDREN AND AGE PENSIONERS WITH HEARING AIDS

Percentage Loss of Hearing	Number of Clients
0-4.9	1
5-9.9	10
10-14.9	22
15-19.9	39
20-24.9	33
25-29.9	31
30-34.9	48
35-39.9	47
40-44.9	28
45-49.9	36
50-54.9	17
55-59.9	26
60-64.9	23
65-69.9	15
70-74.9	14
75-79.9	9
80-84.9	8
85-89.9	7
90-94.9	5
95-99.9	16
100	1

3. RETEST VARIABILITY OF PERCENTAGE LOSS OF HEARING

Percentage loss of hearing is obtained from the claimantís hearing thresholds by means of the National Acoustic Laboratories procedure [1]. Since there is retest variability associated with hearing thresholds and PLH is derived from hearing thresholds, there is retest variability associated with PLH. The purpose of the following investigation was to determine the retest variability of binaural PLH from the known retest variability of hearing thresholds. It is well known that, in the absence of a real change in threshold sensitivity, hearing thresholds vary on retest in accordance with the law of random error and the changes are, therefore, normally distributed and that there are no correlations between the random variations of the thresholds at the various test frequencies.

TABLE 3

RELATIONSHIP BETWEEN PERCENTAGE LOSS OF HEARING AND REQUIREMENT FOR HEARING AIDS FOR WAR VETERANS

Percentage Loss (%)	Number of Clients	With Hearing Aids	Without Hearing Aids	Percentage with Hearing Aids
0-4.9	47	0	47	0
5-9.9	21	3	18	14.3
10-14.9	17	9	8	52.9
15-19.9	20	16	4	80.0
20+	177	177	0	100

The audiograms of 684 war veteran, child and age pensioner clients who had been provided with hearing aids by Australian Hearing Services were obtained from files and the associated binaural PLH was calculated. The thresholds were then varied randomly in accordance with the standard deviations of test-retest differences reported by Jerlvall and Arlinger [5] for cochlear hearing losses tested in steps of 5 dB, using a function in the statistical program CSS:Statistica which provides a random real number from a normal distribution with a mean of zero and a given standard deviation. The values of the standard deviations used in the calculation of the changes are shown in Table 4. The value at 1500 Hz was obtained from those given by Jerlvall and Arlinger at 1000 and 2000 Hz by linear interpolation on a logarithmic scale of frequency. The calculated changes were rounded to the nearest 5 dB. The associated PLH was then re-calculated and the differences between the PLH before and after the random changes were determined. The standard deviation of the distribution of differences was found to be 1.94%. This means that a change in PLH of 3.2 % is significant at the 5% level or, adopting a more stringent criterion of statistical significance, a change in PLH of 4.5% is significant at the 1% level.

TABLE 4

STANDARD DEVIATIONS OF RETEST VARIABILITY FOR COCHLEAR HEARING LOSSES TESTED IN STEPS OF 5 DB

Frequency (Hz)	Standard Deviation (dB)
500	3.73
1000	3.02
1500	3.15
2000	3.24
3000	3.93
4000	4.44

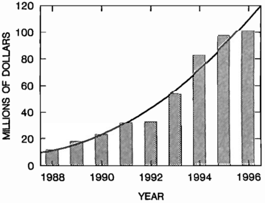

Figure 1. Cost of workers compensation for deafness in New South Wales (1988-1996).

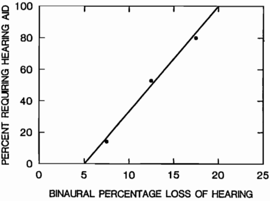

Figure 2. Relationship between percentage loss of hearing and requirement for hearing aids.

4. CONCLUSIONS

The Heads of Workers Compensation Authorities recommend that a PLH threshold of 10% apply for compensability and that a PLH of 5% will trigger rehabilitation for the worker and workplace assessment as a preventive initiative. In the light of the information presented in this article, it would seem more reasonable to set a PLH threshold of 5% for compensation. Figure 2 shows that about 33% of those with a PLH of 10% can be expected to require hearing aids. Requirement for hearing aids begins at a PLH of about 5% for some clients and approximately 16% of claimants with a PLH between 5 and 9.9% will require hearing aids. If a 5% threshold is adopted then there is no need for a trigger for rehabilitation but a trigger for workplace assessment as a preventive initiative should be set at a PLH of 0.1% or greater, since a considerable amount of threshold impairment occurs before the onset of hearing disability. Monitoring audiometry in industry should detect this threshold impairment and trigger preventive action but an extra trigger in terms of PLH may be useful in circumstances where monitoring audiometry is not carried out. If, instead of a threshold of 5%, a threshold of 10% is adopted, the PLH trigger of 5% for rehabilitation and workplace assessment as a preventive initiative becomes especially important. The approved rehabilitative measures should include the provision of hearing aids, where appropriate, since about 16% of claimants with a PLH in the 5 to 9.9% range will need hearing aids.

The Heads of Workers Compensation Authorities also recommend that an increase in PLH of 5% must occur before any subsequent claim can be made. This seems to be a reasonable proposal in view of the results presented in this article. If the more stringent 1% criterion of statistical significance is adopted, then a change in PLH of 4.5% is required before a real change in PLH can be considered to have occurred. This becomes 5% when rounded to the nearest whole percentage point.The error rate for a significance level of 1% is 1 in 100, i.e., for 1 out of every 100 claimants with an increase in PLH of 5%, the increase will not be real. However, for the remaining 99 claimants, a real increase in PLH has occurred. This is a suitably low rate of error. The recommendation that an increase in PLH of 5% must occur before any subsequent claim can be made therefore seems reasonable.

REFERENCES

1. J.H. Macrae, "Improved Procedure for Determining Percentage Loss of Hearing." *NAL Report No. 118*, National Acoustic Laboratories, Sydney, 1988.
2. "Industry Commission, Workers Compensation in Australia. Report No. 36", Australian Government Publishing Service, Canberra, 1994.
3. "Heads of Workers Compensation Authorities, Promoting Excellence - National Consistency in Australian Workers Compensation. Final Report", Heads of Workers Compensation Authorities, Melbourne, 1997.
4. P. Monley, A. West, D. Guzeleva, D. Anh Dinh and J. Tzvetkova, "Hearing impairment in the Western Australian noise exposed population", *Aust. J. Audiol.* 18, 59-71, 1996.
5. L. Jerlvall and S. Arlinger, "A comparison of 2-dB and 5-dB step size in pure-tone audiometry", *Scand. Audiol.* 15, 51-56, 1986.

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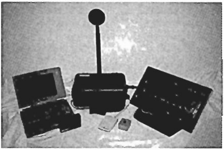

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Broadband Microphone Arrays for Speech Acquisition

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Abstract: A microphone array provides an effective means of hands-free speech acquisition, finding application in large-room video-conferencing, desktop teleconferencing, and hands-free telephony. Unlike a single omni-directional microphone, the array provides high spatial directivity, allowing it to attenuate room reverberation and other unwanted noise. In this paper, we give an overview of the techniques available for speech acquisition using microphone arrays. In particular we will focus on methods of frequency-invariant beamforming, in which the array maintains the same spatial response over a wide frequency range.

1. INTRODUCTION

Hands-free audio communication finds use in many applications, including desktop teleconferencing and hands-free telephony. In these situations the desire is for a high-quality audio input, but without the requirement for the user to either hold or wear a microphone; this is especially important for hands-free telephones in cars. An effective technique for hands-free speech acquisition is microphone arrays. This technology was first applied to large-room teleconferencing in the early 1980s [1]. There has been a renewed interest in microphone arrays because of the increasing capability of cheap digital signal processors — the computational requirements of simple arrays will now comfortably fit on a single DSP chip. The purpose of this paper is to give an overview of the techniques for speech acquisition using microphone arrays, focusing on so-called *frequency invariant beamforming* methods.

2. THE SPEECH ACQUISITION PROBLEM

In hands-free speech acquisition applications the desired signal is corrupted by interfering noise, either from independent sources (such as fans, other talkers, etc.) or room reverberation. In general, these interfering signals originate from points in space separate from the location of the desired source, i.e., the talker's mouth. It is this spatial dimension which is exploited by microphone arrays in order to obtain a high-quality speech signal. By forming a directional microphone, the array is able to pass signals originating from some desired location while attenuating signals arriving from other directions. Unlike a fixed directional microphone (such as a boom microphone), the microphone array is able to adapt to changing signal environments and automatically follow the talker as he or she moves about.

In order to make the following discussion more concrete, consider the linear array shown in Fig. 1. For a single source, the time signal received at the nth microphone is given by

$$y_n(t) = s(t - \tau_n), \tag{1}$$

where $s(t)$ is the source signal, and τ_n is the time delay to the nth microphone (relative to the origin $x = 0$). The time delay to each microphone depends on the microphone location as well as the source position. Assuming the source signal is in the farfield of the array (see [2, 3] for nearfield sources), the delay to the nth sensor is given by

$$\tau_n = x_n c^{-1} \cos\theta, \tag{2}$$

where x_n is the location of the nth microphone, c is the speed of wave propagation, and θ is the direction to the source (measured relative to the array axis).

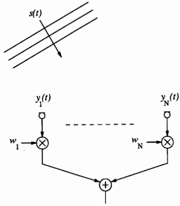

Figure 1. General linear array. The source signal is denoted by $s(t)$, $y_n(t)$ is the signal received at the nth microphone (only the first and last microphone in the array are shown), w_n is the weight applied to the nth microphone signal, and $z(t)$ is the array output.

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The general idea of the microphone array is to apply a complex weight — more generally, a filter — to each microphone signal, and then sum the resulting signals to form the desired output; see Fig. 1. Thus, the output of the microphone array is given by

$$\begin{aligned} z(t) &= \sum_{n=1}^{N} w_n \, y_n(t) \\ &= \sum_{n=1}^{N} w_n \, s(t-\tau_n), \end{aligned} \tag{3}$$

where w_n is the complex weight applied to the nth microphone; it is the design of these weights that is of interest here. The array output is usually expressed in terms of frequency, giving

$$Z(f) = S(f) \sum_{n=1}^{N} w_n \, e^{j2\pi f \tau_n}, \tag{4}$$

where $S(f)$ is the Fourier transform of the time signal $s(t)$.

Since we are particularly interested in how the array performs in passing signals from a given direction and attenuating signals from other directions, we will consider its spatial response, or *beampattern*, defined by

$$b(\theta) = \sum_{n=1}^{N} w_n \, e^{j2\pi f c^{-1} x_n \cos\theta}. \tag{5}$$

Note that the beampattern is given by the array output, $Z(f)$, after factoring out the common signal term, $S(f)$. For a source at a location θ, the beampattern gives the transfer function to the array output.

The typical properties of a beampattern are: (i) signals arriving from a certain spatial region (called the *main beam*) are passed by the beamformer with little or no attenuation; and (ii) signals arriving from other directions (called the *sidelobes*) are attenuated by the beamformer. Thus, the beamformer acts as a spatial filter, and it is this spatial selectivity which makes the beamformer an effective tool in removing unwanted noise from speech. Refer to [4] for more details of beamforming.

If the microphones are equally spaced, then equation (5) reduces to a Fourier series, and digital filter theory can be used to design the array weights. The use of digital filter design tools is a very useful technique for narrowband array design. However, if the array is to be used for broadband signals (such as speech), more sophisticated design techniques are required.

3. BROADBAND BEAMFORMING

The results presented so far have been for a narrowband array operating at a single frequency. In many classical array problems (such as radar or digital communications), this narrowband assumption is valid, and narrowband techniques are effective. However, speech is a broadband signal covering several octaves, and narrowband techniques are ineffective. To understand why this is so, consider again the linear array shown in Fig. 1.

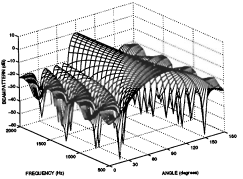

Figure 2. Spatial response of a narrowband array operated over a wide bandwidth (the magnitude of the beampattern).

At a given frequency, a large array with many elements has a very narrow main beam, whereas a small array has a broad main beam; the important dimension in measuring an array is its size in terms of wavelength. Thus, for high frequency signals (having a small wavelength) a fixed array will look large, and the main beam will be narrow. However, for low frequency signals (large wavelength) the same physical array appears small, and the main beam will spread out.

This is illustrated in Fig. 2, which shows the beampattern of an array designed for 1.5 kHz, but operated over a frequency range of 500 Hz to 2 kHz. The frequency variation of this beampattern is unacceptable for speech applications. If an interfering speech signal is present at 60° say, then ideally it should be attenuated completely by the array. However, because the beam is broader at low frequencies than at high frequencies, the interfering speech signal will be low-pass filtered rather than uniformly attenuated over its entire band. This "spectral tilt" results in a disturbing artifact in the array output.

One common approach to overcome this problem is to use harmonically nested subarrays [5, 6]. In this case, the array is composed of a set of nested equally-spaced subarrays, each of which is a single-frequency design. The outputs of the subarrays are then combined by appropriate bandpass filtering. The effect of harmonic nesting is to reduce the beamwidth variation to that which occurs within a single octave. A set of subarray filters can be used to interpolate to frequencies between the subarray design frequencies [7, 8].

The first successful design for a broadband array with a constant spatial response in terms of frequency, was presented by Doles and Benedict [9]. They used the asymptotic theory of unequally-spaced arrays to derive relationships between beampattern characteristics and functional requirements on sensor spacings and weightings. This results in an array with filters on each sensor, the outputs of which are summed to form the final beamformer output. These sensor filters create a space-tapered array: at each frequency the non-zero filter responses identify a subarray having total length and spacing appropriate for that frequency. Although their design method provides a frequency invariant beampattern over a specified frequency band, it is based on a specific array geometry and beampattern shape.

Prompted by the work of Doles and Benedict, we derived in [10] a very general design method for broadband frequency invariant beamformers, suitable for linear, planar and even three-dimensional arrays. Our approach was to develop a frequency invariant beampattern property for a theoretical continuous sensor, and then to approximate this sensor by an array of discrete sensors. Thus, the problem of designing a broadband frequency invariant beamformer reduces to one of providing an approximation to a theoretically continuous sensor.

The basic structure of our frequency invariant beamformer is shown in Fig. 3. This block diagram illustrates the important properties of the beamformer. First, the filter response required on each microphone can be separated into two components: (i) the *primary* (beam-shaping) filter, and (ii) the *secondary* (normalization) filter. The primary filters, denoted by $H(x_n/x_{\text{ref}}\,f)$ in the figure, perform the role of maintaining a constant beampattern shape as a function of frequency; they have a low-pass characteristic and are all related by a frequency dilation property. The output of each primary filter is multiplied by a constant *spatial weighting term*, g_n (which is dependent only on the microphone locations), and these signals are then summed. Finally, the secondary filter, denoted by αf, (which is simply a differentiator and serves to normalize the peak beampattern response) is common to all microphones and is implemented after the summation.

From an implementation standpoint, the most important of these properties is the dilation property of the primary filters. This property means that all primary filters are derived from a single set of filter coefficients, called the *reference coefficients* [11]. Hence, to change the beampattern it is only necessary to change the reference coefficients, and the beamforming structure ensures that the resulting beampattern will be frequency invariant. This is an important property for adaptive beamforming, since it reduces the number of adaptive parameters which must be updated at each step; an adaptive algorithm exploiting this property was presented in [12].

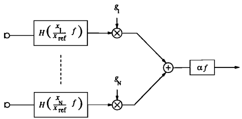

Figure 3. Block diagram of frequency invariant beamformer. The location of the nth microphone is given by x_n, x_{ref} is the location of a theoretical reference microphone, $g_n, n = 1, \ldots, N$, are a set of spatial weighting terms dependent only on the array geometry, and α is a normalization constant..

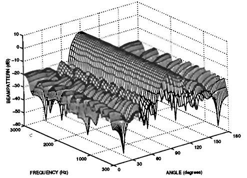

Figure 4. Magnitude of beampattern of an example frequency invariant beamformer.

A typical spatial response obtained with a frequency invariant beamformer is shown in Fig. 4. The design is for a frequency range of 300–3000 Hz, requiring 20 microphones. Notice that, as desired, the beampattern is (almost) frequency invariant over the entire band, exhibiting an almost constant main beam, and only slight ripple in the sidelobe region (c.f. Fig. 2 for a naive design).

4. SOME OTHER ISSUES

The above considerations are entirely theoretical. Can one actually implement microphone arrays with real microphones? In particular, can one achieve the theoretically determined performance using cheap microphones? We have an on-going experimental program to determine this, and certainly have illustrated some simple designs in practice. Some of the factors that are important in practically implementing microphone arrays using digital signal processing technology are:

- Variability between microphones — this affects the null depth considerably, but the main beam pattern and width little. It is also amenable to theoretical analysis.
- Beamsteering — in order to electronically direct the main beam where desired, it turns out that one needs to implement fractional delay filters [13]. These can be combined with the primary filters.
- If the microphone array is used in a small room then the planar wavefront assumption is not valid. In later work [2, 3, 14] we have extended the farfield broadband beamformer to the nearfield case. This work makes use of a standard representation of the signals in a spherical harmonic expansion. The resulting beamformer structure has an additional set of filters which we call *focusing filters*. Adjustment of a single parameter allows the array to be focussed at arbitrary distances (although there are practical limitations to operating closer than about one wavelength from the array and maintaining the desired beampattern).

5. CONCLUSIONS

Microphone arrays provide one of the most effective means of eliminating noise and reverberation from acquired speech. We have given a brief overview of how they may be used to provide a high-quality front-end to systems requiring hands-free speech input.

REFERENCES

1. J. Flanagan, J. Johnston, R. Zahn, and G. Elko, "Computer steered microphone arrays for sound transduction in large rooms," *J. Acoust. Soc. Am.* **78**(5), 1508–1518 (1985)
2. R. Kennedy, T. Abhayapala, D. Ward, and R. Williamson, "Nearfield broadband frequency invariant beamforming," in *Proc. IEEE Int. Conf. Acoust., Speech, Signal Processing (ICASSP-96)*, Atlanta, USA (May 1996), pp. 905–908
3. R. Kennedy, D. Ward, and T. Abhayapala, "Nearfield beamforming using nearfield/farfield reciprocity," in *Proc. IEEE Int. Conf. Acoust., Speech, Signal Processing (ICASSP-97)*, Munich, Germany (Apr. 1997), vol. 5, pp. 3741–3744
4. B. Van Veen and K. Buckley, "Beamforming: A versatile approach to spatial filtering," *IEEE ASSP Mag.* **5**(2), 4–24 (1988)
5. J. Flanagan, D. Berkeley, G. Elko, J. West, and M. Sondhi, "Autodirective microphone systems," *Acustica* **73**, 58–71 (1991)
6. W. Kellermann, "A self-steering digital microphone array," in *Proc. IEEE Int. Conf. Acoust., Speech, Signal Processing (ICASSP-91)* (1991), vol. 5, pp. 81–3584
7. R. Smith, "Constant beamwidth receiving arrays for broad band sonar systems," *Acustica* **23**, 21–26 (1970)
8. J. Lardies, "Acoustic ring array with constant beamwidth over a very wide frequency range," *Acoust. Letters* **13**(5), 77–81 (1989)
9. J. Doles III and F. Benedict, "Broad-band array design using the asymptotic theory of unequally spaced arrays," *IEEE Trans. Antennas Propagat.* **36**(1), 27–33 (1988)
10. D. Ward, R. Kennedy, and R. Williamson, "Theory and design of broadband sensor arrays with frequency invariant far-field beam patterns," *J. Acoust. Soc. Am.* **97**(2), 1023–1034 (1995)
11. D. Ward, R. Kennedy, and R. Williamson, "FIR filter design for frequency-invariant beamformers," *IEEE Signal Processing Lett.* **3**(3), 69–71 (Mar. 1996)
12. D. Ward, R. Kennedy, and R. Williamson, "An adaptive algorithm for broadband frequency invariant beamforming," in *Proc. IEEE Int. Conf. Acoust., Speech, Signal Processing (ICASSP-97)*, Munich, Germany (Apr. 1997), vol. V, pp. 3737–3740
13. T. Laakso, V. Välimäki, M. Karjalainen, and U. Laine, "Splitting the unit delay," *IEEE Signal Processing Mag.* **13**(1), 30–60 (1996)
14. T. Abhayapala, R. Kennedy, and R. Williamson, "Nearfield broadband array design using a radially invariant modal expansion," submitted to *J. Acoust. Soc. Am.* (1997)

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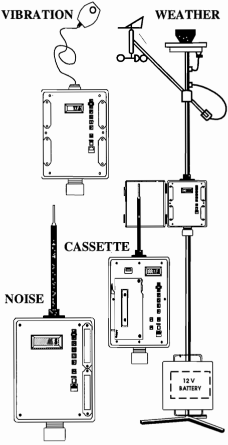

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SOUND PROOFING OF A FORGE

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ABSTRACT: A major forging company in Sydney was required by the NSW EPA to achieve a substantial noise reduction or be closed down. This paper sets out the acoustic solution developed for the company using a light weight multiple layered construction that achieved the stringent noise limits imposed by the NSW EPA. This noise control solution has been tested and proven to be most effective in achieving an outstanding environmental goal that has also resulted in a significant improvement in the occupational environment for air, noise, light and heat of employees working in the forge.

A plant operated by TRW Limited and located in Marrickville produces motor vehicle parts by forging and pressing metal that generates significant noise. The site is located adjacent to railway lines running south of Sydney that carry both passenger and freight traffic with the residential area of Tempe on the opposite side of the railway line and in some cases elevated on an escarpment that overlooks the forging plant. TRW have occupied the site since the turn of the century and operate their facility on a 24 hour basis with forging and pressing operations extending to 11pm at night. In late 1994 as a result of the change in the roof of one of the forges to permit a greater degree of natural light into the working space, residential receivers in proximity to the plant detected an increase in noise resulting in an investigation by the NSW EPA. Testing revealed the operation of the plant to exceed emission limits established in the mid 1970s and continued into the 1980s, resulting in the EPA issuing a requirement to significantly reduce noise emission from the premises some 20 dB(A) below the previous criteria, resulting in the need to reduce noise emission from the plant by some 37 dB(A).

Investigations were carried out in 1995 as to the feasibility of achieving the acoustic design criteria nominated by the NSW EPA, that in effect required the building envelope over the operating forge to achieve a noise reduction of 57 dB(A) instead of the nominal 17 dB(A) achieved by the asbestos clad building (with numerous holes) that had been in existence for many years. The brief for the feasibility study was to consider appropriate noise control solutions that could be implemented to the existing premises whilst maintaining production and guaranteeing compliance with EPA noise requirements. The main forging building now has a plan area of 3,000m^2 and could not support a concrete slab or similar to provide the required attenuation. Failure to comply with the design brief was likely to result in closure of the business in NSW, transfer of production facilities to off-shore or, subject to invitation of other State Governments to transfer the facilities to other States where a suitable site would be provided so as to not have a noise or other pollution problem.

As originally there were maximum levels generated in the building in the order of 110 - 115 dB(A) at 7 metres as a result of press operations and metal to metal impacts, together with a large reverberant energy component in the building, the design concept required the addition of absorption and transmission loss performance to guarantee compliance with the EPA criteria. Our previous design works in relation to aircraft noise insulation for Petersham and Enmore TAFE Colleges had utilised a multiplied layered system of Ortech Easiboard to achieve a high transmission loss performance in the low frequency bands from a light weight construction.

An extension of this principle was considered on a theoretical basis to achieve the required spectrum which necessitated a noise reduction performance in the order of 34 dB at 63 Hz with a proposed design solution incorporating three layers of the Easiboard panel in various combinations for the roof and wall upgrade of the building.

An engineering review by Acoustical Consultants in America on behalf of the parent company confirmed the theoretical conclusions of our study. However, an engineering review by an Australian organisation cast some doubt as to the effectiveness of the design concept (as there was no proven result for the proposed solution) whilst some EPA Engineers had reservations about the proposed solution meeting the design criteria.

Having to guarantee the performance of the complete system and placing our professional indemnity policy on the line, the preliminary design concepts were studied further. The ENM computer program with additional site measurements conducted at ground level and elevated areas of the forge confirmed the preliminary findings that, on the proviso the proposed constructions met our design specification, the EPA criterion would be satisfied. Accordingly having been through various engineering reviews and cost evaluations the company sought to proceed with the project subject to acoustic testing of the design solution. This was carried out in the RMIT acoustic test laboratories in Melbourne for a number of configurations. The testing in some cases reached the limits of the laboratory's capabilities in determining a transmission loss performance. Figure 1 sets out the design

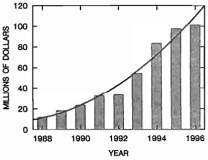

Figure 1. Forge Roof Construction

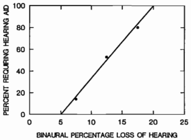

Figure 2. Forge Wall Construction

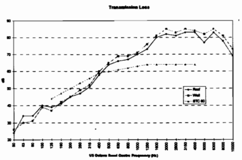

Figure 3. Transmission Loss Results

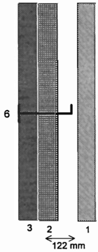

Figure 4. STC46 Dry Wall Construction

1 - 50mm thick Ortech Easiboard
2 - Ortech Acoustiboard with perf. F.C. facing
3 - 75mm thick Fibreglass
4 - 75mm perforated foil faced 8-12kg/m3 fibreglass on wire mesh
5 - 0.47 BMT Colorbond Custom Orb on 50mm thick blanket of 8-12kg/m3 fibreglass
6 - 175mm Ortech Duplex Beam
7 - Purlin Beam

philosophy for the roof/ceiling. Figure 2 shows the wall configuration which is marginally different to the roof/ceiling construction, so as to provide an attenuated passage for natural air flow and achieves slightly different transmission loss results but of similar magnitude (Figure 3).

A consequence of the testing allowed us to also ascertain the small cavity portion of the roof system to reveal a dry wall construction achieving a performance of STC46 (Figure 4).

The complexities of implementing such a noise control program whilst maintaining the operation of the forge required meticulous planning and staging of the project. A supporting structure was constructed over the existing structure, as Council required during the course of the construction that there was to be no increase in noise from the premises during normal operations. Accordingly the construction phase necessitated installing the internal ceiling components such that when roof panels were removed to provide the double layer system there would be no increase in noise emission. The building engineering design to accommodate the SCA acoustic solution was developed by Maunsell Consulting Engineers under the direction of specialist building advice from Montague Consultants, with the building works being supervised by Austin Australia.

Compliance testing carried out during the progress of construction confirmed the effectiveness of the design solution and gave a perfect example to the classic acoustical formulas for openings in a wall of different transmission performance. The closing of a large sliding door to be provided for maintenance purposes, that in itself had a sound transmission class in excess of 60, could be seen to have marginal reduction in noise until the opening was reduced to a small percentage and then the noise breakout dramatically disappeared.

The outcome of the control measures cannot be actually measured at the residential area as the operation of the forge is completely inaudible in the residential area some 150 metres from the factory. In effect when one is standing on the roadway 10 metres from the building one is able to feel vibration through the ground but unable to hear noise from inside the forge.

Measurements conducted inside the work area have revealed from the use of an acoustic pattern Easiboard as the ceiling of the premises a significant reduction in the reverberation component has been achieved. This resulted in a lowering of the maximum sound levels in the building by approximately 5 dB(A), with a reduction in the reverberant component approaching 7 dB(A).

The changes implemented to the building as a result of the noise control measures required by the EPA necessitate the building to be closed at all times, except for access tunnels that are acoustically treated to permit staff and fork lift trucks to enter the forge. The building itself has had to be mechanically ventilated and in addition to reducing by a significant margin the occupational noise levels inside the building, the project has provided a significant enhancement in light quality in the forge resulting in a vastly improved overall working environment for employees for a forging operation that is now in environmental terms permitted to operate 24 hours a day, 7 days a week.

The overall cost of the project approached $3.2 million and the innovative solutions used in addressing the environmental problems unique to the premises have resulted in the project being awarded by the Institution of Engineers (Sydney Division) an Engineering Excellence Award in 1997 for the category of Innovation and a Highly Commended Award for the category of Environment.

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A Sustaining Member of the Australian Acoustical Society

Books

Tuning, Timbre, Spectrum, Scale

William A. Sethares

Springer-Verlag, London 1998 ISBN 3-540-76173-X, 345 pp. plus CD, soft-cover. Australian distributor: DA Information Services, PO Box 163, Mitcham Vic 3132, Tel. (03) 9873 4411, Fax (03) 9873 5679. Price A$92.50

To most people, the 12-note scale of the piano keyboard, and with it the hierarchy of consonant intervals – the octave, fifth, fourth and third – is the basis of all music. Some may be aware that the modern system of equal temperament, in which all semitone intervals have precisely the same frequency ratio, is a compromise that sacrifices the purity of tuning of the consonant intervals (except that of the octave) for the ability to play equally in all keys, but that is about where most knowledge stops.

But what is the basis of these musical principles? Take the octave, for example. Its importance as a concord derives from the fact that ordinary Western musical instruments have harmonic spectra, in which the overtone frequencies are integral multiples of that of the fundamental. If two notes an octave apart (frequency ratio 2:1) are sounded simultaneously, then many of the overtones coincide and the result is a pleasant smooth sound, while any mistuning leads to unpleasant beats and tonal roughness. But what if the individual notes have inharmonic spectra? A recorded example shows that if the spectra of the two notes are stretched, then the "octave" must be similarly stretched to give a concordant sound. It is also possible to divide either the genuine 2:1 octave or a stretched octave into a number of equal "semitones" other than 12 – both 11-note and 10-note divisions can sound very pleasant – provided that the overtone spectra of the component notes are adjusted appropriately. And this is despite the fact that the traditional "concords" have now disappeared!

Non-Western musical traditions based upon non-harmonic percussion instruments, such as the gamelan of Indonesia, have faced similar problems and have developed pleasant-sounding scales with 5 or 7 notes in a slightly stretched octave, but with tunings very different from simply playing selected notes on a piano.

This excellent book, written by a musically minded electrical engineer and computer scientist, examines the basis of our whole concept of melody and harmony and presents compelling recorded demonstrations using computer-synthesised sounds. The presentation requires no mathematical background, though the relevant mathematics and computer programs are given concisely in a series of appendixes for those who want to follow them further. As well as stretched octaves, stretched spectra and non-12-tone scales, the author shows in detail how to construct a synthetic instrument spectrum to match an arbitrary scale, and conversely how to design a scale to fit a given instrument spectrum. There is a detailed treatment of the gamelan, and then, as a virtuoso exercise, he designs a scale and presents musical examples to match the sounds of a small bell, a piece of resonant stone, and the pattern of an x-ray diffraction spectrum! He also shows how a computer can adaptively tune the notes of a scale so that the result is concordant irrespective of key changes – an aim that is only imperfectly fulfilled by equal temperament and that leads to disaster in just intonation – and outlines a treatment of music theory for an equal-tempered 10-tone scale.

The writing throughout is admirably clear and straightforward, the book production is up to Springer's usual high standards, and the recorded passages on the CD, which comprise both short examples and longer compositions in unusual scales on peculiar synthetic instruments, admirably illustrate the points made in the text. They also demonstrate that the author is a very competent and persuasive composer in this new idiom.

This book, which is destined to become a classic, is essential reading for anyone concerned with computer music, or with the study of non-Western music. It should be bought and studied by all lecturers (and read by all students!) in musicology, and should be in the library of every institution teaching music at an advanced level. Perceptual psychologists should also include it high on their reading lists, and I am sure that engineers, mathematicians and physicists will enjoy it. I found it absorbing reading (and listening!), and I can recommend it to anyone with an interest in the fundamental psychological or acoustic basis of music.

Neville Fletcher

Neville Fletcher is a physicist and musician who has written extensively on the physics of musical instruments.

Publications by Australians

The following is a list of publications by Australian authors in the period since June 1996 (excluding publications in Acoustics Australia) and is an update of the list in Acoustics Australia vol 24 (2) p70. It has been compiled to both show the range of work being undertaken and to encourage communication among those working in similar fields. The list has been obtained using a computer searching technique so please advise editors of any omissions.

Free and forced in-plane vibration of rectangular plates. Farag, N.H.; Pan, J. (Mech. & Mater. Eng., WA Uni) *JASA (1998) v103, no.1, p.408-13*

Theory and applications of quarter-wave resonators: a prelude to their use for attenuating noise entering buildings through ventilation openings. Field, C.D.; Fricke, F.R. (Archit. & Design Sci., Syd Uni) *AppAc (1998) v.53, no.1-3, p.117-32.*

Sporadic driving of dynamical systems. Stojanovski, T. (CATT Centre, RMIT); Kocarev, L.; Parlitz, U.; Harris, R. *Phys Rev E (1997) v.55, no.4, p.4035-48*

An analytical investigation of the active attenuation of the plate flexural wave transmission through a reinforcing beam. Kessissoglou, N.J.; Pan, J. (Mech. & Mater. Eng., WA Uni) *JASA (1997) v.102, no.6, p.3530-41*

Further investigation on actively created quiet zones by multiple control sources in free space. Jingnan Guo; Jie Pan (Mech. & Mater. Eng., WA Uni) *JASA (1997) v.102, no.5, p.3050-3.*

Optimal undercuts for the tuning of percussive beams. Petrolito, J.; Legge, K.A. (Sch. of Sci. & Eng., La Trobe Uni.) *JASA (1997) v.102, no.4, p.2432-7.*

Snapping shrimp noise near Gladstone, Queensland. Readhead, M.L. (DSTO, Pyrmont) *JASA (1997) v.101, no.3, p.1718-22.*

Vibration analysis of symmetrically laminated thick rectangular plates using the higher-order theory and p-Ritz method. Chen, C.C. (Civil Eng., Qld Uni.); Liew, K.M.; Lim, C.W.; Kitipornchai, S. *JASA (1997) v.102, no.3, p.1600-11.*

Actively created quiet zones by multiple control sources in free space. Jingnan Guo; Jie Pan; Chaoying Bao (Mech. & Mater. Eng., WA Uni) *JASA (1997) v.101, no.3, p.1492-501.*

Power transmission from a vibrating body to a circular cylindrical shell through passive and active isolators. Jiaqiang Pan; Howard, C.Q.; Hansen, C.H. (Mech. Eng., Adel Uni) *JASA (1997) v.101, no.3, p.1479-91.*

Global attenuation of random vibrations in a tapered and swept panel. D'Cruz, J. (DSTOMelb) *JSV (1997) v.199, no.5, p.751-76.*

Aerodynamic noise generation by a stationary body in a turbulent air stream. Bies, D.A.; Pickles, J.M. (Mech Eng, Adel Uni); Leclercq, D.J.J. *JSV (1997) v.204, no.4, p.631-43.*

An investigation of the coupling loss factor for a cylinder/plate structure. Tso, Y.K. (DSTO, Vic); Hansen, C.H. (Mech Eng, Adel Uni); *JSV (1997) v.199, no.4, p.629-43.*

Vibration control for a flexible transmission shaft with an axially sliding support. Turkstra, T.P.; Semercigil, S.E. (Mech. Eng, VUT) *JSV (1997) v.206, no.4, p.605-10.*

Free vibration of shear-deformable general triangular plates. Karunasena, W. (Civil & Syst. Eng., James Cook Uni NQld); Kitipornchai, S. *JSV (1997) v.199, no.4, p.595-613.*

A model for calculating the insertion losses of pipe lagging. Kanapathipillai, S.; Byrne, K.P. (Mech. & Manuf. Eng., NSW Uni) *JSV (1997) v.200, no.5, p.579-87.*

Publications continued ...

Algorithm adaptation rate in active control: is faster necessarily better?. Snyder, S.D. (Mech Eng, Adel Uni Australia); Tanaka, N. *IEEE Trans Speech&Audio Proc (1997) v.5, no.4, p.378-81.*

Ambient sea noise dependence on local, regional and geostrophic wind speeds: implications for forecasting noise. Cato, D.H.; Tavener, S. (DSTO, Pyrmont) *AppAc (1997) v.51, no.3, p.317-38*

Vibration isolation performance of an ultra-low frequency folded pendulum resonator. Liu Jiangfeng; Ju Li; Blair, D.G. (Phys., WA Uni.) *Phys Lett A (1997) v.228, no.4-5, p.243-9.*

The nature and distribution of errors in sound localization by human listeners. Carlile, S. (Physiol., Syd Uni.); Leong, P.; Hyams, S. Hearing Res (1997) v.114, no.1-2, p.179-96

Speech breathing and the Lombard effect. Winkworth, A.L.; Davis, P.J. (Sch Commun. Disorders, Syd Uni.) *J Speech, Lang & Hearing Res (1997) v.40, no.1, p.159-69.*

Estimation of autoregressive signals from noisy measurements. Zheng, W.X. (Math., WSyd Uni.) *IEE Proc-Vision, Image & Signal Proc (1997) v.144, no.1, p.39-45*

Vibration analysis of rectangular Mindlin plates resting on elastic edge supports. Xiang, Y. (Civil & Environ. Eng., WSyd Uni.); Liew, K.M.; Kitipornchai, S. *JSV (1997) v.204, no.1, p.1-16.*

Sensitivities of two free vibration torsion pendulums. Xianfang Zhu (Electron. Mater. Eng., ANU); *Jiapeng Shui Rev of Sci Inst (1996) v.67, no.12, p.4235-9.*

Masking produced by broadband noise presented in virtual auditory space. Carlile, S.; Wardman, D. (Physiol., Syd Uni.) *JASA (1996) v.100, no.6, p.3761-8.*

Vibration of circular and annular Mindlin plates with internal ring stiffeners. Xiang, Y. (Fac. of Eng., WSyd Uni.); Liew, K.M.; Kitipornchai, S. *SO JASA (1996) v.100, no.6, p.3696-705*

Vibration of arbitrarily laminated plates of general trapezoidal planform. Lim, C.W. (Civil Eng., Qld Uni.); Liew, K.M.; Kitipornchai, *S. JASA (1996) v.100, no.6, p.3674-85*

Asymptotic solutions for predicted natural frequencies of two-dimensional elastic solid vibration problems in finite element analysis. Chongbin Zhao; Steven, G.P. (Eng. Fac., Syd Uni.) *Intl J Num Methods Eng (1996) v.39, no.16, p.2821-35.*

The partitioned eigenvector method for towed array shape estimation. Smith, J.J.; Yee Hong Leung; Cantoni, A. (Adaptive Signal Process. Lab., Curtin Uni) *SO IEEE Trans Signal Proc (1996) v.44, no.9, p.2273-83.*

A technique for the measurement of cadence using walkway vibrations. Lloyd, D.G.; Svensson, N.L. (Safety Sci., UNSW) *J Biomechanics (1996) v.29, no.12, p.1643-7.*

Free vibration analysis of beams on elastic foundation. Thambiratnam, D.; Zhuge, Y. (Civil Eng., Qld Uni) *Computers and Structures (1996) v.60, no.6, p.971-80.*

A-posteriori error estimator/corrector for natural frequencies of thin plate vibration problems. Chongbin Zhao; Steven, G.P. (Eng., Syd Uni.) *Computers & Struct (1996) v.59, no.5, p.949-63*

Simulation of cocktail party effect with neural network controlled iterative Wiener filter. Cao, Y.; Sridharan, S.; Moody, M. (Lab. of Speech Res., Qld Uni.Tech) IEICE Trans Fund of Electronics, *Comm & Comp Sciences (1996) v.E79-A, no.6, p.944-6.*

Torsional vibration control of a flexible beam using laminated PVD actuators. Spearritt, D.J. (VIPAC Qld.); Asokanthan, S.F. *JSV (1996) v.193, no.5, p.941-56.*

Effects of a porous jacket on sound radiated from a pipe. Kanapathipillai, S.; Byrne, K.P. (Mech. & Manuf., UNSW.) *JASA (Aug. 1996) v.100, no.2, pt.1, p.882-8.*

Design and commissioning of sound reinforcement systems for the Australian parliament-a holistic approach. Leembruggen, G.; Connor, D. (Elecoustics NSW) *J Audio Eng Soc (1996) v.44, no.10, p.821-34.*

A practical error estimator for finite element predicted natural frequencies of membrane vibration problems. Chongbin Zhao; Steven, G.P. (Finite Element Anal. Res. Centre, Syd Uni.) *JSV (1996) v.195, no.5, p.739-56.*

An automated diagnostic expert system for diesel engines Autar, R.K. (Mech Eng, Adel Uni) Trans ASME. *J Eng Gas Turbines & Power (1996) v.118, no.3, p.673-9.*

Free vibration of cantilevered arbitrary triangular Mindlin plates Karunasena, W.; Kitipornchai, S.; Al-Bermani, F.G.A. (Civil Eng., Qld Uni.) *Int J Mech Sciences (1996) v.38, no.4, p.431-42.*

Use of genetic algorithms for optimising vibration actuator placement for minimising sound transmission into enclosed spaces. Simpson, M.T.; Hansen, C.H. (Mech. Eng., Adelaide Uni., SA) *Proceedings of the SPIE - Int Soc for Optical Eng (1996) v.2717, p.409-21.*

Speech enhancement using microphone array with multi-stage processing. Yuchang Cao; Sridharan, S.; Moody, M. (Electr. & Electron. Syst. Eng., Qld Uni. Tech) IEICE Trans Fundamentals of Electronics, *Comm & Comp Sciences (1996) v.E79-A, no.3, p.386-94.*

Approximate pole placement for acceleration feedback control of flexible structures. Goh, C.J.; Yan, W.Y. (WA Uni.) J Guidance, *Control, & Dynamics (1996) v.19, no.1, p.256-9.*

Using the correlation dimension for vibration fault diagnosis of rolling element bearings .II. Selection of experimental parameters. Logan, D.B.; Mathew, J. (Mech. Eng., Monash Uni.) *Mech Systems & Signal Proc (1996) v.10, no.3, p.251-64.*

Flow noise calculations for extended hydrophones in fluid and solid-filled towed arrays. Knight, A. (DSTO SA) *JASA (1996) v.100, no.1, p.245-51.*

Using the correlation dimension for vibration fault diagnosis of rolling element bearings .I. Basic concepts. Logan, D.; Mathew, J. (Mech. Eng., Monash Uni.) *Mech Systems & Signal Proc (1996)) v.10, no.3, p.241-50.*

Modeling chaotic motions of a string from experimental data. Judd, K.; Mees, A. (Math., WA Uni) *Physica D (1996) v.92, no.3-4, p.221-36.*

Use of genetic algorithms to optimize vibration actuator placement for active control of harmonic interior noise in a cylinder with floor structure. Simpson, M.T.; Hansen, C.H. (Mech. Eng., Ade Uni.) *Noise Control EngJ (1996) v.44, no.4, p.169-84.*

Effect of axial load on free vibration of orthotropic truncated conical shells. Tong, L. (Aeronaut. Eng., Syd Uni) Transe ASME. *J of Vib& Acoustics (1996) v.118, no.2, p.164-8*

A long-period conical pendulum for vibration isolation. Winterflood, J.; Blair, D.G. (Phys., Uni. WA) *Phys Lett A (1996) v.222, no.3, p.141-7.*

An asymptotic formula for correcting finite element predicted natural frequencies of membrane vibration problems. Chongbin Zhao; Steven, G.P. (Finite Element Anal. Res. Centre, Syd Uni) *Comm in Numl Meth (1996) v.12, no.1, p.63-73.*

Free vibration of a string with moving boundary conditions by the method of distorted images. Ram, Y.M. (Mech Eng, Adel Uni); Caldwell, J. *JSV (1996) v.194, no.1, p.35-47.*

Control of flexural vibration in stiffened structures using multiple piezoceramic actuators. Young, A.J.; Hansen, C.H. (Mech Eng, Adel Uni) *AppAc (1996) v.49, no.1, p.17-48.*

Non-linear curve fitting for modal analysis. Chalko, T.J. (Mech. & Manuf. Eng., Melb Uni); Haritos, N.; Gershkovich, *V. Env Software (1996) v.11, no.1-3, p.9-18.*

Some applications of the sound intensity technique to noise control in the workplace. Lai, Joseph C.S. (ADFA ACT) *Int J of OccupSafety & Erg v 2 n 1 1996.p 1-15*

Ground vibration generated by blasting and by construction equipment- a comparison. Sen, Gour C. (UNSW, Aust); Yang, Hyung-Sik; Ju, Jae-Seong *J of ExplosivesEng v 13 n 4 (1996)7pp*

Experimental study of different approaches for active control of sound transmission through double walls. Bao, C. (Uni WA); Pan, J. JASA v 102 n 3 (1997).p 1664-1670

Aircraft flight parameter estimation based on passive acoustic techniques using the polynomial Wigner-Ville distribution. Reid, D C. (QldUni of Tech); Zoubir, A M.; Boashash, B *JASA v 102 n 1 (1997).p 207-223*

Prediction of impact forces in a vibratory ball mill using an inverse technique. Huang, H. (Uni WA); Pan, J.; McCormick, P.G. *Int J of ImpactEng v 19 n 2 (1997).p 117-126*

Surface mobility of a circular contact area on an infinite plate. Norwood, C. (DSTO, Melb); Williamson, H.M.; Zhao, J.Y. *JSV v 202 n 1 (1997).p 95-108*

Minimizing the environmental impact of blast vibrations. Djordjevic, N. (Uni Qld) *MiningEng v 49 n 4 (1997).p 57-61*

Phoneme-based vector quantization in a discrete HMM speech recognizer. Zhang, Y (Motorola Austr Res Cent, NSW); Togneri, R; Alder, M IEEE *Trans Speech and Audio Proc v 5 n 1 (1997) p26-32*

Audiological indicators of exaggerated hearing loss in noise induced hearing claims. Rickards, Field W. (Uni of Mel) *Noise & Vib Worldwide v 28 n 8 (1997).p 19-20*

Soil-structure interaction and axial force effect Gao, H. (Uni Syd); Kwok, K.C.S.; Samali, B. *Struct Eng and Mech v 5 n 1 (1997).p 1-19*

Fractional-spectral method for vibration of damped space structures. Horr, A.M. (Uni of Woll); Schmidt, L.C. *Eng Struct v 18 n 12 (1996).p 947-956*

Equivalent input noise level criterion for hearing aids. Macrae, John H. (NAL); Dillon, Harvey *J of Rehab Res & Dev v 33 n 4 (1996). p 355-362*

Spectrally formulated finite element method for vibration of a tubular structure. Horr, A.M. (Uni of Woll); Schmidt, L.C. *Struct lEng & Mech v 4 n 3 (1996).p 209-226*

Optimal locations of point supports in plates for maximum fundamental frequency. Xiang, Y. (Uni of W Syd); Wang, C.M.; Kitipornchai, S. Structural Optimization v 11 n 3-4 (1996).p 170-177

Experimental evaluation of squeeze film dampers without centralizing springs. Rezvani, M.A. (UNSW) Hahn, E.J. *Tribology Int v 29 n 1 (1996).p 51-59*

New Members

NSW

Member -	Mr D Mazlin, Mr L Clark, Mr D Blair, Mr L Dickenson
Subscriber -	Dr D Mathews, Dr B Jessup, Mrs S Tavenor, Mr P Tierney, Dr S Anstee, Mr N Capps, Mr J Thornton, Mr B Yeung.
Student-	Mr G Mace

VIC

Member -	Mr PKY Kwong

News

Noise Effects 98

Noise Effects 98 will take place in Sydney on 22 to 26 November 1998. It is the 7th International Congress in the series on Noise as a Public Health Problem, often referred to as ICBEN. These conferences are only held every five years and this is the first to be held in the Southern Hemisphere. This conference will be of interest to all those involved with any aspect of the effects of noise.

The scientific program will include invited and submitted oral presentations, posters and workshops in the following topic areas:

- Noise-induced hearing loss
- Noise and communication
- Non-auditory physiological & health effects induced by noise
- Influence on performance and behaviour
- Effects of noise on sleep
- Community response to noise
- Noise and animals
- Combined agents
- Regulations and standards

The keynote speakers will include Prof SMOORENBURG, Utrecht University, Netherlands; Prof Andy HEDE, Sunshine Coast University, Australia; Dr EDWORTHY, University of Plymouth, UK; Prof Gary EVANS, Cornell University, USA

The call for papers and the registration booklet are available so for your copy contact Noise Effects '98, GPO Box 128, Sydney NSW 2001, tel +61 2 9262 2277, fax +61 2 9262 2277, or noise98@tourhosts.com.au http://www.acay.com.au/~dstuckey/noise-effects98

Internoise 98

Internoise 98, the 1998 International Congress on Noise Control Engineering, will be held in Christchurch, New Zealand November 16 - 18, 1998 . The theme of INTER-NOISE 98 is "SOUND AND SILENCE: SETTING THE BALANCE". The conference is sponsored by I/INCE, the International Institute of Noise Control Engineering, and is being organised by the New Zealand Acoustical Society. The technical programme will provide for the presentation of posters and both invited and contributed papers with as many sessions in parallel as needed to accommodate the topics offered. Distinguished Lectures will be given by Dr Leo L Beranek, and Professors Jeremy Astley, Christopher Rice and Colin Hansen as plenary sessions. Topics will be grouped with a Keynote Paper invited for each session. Technical Papers will be presented in a wide range of topics on noise and vibration

The call for papers has been distributed and the registration brochures will soon be available.

Further Information: INTER-NOISE 98, NZ Acoustical Society, PO Box 1181, Auckland 1001, New Zealand, Tel: +64 9 623 3147, Fax: +64 9 623 3248, internoise98@auckland.ac.nz http://www.auckland.ac.nz/internoise98

Recreational Noise 1998

November 20, Queenstown

Recreational noise is a subject rarely appearing in scientific journals, although many leisure activities produce excessive sound - the hidden factor in the population's declining health and the degradation of the environment. Information on the extent of noise in recreation, and its effects on man and on the environment, is largely unknown. This Symposium, believed to be the first of its kind, will attempt to answer some of the questions, and will cover not only the aspects of environmental noise control for recreational activities, but also the effects on health of those engaged in the business of running the activities, of those taking part by choice and of those on whom the activities intrude. The effects of tourism on our National Parks and Heritage areas will also be covered.

Queenstown and the Lakeland Hotel is an ideal place for such a conference. Queenstown is one of the very finest recreational areas in the world, and the scenery arguably the most beautiful to be found in any country.

On Sunday November 22 delegates attending the Queenstown Symposium may travel direct from Queenstown International Airport to Sydney to arrive in time for registration at the Noise Effects Congress.

Information: Conference Secretary ECS, PO Box 76-068 MANUKAU CITY New Zealand Fax: (+64) 9 279 8833 grantm@bitz.co.nz

ICA

June 20-26, Seattle

The 16th ICA will be held 20-26 June 1998 in Seattle Washington. It will comprise 16 plenary sessions well spread over the range of disciplines. The number of abstracts for contributed papers that have been offered is approximately 2,000 and the proceedings will be provided on CD. The conference should be very well attended. Information about the conference can be obtained from http://www.apl.washington.edu/asa/asa.html

At the General Assembly of the ICA, to be held during the congress, the new status of the ICA will be confirmed. Since its start ICA has been a subcommittee of the International Union for Pure and Applied Physics (IUPAP). While there will still be strong links to IUPAP, the new International Commission on Acoustics will be directed by a board of 15 members elected by the General Assembly.

More information on ICA can be found at http://www.nrc.ca/ims/ica/

Indonesian Society

The Indonesian Acoustics and Vibration Society (IAVS) has recently been formed. Following on from communications with some of the members of the Aust Acoustical Society a similar structure has been adopted. The initiators of the society came from universities (ITB, IPB), government institutions (BAPEDAL, BPPT, LIPI), Ind. Navy (TNI-AL), Ind. Aircraft Industry (IPTN)and private companies (B&K, LITAC, B&H, CMA). It is hoped that the society will attract many experts from all over Indonesia who are dealing with acoustics and vibration in their daily activities. The main program would be introducing the society nationally and internationally, and preparing the first national meeting in 1998. Since the field of acoustics and vibration is relatively new among industry practitioners, the IAVS will be planning to conduct short courses which may be in the form of structured practical education. There is considerable interest in maintaining a close relationship with the Australian Acoustical Society.

Further information: Indonesian Acoustics and Vibration Society, Jl. Cemara 13, Blok-S, Kebayoran Baru - Jakarta 12110 INDONESIA, Tel +62 21 5213030 Fax +62 21 5737753

5th International Congress on Sound and Vibration

The University of Adelaide, South Australia was proud to host the 5th in a series of congresses which began in 1990 at Auburn University, USA under the guidance of Professor Malcolm Crocker, and which now are sponsored by the International Institute of Acoustics and Vibration. By all accounts, the 5th Congress, held from December 14 to 18 1997, was a resounding success, both in terms of the technical program and social events. It was attended by 400 local, interstate and international delegates.

There are some who say that there are too many conferences on sound and vibration and that the series which is the subject of this article is unnecessary. The large number of delegates attending the 5th congress are testament to the need for a congress of this type in which education is emphasised, where vibration and sound receive equal emphasis and where the interaction of vibration and sound is of particular interest.

The 5th Congress also provided opportunities for two meetings of The Board of Directors of The Institute of Acoustics and Vibration, The Editorial Board of the International Journal of Acoustics and Vibration, The Council of The Australian Acoustical Society and The Annual General Meeting of The Australian Acoustical Society.

For the first time in the congress series, the 5th congress introduced a series of six two-hour educational tutorials on recent advances in acoustics: "Active noise control" by Professor Osman Tokhi, "Dynamics of vibro-impact systems" by Professor Vladimir Babitsky, "Sound Intensity" by Professor Malcolm Crocker, "Statistical Energy Analysis" by Professor Ken Heron and Paul Bremner, and "Wavelets" by Professor David Newman. All tutorials were well attended and certainly added educational value to the congress. Another first was the introduction of specialist keynote presentations which were used to introduce the state of the art of the subject of 15 different special sessions. The specialist keynote presentations occupied two time slots at the beginning of the particular session they introduced and were very well received. Also for the very first time, the 5th Congress was held jointly with another conference which in this case was the 1997 Annual Meeting of The Australian Acoustical Society.

Immediately following the Opening Ceremony, Sir James Lighthill entertained and educated the audience with his opening Presidential Address, "A century of shock wave dynamics". In his usual modest way, Sir James Lighthill told us in detail of the exciting contributions of many distinguished scientists to the field while barely mentioning his own enormous contributions which we know played a pivotal role in the advancement of the field over a number of decades. The discussion in this field was further enhanced by a special technical session on shock wave dynamics held on the next day which included presentations from four world leaders in the field.

Other Distinguished Plenary Keynote Addresses which were presented at various times throughout the congress were: "Into the Physics of Rotor Aeroacoustics: highlights of recent European helicopter noise research", by Dr Hanno Heller; "Recent developments in acoustics", by Professor Malcolm Crocker; Recent advances in the active control of structurally radiated sound", by Professor Chris Fuller; "Vibration suppression through smart damping", by Professor Dan Inman; "Developments in digital analysis techniques for diagnostics of bearings and gears" by Professor Bob Randall; and "Hearing protectors" by Professor Samir Gerges. There was one Distinguished Keynote address every morning and afternoon of the 4 days of technical sessions, except for the final afternoon. Following each Keynote Address were parallel technical sessions and in all, over 300 technical papers were presented.

During the banquet various awards were presented. The first was The Australian Acoustical Society (AAS) President's medal for the best written paper by a member of The AAS. The award was made by the President of The AAS, Charles Don and the winners were Suzanne Thwaites and Norman Clark for their excellent paper, titled, "Non-destructive testing of composites using long waves" (included in this issue). The second award was the "David Bies Prize" was won by David Rennison of Vipac Engineers and Scientists for his work on the sonic fatigue analysis testing of Hercules C130 wing flaps.

The next award was the first Honorary Fellowship of the International Institute of Acoustics and Vibration (IIAV). After a most entertaining speech which had the audience on the edge of their seats in anticipation, Sir James Lighthill, President of the IIAV made the award to Professor David Crighton.

This Congress was organised by a committee consisting of members of the SA Division of the AAS, and staff and postgraduate students of The Department of Mechanical Engineering, University of Adelaide. The strong technical program for the congress largely resulted from the considerable efforts of many members of the 59-strong Scientific Committee.

Colin Hansen

STANDARDS

Occupational Noise Management

To aid organisations in the implementation of an integrated occupational noise management program, a new five-part Standard is being published by Standards Australia and Standards New Zealand. Each part covers a separate aspect of the management program. The full AS/NZS 1269 series on Occupational Noise Management is as follows:

- 1269.0-1998: Overview.
- 1269.1-1998: Measurement and assessment of noise immission and exposure.
- 1269.2-1998: Noise control management.
- 1269.3-1998: Hearing protector program.
- 1269.4-1998: Auditory assessment.

This series is a revision of AS 1269-1989: Acoustics-Hearing conservation. Major changes include the expansion of the noise control/reduction section to emphasise noise control as the primary goal of an occupational noise management program, the provision of more detailed guidance on the implementation and management of both noise control and hearing protector programs and the improvement of procedures for auditory assessment. The revision also reflects the change in concept from a "noise dose" to that of "noise exposure". Noise exposure has an absolute value which is independent of the noise exposure criterion and the Standard does not set occupational noise criteria. Occupational noise criteria are governed by state or national regulations and may be different according to the relevant regulative requirements.

Part 0 gives an overview to the AS/NZS 1269 series and provides an outline for an integrated approach to establishing, implementing and evaluating an occupational noise management program. It also highlights some of the concerns not covered in the other parts of the Standard and provides an explanation of terms such as exposure, emission and immission.

Part 1 specifies the types of noise assessments which may be required in a workplace, the general objectives of each type of assessment and the instrumentation and procedures required to carry out an assessment.

Part 2 provides guidance and procedures for incorporating noise control strategies into the design of new workplaces or implementing noise controls into existing workplaces. Technical information on basic noise control techniques is provided in a series of informative appendices.

Part 3 provides guidance and requirements in relation to establishing a hearing protector program. It includes an outline of the responsibilities associated with a hearing protector program and discusses the requirements for selection, use and maintenance of various types of hearing protectors. It also provides information on how to ensure the continued effectiveness of the hearing protector program by way of continual auditing of the program and the training of personnel in the use of hearing protectors.

To simplify the process for selection of hearing protectors, a system that splits the attenuation properties of hearing protectors into five classes has been included. With this classification system only an A-weighted noise measurement is required and the hearing protector is then chosen from the appropriate class.

Part 4 specifies procedures and requirements for audiometric testing that is used to monitor the hearing of individuals exposed to excessive noise. The specified audiometric method employs an averaging technique at those frequencies most likely to be affected in the early stages of noise exposure. This averaging technique increases the effectiveness of the audiometric technique in early detection of hearing loss. The method also places emphasis on detecting temporary threshold shifts, which provides an early indication of the likelihood of permanent hearing loss.

From the Australian Standard

FASTS Activities

The Federation of Australian Scientific and Technical Associations (of which the Aust Acoustical Soc is a member) has been active in recent months.

The new policy document was released in January and includes considerable revisions following the FASTS' Council Board meetings in Nov. This is in the light of the Government's actions over the last years. In some cases they have addressed our concerns, and in other cases they have created new problems.

The Minister for Industry, Science and Tourism John Moore and the Prime Minister are to be congratulated for picking up many of the reforms to PMSEC suggested in Chief Scientist John Stocker's recent review. PMSEC has been substantially revamped, along lines that fit very comfortably with the FASTS' Policy Document, and will strengthen and simplify policy advice to the Government. The President of FASTS will be able to meet regularly with other ex officio members as well as a small group of distinguished scientists who are members of PMSEC in their own right. The casualty in the process is ASTEC, which is to be wound up as soon as the current terms of its members have expired and when current inquiries have been completed.

FASTS is also concerned about the declining numbers of undergraduate students enrolling in science and technology courses at universities in Australia and the President has urged the PM to take up this issue with his Ministers

Dr John Rice, Chair of the Australian Council of Deans of Science (ACDS), and Professor Peter Cullen, President FASTS, said that university science is in danger of spiralling out of control. They said that the pressures and the rate of change in university science are building up to an unsustainable level. "Science departments are being subjected to pressures from all quarters. Falling budgets, a switch from basic to applied subjects, a decline in student demand, expectations that staff can carry ever greater loads, and confusing signals from Government all contribute to the pressure," Dr Rice said. "A clear and coordinated vision is needed, to bring about productive change and avert chaos." The issues were explored at a forum at the National Press Club on February 25. "University Science: Crisis or Crossroads?", featured speakers from industry and universities.

QLD Noise Policy

The Environmental Protection (Noise) Policy 1997 identifies environmental values, provides guidance for the administration of environmental authorities and environmental management programs, addresses the control of neighbourhood noise, and provides for the preparation of co-ordinated programs to enhance or protect the identified environmental values.

Infringement notices for certain offences can now be issued under recent amendments to the Justices Act and Regulations. Infringement notices, which allow for on-the-spot fines, can be issued by authorised officers of administering authorities. In deciding whether to issue an infringement notice, authorised officers will need to consider the Enforcement Guideline for the Act. It is anticipated that infringement notices will be used only when evidence of an offence is clear-cut and can be clearly perceived by the authorised person.

Information : Bob Thorne (07) 3225 1772

WWW in Qld

The Department of the Environment in Queensland is now on the web at www.env.qld.gov.au. This is a good way to start when you are seeking information on the latest issues relating to noise as well as other aspects of the environment.

Noise Fines in NSW

It is hoped that noise pollution in residential areas will be reduced with the extension of enforcement powers to police and council officers throughout NSW. EPA Director-General, Neil Shepherd, said the enforcement of a range of motor vehicle noise offences will be more effective as council and police officers will have the power to issue penalty infringement notices. The fines would range from $150 to $300 depending on the type of offence. During 1996/97, the EPA issued 522 Penalty Infringement Notices for motor vehicle noise offences. It is hoped that the extension of penalty powers will act as a deterrent and encourage people to help reduce noise pollution.

The offences will apply to situations such as:

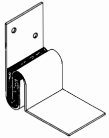
- Noisy sound systems in cars affecting people outside the vehicle. This problem has increased with the use of more powerful sound systems, particularly around shopping centres and residential areas.
- The use of noisy vehicles on private property and affecting neighbours. This can be a problem on rural properties where noise from vehicles, some of which may be unregistered, can cause a great deal of annoyance to neighbours.
- Operating noisy vehicle refrigeration units at night when they can be heard inside a residence. This can be a problem near commercial areas and can be overcome through better parking or operating arrangements for such vehicles.

Dr Shepherd said other offences include connecting a vehicle's horn or alarm to a mobile telephone so that either the horn or alarm sounds when the telephone rings.

The granting of the penalty notice powers to council and police officers was made in consultation with the Police Service and councils. "The community and the environment will both be winners as the result of less noise, particularly in residential areas" said Dr Shepherd.

ACT Noise Regulations

The ACT Government has recently passed the Environment Protection Regulations which include measurement of noise levels, determination of excessive noise levels and the noise conditions for sale and hire of articles. These regulations represent a change in the approach to the assessment of noise as the procedure involves comparison of the noise levels with the zone noise standard for the area. The seven zones are based on the land use policies under the Territory Plan and the standard levels range from 45 to 65 dB(A) during daytime which is from 0700 hrs (or 0800 for Sundays and holidays) to 2200 hrs. During nightime the standards range from 35 dB(A) to 55 dB(A). Certain activities are listed in a Schedule and approvals for other activities such as special event can be applied for.



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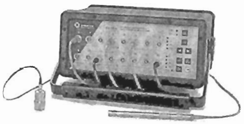

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Ashfield, NSW 2131
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Tel: (02) 9797 1790
Fax: (02) 9797 1792
PO Box W16
Wareemba, NSW 2046

Vic Meetings

The final Victoria Division meeting for 1997 took the form of a dinner on November 26 at Monroe's, St Kilda, at which Louis Challis was the invited guest speaker. Twenty members and friends were present. In his talk Louis Challis told those present about his very varied experiences as Acoustic Consultant to Parliament House, and, in particular, in designing the acoustics of the House of Reps chamber so the speeches of parliamentarians would be clearly heard, but the extraneous noises such as from the public gallery would be minimised.

The first Division technical meeting for 1998 consisted of a double visit (Feb 24/25) to several sites along the Citylink road tunnels at present in course of construction. The Feb 24 meeting, begun at Burnley, was a tunnel excursion through both the cut-and-cover and bored tunnel section. Those present wore all available safety equipment from safety boots to hard hats and earplugs. Observed noise emanated from various large axial tunnel ventilating fans (of diameter approx 1.5m), some of which gave rise to complaints at night from nearby residents, though at the St Kilda Rd site this noise was considered as valuable for masking other construction noises. Other noises (eg. reversing beeps) appeared to cause less complaint. The Feb 25 meeting, at the Citylink Display Centre, consisted of a more general description of the whole project.

Louis Fouvy

Ultrasonography

Although the role of sonography in oncology has been largely unexplored, a recent study in the Journal of Ultrasound in medicine found ultrasonography to be valuable in the diagnosis and staging of breast cancer. The authors from the Chinese University of Hong Kong compared the performance of high resolution digital ultrasound, MR imaging and x-ray mammograms to measure breast cancer size in 39 women before they underwent surgery, in order to determine the most accurate method of sizing breast cancer. In this study, ultrasonography proved to be as accurate as MR imaging in evaluating tumour size. This study shows that both sonographic and MR imaging measurements are superior to mammography in determination of the size of breast cancer. The authors write, "Whereas MR imaging is costly, is time consuming and suffers from a lack of specificity, ultrasonography is inexpensive, relatively quick and highly specific.

Although the airway has been traditionally considered a poor acoustic window and thus not suitable for sonographic examination, another study in the same Journal shows that real-time ultrasonography may actually be useful in imaging the trachea. Non invasive and portable, the role of ultrasonography in the evaluation of the neck region has become increasingly important and applied to various organs of the neck including vessels, lymph nodes, the thyroid gland and larynx.

Processing Course

The CRC for Sensor Signal and Information Processing (CSSIP) offered for the first time in 1997 a Masters by Coursework in Mathematical Signal and Information Processing (MSIP). This year it will be offered in a distance education format as a three year part-time course with the award to be conferred by the University of SA, (approval pending).

The MSIP course aims to develop advanced mathematical skills for research and development in signal and information processing and is aimed at Honours degree graduates in electrical or electronic engineering, mathematics, physics or related areas. The three year distance format course consists of ten subjects plus a project.

In 1998 two subjects in distance format will be offered and there is some flexibility in the time that the courses can be undertaken. The fee payable for the two subjects offered in 1998 will be $1483.33 per subject

These subjects, Introduction to Discrete Linear Systems and Detection, Estimation and Classification. may be taken as part of an MSIP award or individually as non-award courses of study.(Persons wishing to take an individual subject as a non-award course of study should contact me about the fee for this service)

Information:
www.cssip.edu.au/CssipEducation/Awards (look for Master of Mathematical Sciences (Signal and Information Processing))

Acoustic Research Laboratories has appointed *Mark Palmer* as the NSW Sales Manager. Mark formally provided technical sale, service and support for Fujitsu Australia in their computer division. In the coming months Mark will be contacting our existing clients in NSW and those of you yet to see an ARL representative. We look forward to improving our customer service and support with this appointment.

ACU-VIB have recently moved their Sydney office. The new contact details are:
Unit 2, 2 Charlotte St,
Ashfield, NSW 2131
Tel: (02) 9797 1790
Fax: (02) 9797 1792
Mobile unchanged: 018 470 179

New Product

RION Vibration Meter

The new Rion VM-82 vibration meter is now available from Acoustic Research Laboratories. This new meter is designed for a wide variety of industrial applications. It is particularly suited to routine maintenance and monitoring of rotating machinery, as well as for performance testing during machine development. Acceleration, velocity and displacement can easily be measured using a suitable frequency range, allowing comprehensive and precise evaluation of machine vibrations. The large LCD panel contains a numeric readout as well as a bar graph to let the user check vibration fluctuations at a glance. Measurement results can be stored in the internal memory of the unit for later processing.

Further information: Acoustic Research Labs, Tel 02 9484 0800 Fax 02 9484 0884, acoustic@hutch.com.au

Letter

I was interested to note in JH Macrae's recent article (AA Vol 25 (1997) No. 3 pp 109-12) on "A Discussion of the Australian National Standard for Occupational Noise" that he concluded, inter alia, that "A standard of 80 dB(A) would come much closer to an acceptable solution to the problem of occupational noise-induced hearing loss." for it bears out a conclusion published 44 years ago (Peterson APG and Beranek LL, Handbook of Noise Measurement, Cambridge, Mass, General Radio Co, 1958, p 76) that noise level above 100 dB(B) should be regarded as probably unsafe for everyday exposures extending over a period of months and ear protection or noise reduction is necessary. Levels below 80 dB(B) are probably safe even when the noise is a pure tone."

This shows that the battle between the noisemakers and those working for safe human environments is not a new one; and also, that Macrae's conclusion of 80 dB(A) (probably equivalent to around 82 to 85 dB(B), depending on the frequency composition of the particular noise) coming closer to solving the occupational noise-induced hearing loss problem is a necessary maximum exposure level for long-term noise exposure for which we must aim at and strenuously work for. *Louis Fouvy*

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http://www.adfa.oz.au/~mxb/aa

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Tel (02) 9514 2687
Fax (02) 9514 2665
david.eager@uts.edu.au

AAS - Queensland Division
PO Box 165,
BROWNS PLAINS 4118
Sec: Mr J Carter
Tel (07) 3806 7522
Fax (07) 3806 7999

AAS - SA Division
C/–Department of Mech Eng
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Diary...

* Indicates an Australian Activity

1998

May 12-15, SEATTLE
IEEE Conf. on Acoustics, Speech & Signal Processing
Details: L. Atlas, Dept. EE (FT 10), University of Washington, Seattle, WA, USA. Fax +1 206 543 3842, atlas@ee.washington.edu

May 25-27, ITALY
Noise and Planning 98
Details: Noise & Planning, via Bragadino 2, 20144 Milano, Italy, Fax: +39 248018839, mdl467@mclink.it

June 2-4, KRYNICA
Noise Control '98
Details: Noise Control '98, Katedra Mechaniki I Wibroakustyki AGH, al. Mickiewicza 30, 30-059 Krakow, Poland. Tel: + 048 12 173620, Fax: +048 12 332314, kmiw@uci.agh.edu.pl, http://www.wibro.agh.edu.pl

June 8-10, TALLINN
Transport Noise and Vibration
Details: East-European Acosutical Assoc., Moskovskoe Shosse 44, 196158 St. - Petersburg, Russia. Fax: +7 812 127 9323, krylspb@sovam.com

June 9-12, SWEDEN
8th Int Conf. on Hand-Arm Vibration
Details: National Institute for Working Life, Conf. Secretariat HAV98, PO Box 7654, 90713 Umeá, Sweden, Fax: +46 90165027, hav98@niwl.se

June 20-28, SEATTLE
16th Int Congress on Acoustics
Details: 16th ICA Secretariat, Applied Physics laboraty, Uni of Washington, 1013 NE 40th St. Seattle, WA 98105-6698, USA. http://www.apl.washington.edu/asa/

June 21-26, USA
13th U.S. National Congress of Theoretical and Applied Mechanics.
Details: M. Eisenberg, AeMES Dept., Uni of Florida, PO Box 116250, Gainesville, FL 32611-6250, USA, Fax: +1 3523927303, meise@eng.ufl.edu

June 26 - July 1, LEAVENWORTH
Tone and Technology in Musical Acoustics
Details: Catgut Acoustical Society, 112 Essex Avenue, Montclair, NJ 07042 USA, Fax: +1 2017449197, catgutas@msn.com, http://www.boystown.org/isma98/

September 14-18, CZECH
35th Int. Conf. Ultrasonics and Acoustic Emission.
Detail: H. Kotschova, Geophysical Inst AS CR Bocni II/401, 14131 Prague 4 Czech Republic, Fax: +42 2 761549, hko@ig.cas.cz, http://www.ig.cas.cz

September 16-18, BELGUIM
Int. Conf. on Noise and Vibration Engineering
Details: Ms L Notré, KU Leuven, Division PMA, Celestijnenlaan 300B, 3001 Leuven, Belgium, Fax: +32 16322987, lieve.notre@mech.kuleuven.ac.be, http://www.mech.kuleuven.ac.be/pma/events/isma/isma.html

October 4-7, GERMANY
EURO-Noise 98
Details: CSM, Industriestrabe 35, D-82194 Grobenzell, Tel: +49 8142 570183, Fax:49 8142 54735, csm_congress@compuserve.com

October 7-8, SLOVENIA
1st Cong. Slovenian Acoutical Soc.
Details: Erika Zelezic, Mech Eng'g, Uni Ljubljana, Askerceva 6, 1000 Ljubljana, Slovenia, Fax: +386 61 218567, erika.zelezic@fs.uni.lj.si

October 12-16, AMERICA
Meeting of ASA,
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax: +1 516 576 2377, asa@aip.org

Oct 31 - Nov 3, DENMARK
AES Int. Conf "Audio, Acoustics and Small Spaces.
Details: Acoustical Soc. Denmark, Bldg 352 DTU 2800 Lyngby, Denmark. Fax: +45 4588 0577, atc.das@dat.dtu.dk

November 12-15,UK
Inst. Acoustics Autumn Conf.: Speech and Hearing
Details: Inst. Acoustics, Agriculture House, 5 Hollywell Hill, St Albans, Herts AL 1 1EU, UK, Fax: +44 1727850533, acoustics@clus1.ulcc.ac.uk

November 11-13, SINGAPORE
APAV 98
Details: APAV 98, 1 Selegie Rd #09-01, Paradiz Centre, Singapore 188306, Tel: +65 3399129, Fax: +65 334 7891, apavcon@singnet.co.sg

November 16-20, CHRISTCHURCH
INTER-NOISE 98
Details: NZAS. P.O. Box 1181, Auckland, NZ, Fax +64 9 309 3540
http://www.auckland.ac.nz/internoise98/

November 20 QUEENSTOWN
I-INCE Symp. on Recreational Noise
Details from: Conference Secretary Grant Morgan ECS, P O Box 76-068 MANUKAU CITY New Zealand Fax: (+64) 9 279 8833 email: grantm@bitz.co.nz
Or from the General Chairman: Dr Philip Dickinson Fax: (+64) 4 234 1185 email: philip_d@iconz.co.nz

***November 22-27, SYDNEY**
Noise Effects 98
ICBEN Congress
Details: Noise Effects '98, GPO Box 128, Sydney NSW 2001 Australia Tel: 02 92622277 Fax: 02 92622323, tourhosts@tourhosts.com.au, http://www.acay.com.au/~dstuckey/noise-effects98/

***Nov 30 - 4 Dec, SYDNEY**
5th Int. Conf. on Spoken Language Processing
Details: Tour Hosts, GPO Box 128, Sydney NSW 2001 Australia, Fax: 02 92623135, tourhosts@tourhosts.com.au, http://cslab.anu.edu.au/icslp98

***December 8-11, TASMANIA**
COMADEM 98
Details: Centre of Machine Condition Monitoring, Monash Uni. Dept. of Mechanical Engineering, Wellington Rd, Clayton VIC 3168, Tel: 03 99055699, Fax: 03 99055726, maltezos@eng2.eng.monash.edu.au, http://www.monash.edu.au/cmcm/

December 15-17, INDIA
"Designing for Quietness" an Int. Symp.
Details: Prof. ML Munjal, Senter of Excellence for Technical Acoustics, Dept. of Mechanical Engineering, Indian Institute of Science, Bangalore 560 012, India, munjal@mecheng.iisc.ernet.in

1999

March 15-19, BERLIN
Forum Acusticum & ASA Meeting
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June 28-30, RUSSIA
EEAA Congress - 1st Int. Cong. East European Acoustical Society
Details: EEAA, Moskovskoe Shosse 44, St Petersburg 196158, Russia, Fax: +7 812 1279323, krylspb@sovam.com

July 5-8 DENMARK
6th Int. Congress on Sound & Vibration
Details: Dept Acoustic Tech, Tech Uni of Denmark, Bldg 352, DK-2800 Lyngby, Denmark. Tel: +45 45 881622 Fax: +45 45 880577 icsv6@dat.dtu.dk, http://www.icsv6.dat.dtu.dk

September 1-4 GERMANY
15th Int. Symp. Nonlinear Acoustics (ISNA-15)
Details: W. Lauterborn, Drittes Physikalisches Inst., Universitat Gottingen, Burgerstr 42-44, 37073 Gottingen, Germany, Fax: +49 551 39 7720, lb@physik3.gwdg.de

November 1-5, COLUMBUS
138th Meeting of ASA
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December 5-9, USA
Inter-noise 99
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October 3-5 KUMAMOTO
WESTPRAC VII
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