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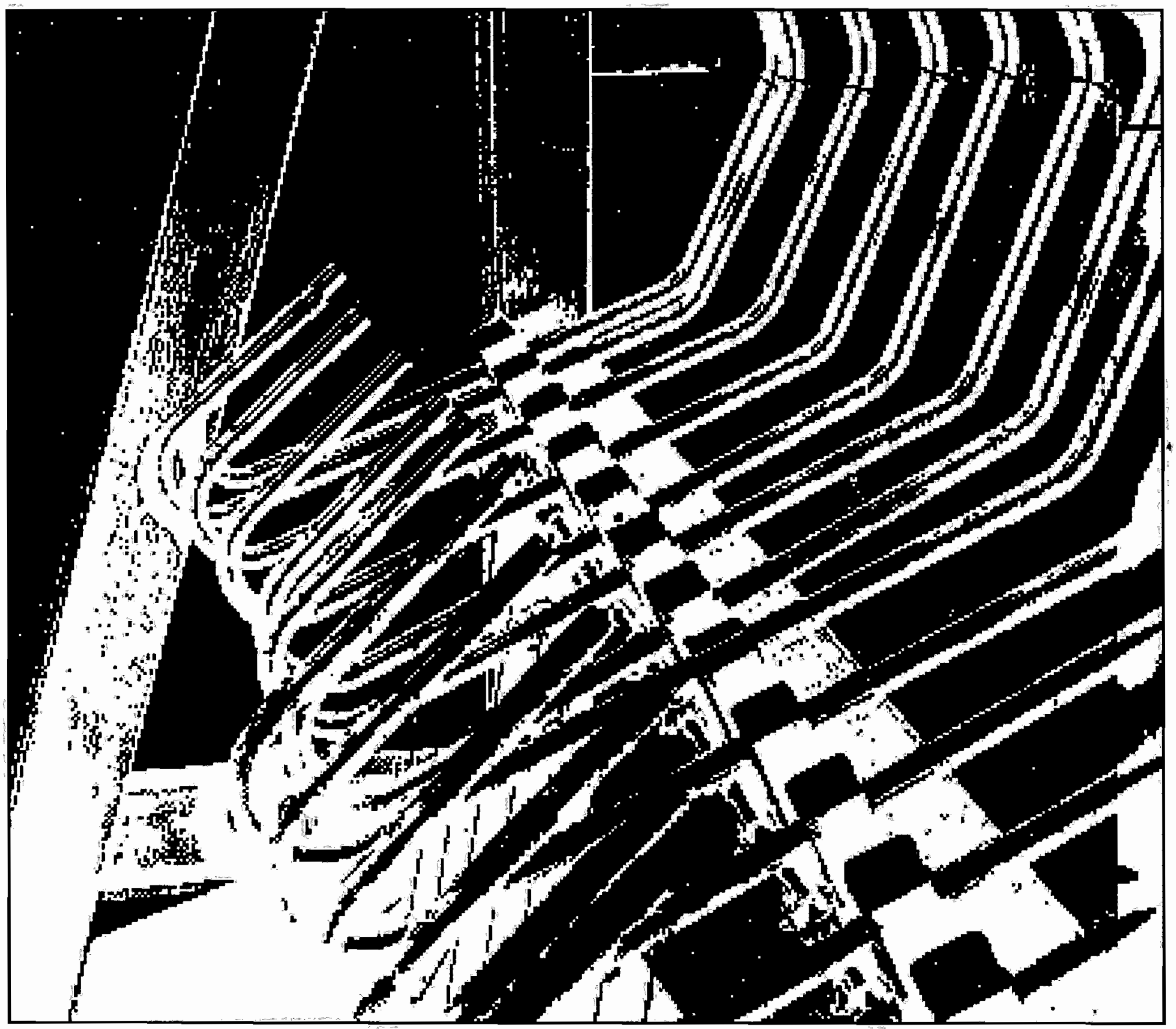

- *Location of Buried Objects*
- *Automatic Speech Recognition*
- *Tosca Alemba*
- *Illumicube*

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From The President

At the last Federal Council meeting I had the privilege to be elected President of the Australian Acoustical Society. I am looking forward to this role and the challenges it offers.

In taking on this role I realise that I am following a President who has worked hard to ensure that the Society has been successful during his term. Bob Hooker has also made my introduction as President an easy one with no outstanding issues remaining unresolved. I therefore extend my personal thanks, and I am sure the thanks of all the members of the Society, to Bob. I also thank all past and present Councillors and the other members of Divisional Committees. Each member gives up a substantial amount of time to help the Society continue to prosper and without them the Society would not function. Special thanks must also go to those people who prepare Acoustics Australia, a Journal that we can all be proud of. Many years ago I participated in the editorial committee for the predecessor of Acoustics Australia and know how much time and effort these people give to produce such a high quality publication.

My role as President has been made easier by the efforts of people such as Bob Hooker and the previous years' Councillors and committee members. But there are a number of particular challenges for 1994 and 1995. The most important challenge will be to increase the awareness of acoustics in the community. In the area of environmental noise members of the Society are aware that long term exposure to noise will affect the health and well being of people but environmental noise, remains a low priority to the Governments of Australia. Hearing conservation in industry and in recreation activities is also not given the high priority it deserves. However, internationally the health effects of noise are being recognised. It is therefore important for the Society to provide information to our politicians and the community about noise and acoustics so that appropriate decisions for the future can be made. If we do not face this challenge, funding for research will continue to decline and standards will fall.

At the last Council meeting it was agreed that several important steps would be taken to increase the awareness of acoustics and noise:

1. To prepare an article to forward to the Federal Minister responsible for the Environment and to the proposed National Environment Protection Authority. This article will summarise the known health effects of noise to encourage governments to recognise that noise can have significant health effects and is a significant form of pollution.

2. To support projects in Western Australia and in Victoria to prepare publications on acoustics and noise. These publications will be aimed at different audiences but will both help to increase the knowledge of acoustics and to make students aware of career opportunities in the acoustics area.

3. To support a bid to hold the next ICBEN in Melbourne. This Conference is held every five years and brings together experts from around the world to quantify the relationship between noise and health effects.

As members of the Australian Acoustical Society I ask you all to encourage a greater understanding of acoustics in the community. I also ask you to encourage young Australians to develop skills and knowledge in acoustics and noise so that Australia maintains this high level of expertise well into the next century. As part of this we should all look for opportunities to support research into acoustics, particularly into the health related effects of noise such as sleep disturbance studies.

Most people, particularly the young, are concerned about jobs. They will not study acoustics unless they see a need and a job in the future. Politicians are also interested in jobs and will not direct funding into acoustics unless they see a need. Opportunities in acoustics and standards will therefore decline over the next decade unless we ensure that the community is aware of acoustics and the effects of noise. I believe that the members of the Society will meet the challenge of the last part of this Century and therefore look forward to my term as President of the Australian Acoustical Society.

John Lambert

Letters to the Editors are invited on any relevant matters.

LOCATION OF BURIED OBJECTS BY AN ACOUSTIC IMPULSE TECHNIQUE

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Clayton, Victoria.

This paper was awarded the 1993 PRESIDENT'S PRIZE
The President's prize, established in 1990 by the Australian Acoustical Society, is awarded to the best technical paper presented in the Annual Australian Acoustical Society Conference.

Abstract: Often it is desirable to locate a shallowly buried object and deduce something of its shape and size, without digging up the ground in the process. If the object is metallic, then metal detectors are adequate, however, non-metallic objects are more difficult to locate. Since the acoustic impedance depends not only on the surface properties of a substance, but what lies within the region penetrated by the sound, an object under the surface will cause a change in impedance compared to a homogeneous sample.

Recently, a technique, utilizing two microphones equidistant from a stable impulse sound source, has been used to locate a plastic object buried under small pebbles. The method involves examining the differences between the two recorded signals, one of which contains a reflection from an object under the ground. The depth of the object can be deduced from the time delay of the reflected impulse from the buried object. Because its reflective surface is only at one depth, a flat, horizontal object gives a larger return signal than the same object when tilted. An irregular rock will give a more diffuse signal. With suitable signal processing it is possible to distinguish between unlike objects and to make an estimate of their shape, size and position.

Results are presented which distinguish between plastic strips, disks and rocks of varying sizes, buried in small pebbles between 4 cm and 15 cm deep. The advantages and limitations of the technique will be discussed.

1. INTRODUCTION

In our plastic oriented world, it would be useful to have a method for finding and identifying buried, non metallic objects. A technique for achieving this aim has recently been developed. It is based on the reflection of acoustic pulses from the ground surface and has applications in finding drainage pipes, archaeological artefacts and even plastic landmines.

The technique relies on sensing how the pulse waveform recorded above the ground surface is altered by the acoustic impedance produced by the object immersed in the ground matrix. Impedance is often determined at normal incidence [1] but it can also be calculated at any angle down to grazing incidence[2]. The normal incidence method determines the localised impedance of the area directly below the microphone, while using grazing incidence gives an averaged impedance over the whole region between the sound source and the microphone. To see the implications of these ideas, it is convenient to briefly examine the measurement of surface impedance.

2. IMPEDANCE OF PEBBLES

Measurements were undertaken over a large bed of approximately 1cm diameter pebbles, which permitted partial penetration of the sound as well as being a relatively homogeneous medium, allowing easy placement and retrieval of buried objects. The depth of the pebble bed was over 50cm, which meant that it could be treated as effectively an infinitely deep medium. Fig. 1(a) shows that over a pebble surface which has been smoothed as flat as possible, the normal and grazing incidence methods give complex impedance values which are relatively frequency independent out to 10kHz, although the real component tends to be higher for the grazing condition.

If the surface is roughened, by producing, say, 4cm deep depressions, the effect on the normal impedance is very point dependent compared to the grazing result, as is apparent by comparison of Figs. 1(b) and (c). Thus, it would appear to be advantageous to use the grazing incidence technique as the results are virtually independent of the surface roughness. However, the inherent averaging over an area makes it impossible to locate a buried object precisely, making it necessary to use a near normal incidence geometry.

When a layer of pebbles is formed, by placing a large rigid sheet at a known depth below the top surface, broad 'resonances' occur in the impedance due to interference between sound reflected from the top and bottom surface. As shown in Fig. (2), the two geometries result in resonances at different frequencies.

A buried object creates a small layer just under the surface, which can be modelled as portion of a complete plane and so would be expected to produce similar but smaller magnitude resonances. The problem is, however, that irregularities in the impedance due to the surface roughness are of the same magnitude as the resonances caused by the layering. This can be seen by comparing Fig. 2 with Fig.1 (b). Thus, it is not immediately possible to state the existence of an object by its layering effect alone.

In Fig. 3, resultant waveforms from a pulse reflected at normal incidence from two different regions of a roughened layered of pebbles are displayed. The first pressure maximum, A, is due to the reflection from the rough surface and

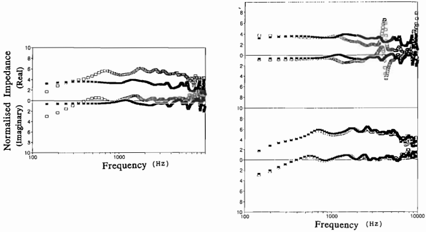

Figure 1: The impedance of a pebble surface (a) when smoothed flat and using ■ normal, □grazing incidence; (b) at normal incidence when ■ smooth, □ rough; (c) at grazing incidence when ■ smooth, □ rough. In each case the two top curves are the real components and the lower two curves are the imaginary ones.

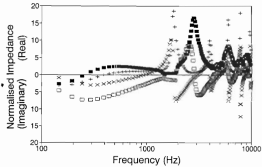

Figure 2: The impedance of a 6cm deep layer of pebbles with a hard backing at grazing incidence, ■ real and □ imaginary; and at normal incidence + real and x imaginary.

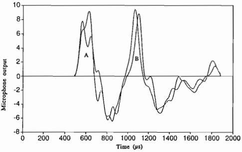

Figure 3: Pulse waveforms obtained over two areas of a roughened layer of pebbles.

is found to vary greatly from area to area. The second pressure maximum, B, is the result of reflection of the impulse from the bottom of the layer and is much more consistent, regardless of surface irregularities. It is this reflection which will contain the information about the buried object and so a technique is required which enhances this second reflection and removes, or minimises, the surface reflection.

3. DETECTION OF BURIED OBJECTS

The geometry adopted is shown in Fig. 4 where a microphone is located symmetrically on either side of a very reproducible acoustic pulse source created by a loud speaker acting down a long sound tube. Over a uniform surface, both microphones record the same direct and reflected pulse waveforms and the difference between the two signals is approximately zero. When an object lies under the surface near one of the microphones as shown in Fig. 5, it changes the impulse waveform of the sound reflected to this microphone and consequent the difference between the two microphones is no longer zero.

The impulse source consists of a JBL horn driver powered by an amplifier connected to a Data Precision 2020 polynomial waveform synthesizer. The signals are captured using two Brüel & Kjær $^1/_4$ inch microphones and type 2218 sound level meters connected into a Data 6000 waveform analyser. At the present time the data are manipulated in the analyser but as more sophisticated processing is developed, it is expected that the data will be down loaded to a PC, in real time. The sensitivity of detection depends on the height of the microphone/source probe above the surface and the separation between the microphones. These factors are not independent, but if separation is too large the grazing condition is approached and spatial resolution is impaired. If the microphones are too close they both receive essential the same reflected signal and detecting the object becomes more difficult. The optimum separation is also linked to the probable width of the buried object. The probe used in this study has a separation of 8cm and is supported 4cm above the ground.

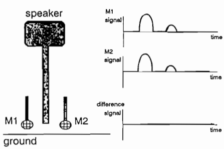

Figure 4: Geometry of probe and waveforms over homogeneous ground showing the direct signal from the source followed by the ground relection.

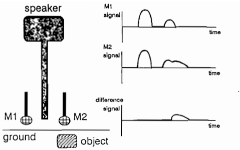

Figure 5: Probe and waveforms over a buried object showing the additional signal from the object.

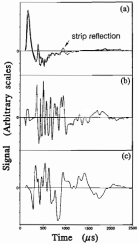

Figure 6: Probe over buried strip: (a) Waveforms with one microphone showing reflection from strip, (b) Subtraction of waveforms, (c) Correlation of subtraction.

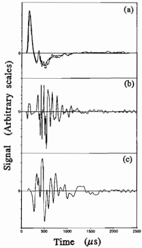

Figure 7: Probe over smooth surface of homogeneous pebbles: (a)Waveforms with no strip, (b)Subtraction of waveforms, (c)Correlation of subtraction.

In examining the idealized signals of Fig. 5, the characteristic reflection of the object can clearly be seen in both the individual and the subtracted signal. However, as discussed above, in actual measurements the reflection from an uneven surface is sufficiently variable that the signals do not cancel and may partially overlap with the pulse from the object. The wanted reflection is a function of the original pulse waveform, but the random surface noise remaining after subtraction is only weakly related. Use can be made of this fact by correlating[3] the known direct pulse shape, $g(t)$, with the subtracted signal, $s(t)$, to obtain a modified signal, $x(t)$, where

$$x(t) = \frac{\sum_{n=0}^{\infty} g(t) * s(t+n)}{[g(t)]^2}$$

This process enhances the required reflection as the output, $x(t)$, has a large magnitude whenever a portion of the subtracted signal has the same waveform as the direct pulse.

As an example of this technique, the signals obtained over a smoothed pebble surface, with a 21cm wide plastic strip buried 7cm deep, are shown in Fig. 6a. The reflection from the strip shows up as a small impulse at about 900μs (arrowed) in the signal from one of the microphones and is not present in the signal from the other microphone. Even over the relatively smooth surface of the pebbles, the difference signal, Fig.6(b), is dominated by the residue, arrising from the surface irregularities, preceding the required reflection. However, after correlating with a direct pulse there is a significant enhancement of the reflection, Fig. 6(c). Compare these results with the signals in Fig. 7, where there was no buried strip. The final processed signal, Fig 7 (c), contains the unavoidable remainder due to surface fluctuations. [Note that the vertical scales on Figs. 6 and 7 are arbitrary as they have been adjusted to display the signal variations.]

A rough surface increases the amount of noise in the correlated signal. As this occurs before the reflection from the object, it can be time isolated with a window which includes only the portion of the trace where an object re-

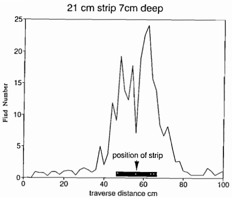

Figure 8. The find number vs distance along pebble bed for a 21 cm wide strip, buried 7cm deep, showing the actual position of the strip.

flection may occur. By summing the square of the instantaneous values of the correlated signal, such as Fig. 7 (c), a single ìfind numberî can be created for that probe position, which can then be used to locate the buried object. An example of the success of this technique is presented as Fig. 8, where the probe was progressively moved in 2cm steps across the buried strip. Note that there is a tendency for a minimum to occur in the find number when the probe is directly over the strip, as both microphones then record essentially the same signal.

The position of the time window can be adjusted to suit the depth being examined. For a deeply buried object, there will be a greater time delay before the appropriate reflection arrives at the microphone and so the appropriate time window will occur later. In the example of Fig.8, the window commenced 620µs along the correlated signal and was 320µs long. These values were determined experimentally by inspection of the signals but could be calculated theoretically if the acoustic properties of the matrix material are known.

As the strip is moved closer to the surface the strength of the reflection increases, however, it begins to overlap the surface noise, so the signal to noise ratio remains approximately the same. Although it is now almost impossible to distinguish the object reflected pulse in the microphone outputs, the correlated difference signal indicates that a significant reflection occurs from the object. The technique can also be used to find smaller and more complex objects. It has successfully located a flat 9cm wide plastic strip, Fig. 9(a), while (b) and (c) show the location of a 6cm diameter plastic disk[4] and a similar sized but irregularly shaped rock, all buried 5cm under pebbles. Further, Fig. 9(d) indicates that it is possible to distinguish between the rock and the disk when they are buried about 50cm apart under the pebbles.

More complex analysis, such as the use of multiple time windows, provides a way to establish the depth of the buried object. In fact, dual window processing was used in Fig. 9(d) to help differentiate between the objects as, after correlating, the irregular rock gave a signal in both windows while the flat disk signal occurred only in one window. A

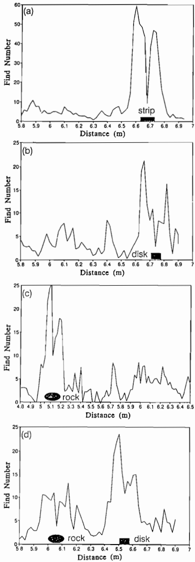

Figure 9. The find number for (a) a 9 cm wide strip, (b) a 6 cm diameter disk, (c) a rock, (d) both the rock and the disk after additional processing.

tilted object will also give rise to readings in more than one window. It is probable that different objects all have their own specific find number signature and thus further research may make the prediction of the size and shape of the object possible.

4. CONCLUSION

The system, as it stands at the moment, can easily detect objects as small as 6cm in diameter, buried as deep as 15cm in a pebble bed. A traverse is made in the direction set by the axis of the two microphones. If the object is midway between the microphones or large enough to extend beyond both microphones then the microphone signals become almost identical and a minimum in the find number may be recorded. This is because the system is essentially an edge detector, sensing a change of impedance. A number of traverses must be made to estimate both the length and width of the object, two more microphones positioned on an axis perpendicular to the direction of traverse would give information about the other dimension. This is the next stage in the development of the instrument.

The method is still to be tested over other matrix materials, although it is expected to work over dry soils and sands, where the sound will penetrate readily. It is unlikely to work on hard packed or water-soaked fields. With further development, the system could be preprogrammed for a particular matrix material so that the predicted pulse waveform for the reflection from a simple object buried in the matrix is calculated and then used in the correlation calculation to give an improved find signal.

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THE TOSCA ALEMBA – RINGING THE CHANGES

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Abstract: The *Tosca Alemba* is a new tuned percussion instrument with steel rods bent into pentangular shape as vibrating elements. The vibrations of these pentangles are communicated to a carefully designed soundboard to enhance radiation of their lower modes. The history of the development of the instrument from an earlier *Alemba* using triangular vibrating elements is traced, and the design of the pentangles considered in detail. The shape of these elements is such as to allow the tuning of five mode frequencies so as to produce closely harmonic frequency relationships, including a minor third, and a consequent musically attractive bell-like sound.

1. INTRODUCTION

Many orchestral scores call for the use of percussion instruments for dramatic effect. The timpani are the most commonly used percussion instruments, but cymbals and triangles are also used occasionally. Some compositions, however, make major use of percussion – for example, in the finale to Tchaikovsky's *1812 Overture*, where we find not only church bells but also cannon!

While it is possible, with modern recording and mixing techniques, to use actual church bells and cannon to produce exciting recorded performances of such works, this is much less satisfactory from both artistic and acoustic points of view in live performances. Leaving aside cannon, which could presumably be simulated using real explosives, there is a continuing problem with the production of bell sounds in orchestral performances. This applies not only to the massive sounds required by the *1812 Overture* but also to the much more subdued and carefully scored bells in operas such as Puccini's *Tosca* and Wagner's *Parsifal.* In each of these operas the bells are required to play particular notes, rather than simply making a joyful noise.

The solution usually adopted in orchestras is to make use of sets of tubular bells. These are hollow metal tubes about 20 mm in diameter and up to 1 m long, suspended freely and struck at a carefully selected point near one end. The sound is certainly "bell-like", but not a close approximation to the sound of a church bell. The basic problem is the lack of any low-pitched fundamental to the sound, so that it has clarity but not weight.

With this problem in mind, we have designed and built a new sort of bell-like percussion instrument specifically to produce bell sounds such as are called for in *Tosca* and *Parsifal.* For the present the instrument is called *Tosca Alemba* for reasons that will become clear, though some more general name might be appropriate when it is fully developed. This article describes some of the acoustic problems involved in the design, and the way in which they were solved.

2. CONCEPT OF THE INSTRUMENT

The *Tosca Alemba* had its genesis in another percussion instrument simply called the *Alemba* which was developed by one of us (MH) more than ten years ago. As described in an earlier publication [1], the *Alemba* consisted of a set of tuned triangles with one apex open, each coupled to a quarter-wave tubular resonator by a taut cord which drove a mylar diaphragm covering one end of the resonator. The length of each resonator was chosen so that its frequency matched that of the lowest vibrational mode of the triangle to which it was coupled, and this then defined the nominal pitch of the note produced. The triangles were initially equilateral, and the bend radius of the corners was adjusted empirically, to give the best sound. It was later found, again empirically, that by lengthening the middle side of the triangles two of their modes could be brought into nearly octave relationship – a frequency ratio of 2:1 – with a consequent improvement in sound quality.

The vibrational modes of the *Alemba* triangles have been discussed in some detail by Dunlop [2,3] who used a finite-element method to calculate the vibration frequencies of a range of isosceles triangles with the apex open but with a variable radius of curvature at the two other corners. From calculations and measurements he showed that the empirically designed triangles had mode frequencies in the approximate ratios 1.0, 2.0, 2.35, 3.0, 3.6 and 4.9. The second mode (the octave 2.0) is well tuned, as is the fourth mode (the twelfth 3.0). The third mode is a somewhat flat-tuned minor tenth (ratio 2.35 instead of 2.4) which does not match well with the sharp-tuned sixth mode (ratio 4.9 instead of 4.8) an octave above it. The fifth mode (ratio 3.6) is similarly not very concordant.

The *Alemba* produced an exciting new sound and succeeded in many ways in reaching its design objectives. The first version of the instrument produced was a medium-pitched treble with a range of two and a half chromatic octaves from C_3 to F_5 or 130 to 693 Hz. (The pitch notation used here is the American standard, in which the lowest C

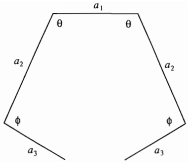

Figure 1. General shape of a pentangle, showing the adjustable parameters.

on the piano is designated C_1, all the notes in the succeeding octave are similarly given a subscript 1, the next octave a subscript 2, and so on. Middle C on the piano is C_4.) The base of each triangle was arranged to be horizontal, with the open apex hanging down, and the instrument was played by striking the base with beaters, the weight and softness of which could be chosen to give the desired sound quality.

Subsequently, at the suggestion of Sir Charles Mackerras, a bass version of the *Alemba* was built covering the octave C_2 to C_3, 65 to 130 Hz, with the objective of providing orchestral bell sounds for Berlioz' *Symphonie Fantastique*. While the sound was full and pleasant, the inharmonic ("out-of-tune") higher modes were judged to be too prominent for the instrument to be really satisfactory. It was the stimulus of solving this problem that prompted the design of the present instrument.

To provide the freedom necessary to tune the frequencies of the higher modes requires the introduction of more adjustable geometric parameters in the design, and it was proposed, on aesthetic rather than acoustical grounds, that this should be done by replacing the triangle with a pentangle, again with one open vertex. Again for aesthetic reasons, it was proposed that the pentangle have reflection symmetry, as shown in Fig. 1. For a given musical pitch, and thus total length of rod, there are two side-length ratios a_2/a_1 and a_3/a_1 and two corner bend angles θ and ϕ available as parameters, if the pentangle is not required to nearly close at the open vertex. This compares with only two adjustable parameters for the triangle problem at this level, though in fact the triangles in the *Alemba* were required to nearly close, thus leaving only one parameter. In both the original and the present designs, the bend radius at the corners was taken as a further parameter, though in the pentangle case it was treated as a secondary, rather than a primary, variable.

3. THE TUNING PROBLEM

Since our aim was to design an instrument with a rather low-pitched fundamental, it would have been convenient to base the pitch on the lowest mode of the pentangle, as in the original *Alemba*. This first mode is not satisfactory as a basis, however, since its frequency is too far separated from those of higher modes to produce a coherent tone quality. For this reason the second mode frequency was taken to define the nominal pitch of the pentangle. The tuning problem is then to adjust all the available geometric parameters to achieve a set of overtones in nearly harmonic relationship to this basis mode frequency.

A "brute force" approach to the tuning problem, using for example a finite-element approach and some global procedure to search for solutions giving frequencies in nearly integral ratios, was quickly seen to be impractical because of the volume of the four-dimensional parameter space to be searched. An altogether simpler approach was therefore adopted. This has been described in detail elsewhere [4] and will be only sketched here.

With four available parameters, in addition to the total rod length, it should be possible to tune the frequencies of four upper modes relative to the nominal second mode, as well as to adjust the basic pitch. To produce a bell-like sound that is musically concordant, we must insist that these upper modes are 3, 4, 5, and 6, since any badly tuned low mode will inevitably degrade the sound quality. Mode 1 for a bent bar lies at about one-third of the frequency of mode 2 and we can almost ignore it, since we can arrange that it is poorly radiated in the final instrument. It takes the place of the "hum" tone of a church bell, which is similarly not part of the main sound.

In a Western church bell [5] the important modes in order are the hum (frequency ratio 0.5), the prime or fundamental (1.0), the minor third (1.2), the quint (1.5) and the octave (2.0), although higher modes continue in roughly harmonic progression. For a bell with fundamental pitch C_3, these pitches would be C_2, C_3, $E\flat_3$, G_3 and C_4. The minor third component is characteristic of Western church bells, and we should try to design it into our pentangle – bells with a major third instead sound altogether different. The other important characteristic is the close frequency span covered by modes 2, 3 and 4. It turns out not to be possible to bring successive low modes of a bent rod into such close relative proximity, so that we must be satisfied with a wider spread.

To simplify the calculation, we first made the initial assumption that the rod from which the pentangle was to be constructed is thin – a quite good approximation – and the corners of the pentangle ideally sharp. With these assumptions it is possible to formulate and solve the in-plane vibration problem exactly and to determine all the mode frequencies for a given shape. The computational strategy adopted was to make a selection of well spaced guesses for two of the parameters and to search for values of the remaining two that gave reasonable approximations to integer-related frequencies for modes 2-6. Interpolation then suggested the regions of parameter space for further investigation. This strategy greatly reduced the computational problem so that it was easily solved on a personal computer. Just three acceptable shapes were found.

Since the pentangle was to be produced by physically bending metal rod, it is not realistic to assume ideally sharp corners. Indeed the sharpest reasonably attainable bend

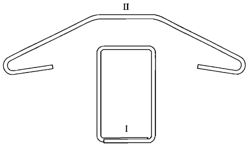

Figure 2. Two practical shapes for tuned pentangle vibrating elements.

corresponds to bending the rod around itself, and even less extreme bends are desirable in practice. A finite element program was therefore used to refine the solutions arrived at from the sharp-corner approximation and to turn them into practical designs. This eliminated one of the initial shapes, for which the bends were too extreme, and left the two shown in Fig. 2. Pentangle I is nearly rectangular, with the terminating sides overlapping, so that they must be bent slightly out of plane, while pentangle II looks rather like an open coathanger. (It has been suggested that it should be called a "boomerangle" to confer an Australian flavour!).

TABLE 1. Mode Frequency Ratios

Pentangle I (ideal)		1.00	2.00	3.00	4.80	6.00
Pentangle I (calculated)	(0.35)	1.00	1.96	3.05	4.82	6.13
Pentangle I (measured)	(0.35)	1.00	2.01	3.05	4.79	5.93
Pentangle II (ideal)		1.00	1.50	2.00	3.00	4.80
Pentangle II (calculated)	(0.32)	1.00	1.50	1.99	3.04	4.76
Pentangle II (measured)	(0.33)	1.00	1.49	1.96	3.05	4.75

The calculated and measured mode frequencies for the two shapes are given in Table 1. It is clear that we were able to achieve quite closely concordant frequency ratios, including the desired minor third (ratio 4.8), and that the experimental frequencies agree very well with those calculated. The pitches of the partials in the sound of pentangle I at a nominal pitch of C_3 are approximately ($F\sharp_1$), C_3, C_4, G_4, $E\flat_5$, G_5, while those of pentangle II are (F_1), C_3, G_3, C_4, G_4, $E\flat_5$, the first mode pitch (in brackets) not being really relevant.

The out-of-plane modes are quite inharmonic in frequency relation, which is actually an advantage since it gives the performer the ability to alter the timbre of the sound by striking directly or obliquely. After subjective acoustic evaluation, pentangle II was judged to give a better sound and was adopted for further development.

4. THE INSTRUMENT

The scaling problem for the pentangles is quite simple. We can either scale both the linear dimensions of the pentangle and the diameter of the rod together, in which case the frequency scales inversely with the length of the rod, or we can keep the rod diameter fixed and scale only the pentangle dimensions, in which case the frequency scales as the inverse square of the length of the rod. We adopted the second alternative, since it is much more economical of materials, though for an instrument with a really large compass some step-wise scaling of rod diameter would be desirable.

Because the rod from which the pentangles are made is only 12.5 mm in diameter, their radiation efficiency is very low at the frequencies of modes 1 to 6. Some sort of radiating structure is therefore required to couple the vibration of the pentangles to the surrounding air. Various possibilities were considered, including individual tuned pipe resonators, as in the *Alemba* and various types of tuned or untuned soundboard resonators. While resonant pipes have the advantage of being tunable to the individual pentangles, they are necessarily large and cumbersome for a low-pitched instrument. We therefore decided to use some form of soundboard radiator and to construct an instrument with a full chromatic octave of pentangles E_2 to E_3 to cover the requirements of the score of *Tosca.*

The design problem for a soundboard radiator for the combined pentangles is closely similar to that of the design of a harpsichord or piano soundboard. The soundboard resonances must be well distributed over the full compass of the fundamentals and upper modes of the pentangles, and it must be possible to provide a coupling that will drive it efficiently. The soundboard as finally designed by Graham Caldersmith was enclosed on its lower surface, to give adequate low-frequency radiation from its rather small size, and cross bracing was glued to its underside in a pattern designed to give an appropriate distribution of resonances, as checked by measurement. The soundboard tapers from bass to treble, and the cavity volume is an integral part of its design. The instrument is shown in general view in Fig. 3.

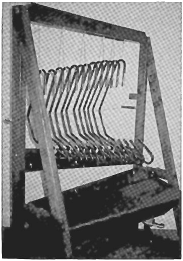

Figure 3. The prototype *Tosca Alemba* instrument.

Each pentangle is coupled to the soundboard by an elastic cord, similar to a guitar string, connecting one of its sides, near a corner, to a point on a line offset from the mid-line of the soundboard. This configuration provides efficient driving of the soundboard while the point of attachment to the pentangle can be adjusted so that the vibration of the pentangle is not too quickly damped. The elastic properties of the linking cord are such that it damps the highest frequencies of the vibration and makes the sound more mellow. The whole design is ergonomic, so that the player can strike the pentangles conveniently and see the conductor through the upper part of the instrument. In a refinement of the instrument we have now provided dampers, operated by a pedal, that can stop the sound quickly, as in a piano.

5. CONCLUSIONS

The success of a musical instrument depends not so much upon its technical virtues as upon its musical effectiveness, and this can be judged only by performers and composers. The *Tosca Alemba* instrument produces a new and interesting deep bell-like sound at a loudness that is adequate for chamber music or a small orchestra. For large groups it would probably require some form of amplification, which certainly detracts from its integrity as an acoustic instrument and raises the question of using a completely electronic synthesiser instead. However it does have the major advantage that its timbre can be controlled over quite a large range by the player – by using beaters of different weight or hardness, by varying the position of the strike, or by using an oblique strike to excite out-of-plane modes. It is this sort of flexibility that appeals to musicians, who interpret a musical score rather than simply acting as technicians.

A prototype of the instrument has now been built and will soon be available for evaluation by the musical community. Following that, the design will certainly be refined in detail before it is settled. We believe the instrument has an interesting musical future.

ACKNOWLEDGMENTS

It is a pleasure to express our appreciation to those who have helped with the development of this musical instrument. In particular we thank Paul Drew of the CSIRO Division of Applied Physics who made and tested all the pentangles over a period of many months with one of us (MH) as technical assistant, and to Graham Caldersmith of Canberra who designed and built the tuned soundboard, the casework and the damping mechanism. Without them the instrument would have remained simply an idea in the minds of its inventors!

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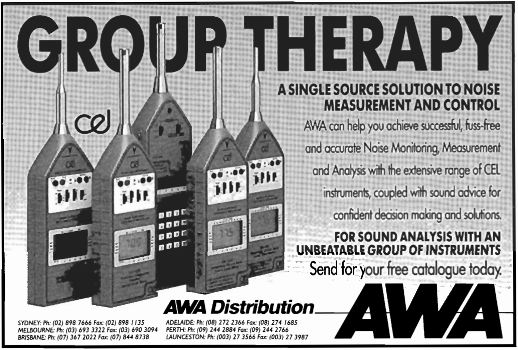

AUTOMATIC SPEECH RECOGNITION

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Abstract: Different basic approaches to the problem of automatic speech recognition are reviewed and their success compared. A survey is then given of Australian research in this rapidly developing field.

1. AUTOMATIC SPEECH RECOGNITION – WHAT IS IT?

The term automatic speech recognition means different things to different people. The popular vision is of something like Hal in *2001* or the sign in *L.A. Story*. To those who work in the field, a more satisfactory definition is that computer speech recognition is the process of mapping automatically a sound pressure wave into an appropriate set of linguistic entities (phones, words, phrases, intonational structures, concepts, etc.). Sometimes the term automatic speech understanding is used for the process of mapping the sound pressure wave to concepts but in recent years even this process has been included in the term 'speech recognition'.

Automatic recognition of words in some particular natural language is not necessarily a hierarchial task of first recognising phonemes, then putting these together to form words, and then joining the syllable to form words, and so on. Over time it has become clear that it is easier, by and large, to recognise words or phrases directly and not to go through a process of hierarchical linguistic combinations. In many ways it is an easier task to recognise words automatically than it is to recognise phones.

Generally speech recognition is qualified as being either 'speaker-independent' or 'speaker-dependent' on the one hand, and 'continuous' or 'isolated-word' on the other. Thus speaker-independent, continuous speech recognition is a considerably different (and harder) task from speaker-dependent, isolated-word speech recognition.

2. AUTOMATIC SPEECH RECOGNITION – WHO DOES IT?

Automatic speech recognition is multi-disciplinary, drawing on the fields of signal processing, statistics, phonetics, linguistics, psychology, artificial intelligence, and hardware design. In universities it is often carried out within electrical engineering departments or computer science/artificial intelligence departments although it is common to find linguists working in speech recognition groups within these departments.

In Australia there are groups working on speech recognition research in Sydney, Canberra, Melbourne, Brisbane, Adelaide, Perth and Wollongong. Telecom/OTC has three groups working on speech recognition research and development. A small number of indigenous companies carry out commercial activities in this field - one does speech recognition research and development directly, others import speech recognition technology and use it in systems they sell. Several multinational companies are bringing speech research products into Australia, albeit in a somewhat limited way.

Before examining Australian activity in this area, it is probably worth reviewing the history of international research in this field briefly.

3. A VERY SHORT HISTORY OF AUTOMATIC SPEECH RECOGNITION

In the drive to incorporate intelligent perception capabilities into computers, automatic speech recognition has been seen as one of the *hard problems*. Speech is a highly complex and redundant code. There is no simple mapping between the sound pressure wave and useful linguistic entities. The development of adequate mapping has been the business of the automatic speech recognition community for over twenty-five years.

While linguists in the 1960s had made some attempts at automatic recognition of limited sets of words using discrimination techniques, the first, major, large-scale attempt to tackle the problem was a multi-million dollar project in the first half of the 1970s funded by the American Department of Defense Advanced Research Projects Agency. The ARPA Speech Understanding Project [1] ended in a surprising way however. The Project specifications had stated that the goal of the various systems funded under the project was the *understanding* of simple queries (to the level that the systems could generate a sensible response in a highly-restricted linguistic domain). Of the four finalist systems carrying out the deliberately-restricted task involved, only one system, Harpy, met the Project goals of over 95% correct understanding of semantically – and syntactically – restricted utterances in a limited domain of discourse, spoken by one of the speakers for whom the system had been trained. What made Harpy such a surprising winner was the simplicity of its architecture. The incoming speech was signal-processed using a single processing technique, then the transformed speech was fed into a simple phonetic decoder which assigned each successive small section of speech to one of 98 possible quasi-phonetic labels. The label string was then fed to a weighted network, paths through which represented all possible legal utterances in the restricted domain. The best-path for the input label string was declared the utterance. Other finalist systems had used much more sophisticated architectures with relatively independent sub-systems taking care variously of semantic, syntactic, pragmatic and phonetic knowledge and analysis. Somehow the concept of 'compiling' most of the system knowledge into a single network seemed messy and certainly was a difficulty when new knowledge (new vocabulary items, for example) was to be incorporated in the system. And this indeed was the problem! The Harpy network had been handcrafted. The handcrafting of more general systems clearly was not feasible. Until someone worked out how to generate such networks automatically, this approach seemed stuck.

After the end of the ARPA Speech Understanding Project other approaches were tried, most notably the notion of rule-based systems which had the advantage of a simple but easily modifiable architecture but which, like Harpy, did very well in restricted situations but failed increasingly as the problem was generalised. Automatic rule generation was needed here in much the same way that automatic network construction was needed to generalise Harpy. Clearly, in both cases, some form of machine learning was needed.

An important step forward was the realisation that if machine learning was to be used, then large, systematically-collected-and-labelled speech data collections were needed on which machine learning algorithms could 'train'. (Before this a remarkably large amount of recognition work was done on a remarkably small set of somewhat odd data, chosen because of the difficulties to recognition the examples presented. The favourite sentence in the U.S.A. was "We were away a year ago". It was often said that the favourite in Australia, both for synthesis and recognition research, was "Good day to you, bad kangaroo"!) Initiatives were started around the world to collect and label large speech databases.

A major breakthrough came in 1988 when Kai-Fu Lee [2] at Carnegie-Mellon University demonstrated a speaker-independent, continuous speech recognition system recognising utterances with greater than 94% accuracy from a restricted-domain, 1000-word vocabulary. The key to its success was the use of a Hidden Markov Model (HMM) as the basic architecture which recognised the input speech as a series of overlapping trigrams and which in turn reasonably easily yielded word strings. The system, called SPHINX, was automatically trained on a hand-labelled database of 4200 utterances from 105 speakers. Here was the generalised Harpy, not 'understanding' much perhaps, but recognising words well - far better in fact than humans can do on certain tasks such as the recognition of digit strings.

It seemed that the recognition task (speech to string of words) was solved provided one had an appropriate training database covering all possible words in the utterance. And of course this is where one of the main problems with generalising this technology lies - understanding what constitutes, let alone collecting, an appropriate database.

Before proceeding, it is worth briefly considering the commercial spinoffs of both Harpy and then HMM technologies. The spinoff from Harpy has been the speaker-dependent, isolated-word systems marketed by firms such as Dragon, Kurzweil and Verbex. These systems have extremely large vocabularies, do not take long to train for a new speaker and are easy to use (in terms of leaving a short gap between the words) after very little practice. The early spinoffs from the HMM technology will most likely be seen in systems where the vocabulary is naturally fairly limited. Systems of this sort currently in advanced trial stages are various telephone systems such as bill-paying systems where the system is required to recognise digit strings and simple commands spoken by the caller. These systems are feasible because large databases of digit strings collected over the telephone currently exist.

4. RECENT DEVELOPMENTS AND PRE-OCCUPATIONS

Over the last ten years, but more particularly over the last five, the development of spoken language systems (SLS) has been identified as an important goal within several national and international projects. The system specifications for these SLS require high levels of understanding and the production of suitable responses, often to spoken database queries. The massive industry-government Japanese Automatic Telephony Research (ATR) Project goes even further and aims at machine translation systems although several specialist groups within the Project examine particular hard problems within the general SLS framework (see ATR annual reports which contain all papers – several hundred in 1992 – published from ATR within the year covered by the report). In the United States a major SLS effort is coordinated through DARPA. This work is notable for the regular system comparisons and evaluations that are held two to three times each year. The results of these are published by Morgan Kaufmann under the title "Proceedings of the Speech and Natural Language Workshop". In Europe large-scale, multi-language SLS work has been funded through various European Union initiatives, most notably ESPRIT. This work is published in a variety of EU-sponsored publications.

Communication between the big projects and between them and researchers in other countries not involved directly in major SLS initiatives (e.g. Australia) has been facilitated by the emergence of new and now major conferences such as Eurospeech and ICSLP (International Conference on Spoken Language Processing) and by the introduction of new topic areas into existing major conferences such as the session on Wordspotting that has been a feature of recent ICASSP (IEEE International Conference on Acoustics Speech and Signal Processing). By any measure – the capabilities of the systems demonstrated, the amount of money invested in the projects, the number and quality of the researchers working in the field, the level of industry money being spent in the area – the modern activity in SLS is impressive.

5. AUSTRALIAN SPEECH RECOGNITION RESEARCH

In considering work done in Australia it is worth bearing in mind that Australian research work has not had the same strategic funding impetus that has occurred in large national and transnational projects such as the ATR Project in Japan, the DARPA Speech Initiative in the U.S.A. and the ESPRIT Program in the European Union. Certainly funding for speech recognition research in Australia has increased in recent years but not through any special funding initiatives. Also, the amount of speech research carried out in Australia has increased over the last decade. Relatively however, Australia's importance in global speech recognition research has declined. This can be seen in various ways such as the ratio of the number of Australian papers in major international conferences to the number from other countries or by comparing the ratio of the number of citations of Australian papers to papers from other countries in 1993, say, to the ratio for 1983.

Australian Speech Recognition Research – Major Themes

There are two possible ways to describe speech recognition research in Australia either by group or by theme. I have chosen the latter approach as several groups carry out a variety of projects on different topics and because there is a high degree of co-operation and collaboration between the Australian laboratories working in speech recognition.

In Australia there is significant co-operation also between speech recognition groups and groups working on other areas of speech research (speech synthesis, text-to-speech, speaker identification and characterisation, speech compression, speech aids for the deaf, developmental trends in child speech, aphasia, etc.). An overview of the overall picture of Australian speech research can be obtained from the proceedings of the two main national, speech-related conferences which are held in alternate years. These conferences are the Speech and Language Conference which has a psycholinguistic focus and the Speech Science and Technology (SST) Conference which has a machine speech focus. There is also a speech society – the Australian Speech Science and Technology Association (ASSTA).

Databases and Infrastructure

Australian groups were amongst the earliest to realise the importance of large, carefully-collected-and-labelled speech databases. With the support of Computer Research Board funding, Dr Bruce Millar and Dr Pauline Bryant, from the ANU, and I collected a large database in 1982 - 83. This database which was designed to be useful in a range of speech research including speech recognition studies, contained speech from a large number of speakers. Each speaker performed a variety of spoken tasks including free conversation, reading set passages, descriptive and conversational, reading phonetically-balanced sentences, reading word lists and playing word games. Details of each speaker's health, medication and frame of mind were recorded at each recording session. All speakers recorded at least ten times over a period of some months. Thus this database was well-controlled for speaking style and provided ideal material for studies of speaker voice changes over time. This database was used for various projects and with databases contributed from the United Kingdom, the Netherlands and the U.S.A. became one of the first databases available for international comparative studies .

In order to be useful for most speech projects, and most particularly for training of speech recognisors, speech databases need to be labelled carefully and consistently. The task of speech database labelling is extremely time-consuming both in the actual labelling phase and in the quality-control-checking phase. Dr Michael Wagner of the Australian Defence Force Academy (ADFA) devised an algorithm early in the 1980s for assisting in the automatic alignment of speech with a label file. This algorithm provided inspiration for many alignment algorithms in use today.

The need for very large amounts of data has increased in recent years with the development of speech recognition algorithms which perform well if trained with large amounts of data. Even if it is only to use speech recognition technology developed elsewhere, there is now a need in Australia for extremely large amounts of data comparable to that collected by telephone companies such as AT&T in the U.S.A. Recognising this, four laboratories (at Macquarie University, the University of Sydney, the ANU and the National Acoustic Laboratories) initiated in 1990 a new and very large national speech database project now funded by ARC Mechanism C funding. This project is coordinated by Dr Jonathan Harrington at Macquarie University.

Special-Purpose Signal Processing for Recognition

Speech recognition algorithms are generally not designed to work on digitally-sampled speech directly. In most systems the speech is signal-processed according to one or more signal-processing algorithms and it is the output of this signal-processing phase which is fed to the speech recognition algorithms per se. Different signal processing algorithms give rise to different recognition results and so an important aspect of speech recognition research is finding the best combination of signal processing and speech recognition algorithms.

Australia has a well-established reputation in the signal-processing field. It is noteworthy tribute to this reputation that the IEEE International Conference in Acoustics, Speech and Signal Processing is to be held here (in Adelaide) this year. Professor R. E. Bogner's group at the University of Adelaide has carried out research in speech signal processing for the last twenty years. While most Australian speech recognition groups do some research in signal processing, the most interesting recent developments have been in auditory modelling and in the use of wavelets.

Auditory modelling research aims to signal process speech analogously to the way in which the human auditory system processes it. It is an attractive goal because the human auditory processing system is both computationally efficient and very robust at processing speech in the presence of background noise. Building and testing various auditory models, both in software and hardware, was a major feature of the GLASS Project, a multi-laboratory speech recognition project, running from 1991-93 and funded by an International Science and Technology Committee Grant. Within this project, Ara Samouelian's group at OTC (now at the University of Wollongong) concentrated on the development of auditory models in software, Dr Clive Summerfield's group at Syrinx Speech Systems built efficient hardware implementations of the best models and Dr Phillip Dermody's group at the National Acoustic Laboratories tested alternate models both in quiet and against controlled background noise. Several other groups have investigated auditory models, most notably Michael Wagner's group at the Australian Defence Force Academy.

Wavelet processing is, like the Fourier Transform, a means of obtaining a frequency representation of the speech signal. However, unlike the Fourier Transform, its frequency representation is quite similar to the frequency transformation done by the human auditory system - not as similar as the frequency representation achieved by some of the auditory medelling processes but a great deal more efficient. The main Australian proponent of wavelet processing for speech recognition is Professor Ah Chung Tsoi at the University of Queensland. Recently, Professor Peter Hall and his group at the ANU, the leading statistics researchers in the country and old hands at general wavelet processing, have started applying a series of improvements to wavelet processing of speech with a view to achieving major speech recognition score improvements.

Speech Recognition Using Hidden Markov Models

As explained above, the Hidden Markov Model (HMM) has led to the greatest improvements in speech recognition rates worldwide. Most speech research groups in Australia have now acquired and implemented some form of an HMM recognisor, either for applications work or as a benchmark for comparing other recognition technologies. Some groups are also actively pursuing research into refinements to the HMM. Most notable in this respect is Professor Kuldip K. Paliwal at Griffith University who recently came to Australia from the AT&T Laboratories in the United States. He has worked on improvements to HMM training algoithms and on the use of HMMs on noisy speech, a topic also being tackled by the group at the University of Sydney, led by Associate Professor Robin King and Dr Julie Vonwiller.

Several groups have developed particularly interesting demonstrations of speech recognition applications using the HMM. These include Associate Professor King's group at the University of Sydney, Dr Michael Flaherty's group at Telecom Research Laboratories, Dr Michael Skordalis' group at the University of Melbourne and Dr Jan-Ming Soong working with Ara Samouelian at OTC (now Wollongong). Syrinx Speech Systems has been funded by the Industry Research and Development Board to develop HMM technology for commercial applications in Australian business.

Neural Network Approaches

It is clear that some form machine learning is necessary in a speech recognition system in order to achieve high speech recognition scores. However it is by no means clear that the HMM is the best or most appropriate form of machine learning for speech recognition. It has often been suggested that a more appropriate form of machine learning could be achieved by using neural networks. This issue is being investigated by several groups in Australia. The first to experiment with this was Dr Michael Alder who works with Professor Yanni Attikiouzel at the University of Western Australia. Dr Alder started investigating the use Kohonen nets for speech recognition in 1980 and since then the group at the University of Western Australia have investigated several different neural network approaches to the problem.

Others doing innovative research on using neural networks for speech recognition include Ah Chung Tsoi's group at the University of Queensland, Dr Marwan Jabri's and Robin King's groups at the University of Sydney and Shu-Ping Ran working with Bruce Millar's group at the ANU.

Chris Rowles' group at Telecom Research laboratories constructed a clever neural net speech recognisor which, while only recognising about ten words, was a remarkably friendly, fast and robust system which allowed users to find out what movies where on in their local areas. This system demonstrated the feasibility of introducing well-tailored and cleverly-limited applications of speech recognition into Australian telephone-based query systems.

Rule-Based Automatic Speech Recognition

Through the period 1976-87, the predominant paradigm in speech recognition was the use of rule-based systems, a technique that evolved from the application of expert systems technology to the problem of automatic speech recognition. While many such systems were one-off systems, my group (then) at the University of Canberra developed a programming language, WAL, which has a syntax which is easy-to-use and particularly suited to writing rules for recognition of speech at any linguistic level (phones, diphones, words, phrases) or any combination of levels. By developing speech recognition systems in WAL, rules developed from one application can easily be incorporated into new applications. The language can also be used to test phonetic hypotheses (e.g. rules about how particular phoneme manifestations change in varying phonetic contexts) and is also applicable to the development of non-speech-wave analysis rules.

Some very sophisticated speech recognition rule systems have been developed which shed a great deal of light on complex phonetic research problems, particularly the problem of coarticulation, the phenomenon whereby, in human speech, any particular sound is modifed according to which sounds proceed and follow it. I worked on this problem for a number of years but currently the most active Australian researcher in this field is Dr Franz Clermont, a member of the ADFA speech research group, who has developed sophisticated, coarticulation-sensitive rules for various difficult sound classes.

As stated above, the problem with rule-based recognition systems developed in the 1980s is that it was hard to see how to incorporate machine learning into these systems and thereby take advantage of the large training databases being collected. The Canberra group has shown in recent years that this can be done. Ara Samouelian has devised a particularly neat solution to the problem by applying Professor Ross Quinlan's (from the University of Sydney) famous generalised machine learning algorithm, ID3, to sets of speech recognition rules.

A spinoff development at the University of Canberra from the work on incorporating machine learning into rule-based speech recognition systems has been work on the topic of recognition of speech using broad encodings, a technique which takes advantage of the high information redundancy in speech and leads to a naturally parallel algorithm for very efficient speech recognition.

Recognition of Chinese

Michael Wagner's group at ADFA have been working on the recognition of Mandarin Chinese for many years. This group was one of the first groups in the world to attempt to recognise tonal languages. Surprisingly, given the multicultural nature of Australian society and its proximity to Asian and Pacific countries, there has been remarkably little speech recognition research in Australia on languages other than English.

Prosody-Assisted Recognition

Robin King and Julie Vonwiller, working in conjunction with Chris Rowles and his group have for some time been investigating ways in which recognition of prosodic factors can enhance automatic speech recognition results. Prosody includes intonation, stress, speaking rate and loudness, all of which contribute significantly to human recognition of speech.

Wordspotting in Continuous Speech

The groups at the University of Queensland and the University of Canberra have been working in the field of wordspotting in continuous speech in recent years. Wordspotting involves automatically 'spotting' a set of target words in the presence of words on which the spotter has not been trained. The aim in wordspotting is to maximise the spotting of real occurrences of the target words and to minimise mis-spots. Wordspotting is particularly useful for automatic indexing of long, spoken documents such as telephone, court, parliamentary and media recordings.

Measuring Recognisor Effectiveness

Another major aspect of the GLASS Project was the systematic study of popularly-used measures of speech recognisor effectiveness. This work, carried out by the University of Canberra group, demonstrated the over-optimistic nature of some of these measures and proposed various modifications which would give speech recognition system developers a better indication of how their systems improve as more training data is used in the system.

Spoken Language Systems

With the drastic improvement in automatic speech recognition rates over the last five years, many researchers are now investigating the development of systems which can, in a limited way, understand spoken language input naturally and efficiently and produce appropriate responses to queries. This is a particularly difficult problem because of the stop-start nature of spoken, as opposed to written, language. Chris Rowles' group at Telecom Research Laboratories, Robin King's group at the University of Sydney and my own at the University of Adelaide are all working on the problem of building telephone-dialogue-query systems which have the capability of dialogue repair, that is, even if they do not fully 'understand' the query, they can sustain the dialogue and elucidate what is required through appropriately sensitive questioning.

Commercial Ventures in Speech Recognition

Syrinx Speech Systems, established by Dr Clive Summerfield and Professor Trevor Cole, is the only indigenous company actively carrying out research and development in speech recognition. Several other companies are importing speech recognition technology into Australia and selling either stand-alone systems or systems that can be incorporated into multi-purpose developments. One of the most innovative such companies is the Western Australian company, Digital Technology, which imports Dragon Systems speech recognition technology and sells it as a complement to its own locally-developed speech massive-storage technology. An example of clever incorporation of speech recognition into a larger system is the Verbex speech recognition facility in the Sydney Futures Exchange.

Introducing Speech Recognition Technology to the Courts and Parliament

In recent years various Commonwealth and State authorities have been investigating efficiencies that can be achieved through introducing automatic speech recognition systems into their operations. Aucript, the part of the Commonwealth Attorney-General's Department which provides transcription services to the Federal Court, has been particularly active in this, working closely with state court reporting authorities and with Hansard both federally and in various states, in investigating the potential for speech recognition in assisting in the massive transcript production that is carried out in Australia each week. The work done by these groups has led to keen interest in speech recognition applications in associated groups such as law firms.

Finding Out More About It

This has been necessarily a very brief overview of speech recognition work in Australia. I have not given references to publications on the various Australian projects as the reference list would be massive. A good starting point for more technical details is the proceedings of the various SST conferences held every two years since 1986. The 1994 conference is to be held in Perth in November. Attending an SST conference is a splendid way to meet the speech science community in Australia and a good way to hear latest developments in the various local projects.

REFERENCES

1 D.H. Klatt, "Review of the ARPA Speech Understanding Project" *J. Acoust. Soc. Am.* **62**, 1345 - 1366 (1977).

2 K.-F. Lee, *Automatic Speech Recognition: The Development of the SPHINX System*, Kluwer Academic Publishers, Boston, (1989)

Technical Report

The Illumicube - Art, Light And Sound

Kerry Simpson,
Philips Lighting, 86 Wentworth Avenue, Kingston, ACT
(formerly with ACT Electricity and Water)

The illumicube evolved from a desire by ACT Electricity Authority to celebrate its silver anniversary by donating a gift to the city of Canberra. The gift was to take the form of a "light sculpture" which, among other features, was to be dynamic and "people responsive"

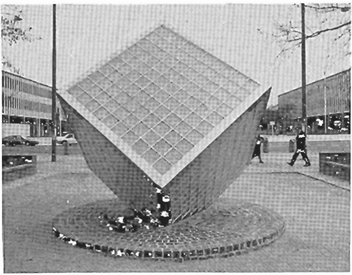
A cube shape was selected to compliment the nearby shapes in the city centre location and to allow the light to project downwards. The sides of the cube are approx two metres and each face comprises a grid of glass blocks. The cube is installed in a city plaza and is orientated so that it appears to be delicately balanced on one corner.

The dynamic requirement is provided by changes in the colour and intensity of the light with changes in the surrounding sound. A simple musicolour/chaser kit is the heart of the control system. Electret microphones - disguised as structural elements - are installed in the corners of the cube and the signal is fed to a mixer/amplifier in the service pit. The amplified signal is then sent to the controller, located in a garden bed nearby. The audio signal is separated into four frequency bands. The signal from each frequency band is transmitted via a relay system to a patch panel for initiating the various coloured lights. A fifth channel monitors the signal of the other four channels and provides for lighting when there are no acoustic inputs.

Each of the four frequency bands have separate sensitivity controls, allowing for "tuning" of their responses, ie the high band is set to respond to a whistle while the bass end is set to respond to low frequency rumblings. The lights are switched on or off, ie not regulated in intensity. Due to the thermal dynamics of the 500 watt filaments they do appear to dim up and down. Also a brief triggering will not allow the lamp to reach full brilliance, again creating the impression of varying intensity.

The simplicity of the technology has kept the operating costs to less than $2 per night. The lamps and filters need to be changed as part of routine maintenance. The only maintenance so far on the sound system has been a change of in-line connectors to the microphones. The originals suffered from moisture penetration following the use of steam cleaner units by over-exuberant cleaners.

The illumicube has been operating successfully for a number of years and has established itself as a landmark in the ACT. Passers-by are drawn to the display and will make various sounds such as shout, whistle, clap, sing etc, to get the different effects. Often adults will wait until no one is looking before joining their less inhibited children in some type of noise making. The design won the ACT Administration Award for outstanding technical and design innovation. However, most satisfaction is gained from seeing the excitement of children as the sculpture responds to their sounds by changes in colour.



This is the second of an occasional series on public sculptures featuring acoustics (first in Vol 21 (2) 51-54).

Articles or Reports to continue this series are invited.

News...

Report AAS Council Meetings

The 51st and 52nd Council meetings were held in Adelaide on 8 and 10 November 1993. The meetings were well attended with all States represented by two Councillors.

The Chairman of the Council Standing Committee on Membership, Ken Cook, reported that 11 gradings had been made throughout the year. They comprised 6 Members, 2 Affiliates (now Associates), 2 subscribers and 1 student. The members of the Committee are Ken Cook, John Davy and Bill Davern. All Committee members were re-elected. The Registrar, Ray Piesse, reported that the number of admissions and elevations to the Society was 16 in 1993. The number of new Members per year has decreased from 25 in 1992 to 14 in 1993. There were 12 resignations and removals from the Register. Current State statistics are:

NSW 177	Vic 115	Qld 46
SA 34	WA 46	Total 418

It was noted that Science Centre had incorrect data on some members which resulted in Subscription Notices. Science Centre has been advised of these matters. Council proposed a Special Resolution to set the levy on Divisions at 60% of the annual subscription payable by members on the Register as at 30 November 1993. Councillors will be voting on this matter at the end of February.

The 1994 AAS Conference is being held in Canberra 9 - 11 November and the AGM and Council meetings are planned for this time. John Dunlop received the agreement of Council to sponsor a conference on Acoustic Imaging and Remote Sensing 5 - 7 December 1994. The Victorian Division bid for the 7th International Congress on the Biological Effects Noise (1998) and is awaiting the outcome.

The General Secretary advised of the importance of circulating Divisional Minutes as important information is collected from these documents. Council received reports from AAS representatives on Australian Standards Committees. It was noted that there is not a lot of activity in some Committees at the moment and that it is the prerogative of AAS to request the development of standards as appropriate. Western Australia and Victoria presented proposals for the development of publications to help promote the Society. Both Divisions will be proceeding with their initiatives.

Noela Eddington - General Secretary

1993 Annual Conference, Australian Acoustical Society

Progress in Acoustics, Noise and Vibration Control

The Society's Annual Conference for 1993 was hosted by the South Australia Division and held at the Ramada Grand Hotel, Glenelg on 9-10 November 1993. Excellent conference facilities and catering set the stage for a very successful conference which was attended by 80 delegates.

Mr Rob Thomas, Executive Director, Office of the Environment Protection Authority, South Australia opened the Conference. Keynote speaker, **Dr Bernd Rohmann** recently appointed to the University of Melbourne, Department of Psychology, and previously Adjunct Professor at the University of Mannheim presented a very stimulating address, "Psychological Perspectives on Regulating Noise Emissions".

A total of 28 Technical Papers covered a broad spectrum of acoustic topics and Trade Exhibition provided up to date information on measuring equipment, processing techniques and acoustic products. The Conference Dinner, attended by approximately 70 delegates and accompanying persons, was a highlight of the conference functions.

At the close of the conference, newly elected President, **Mr John Lambert**, presented the President's Prize for the best paper submitted to the conference, by a member of the Society. The paper "Location of Buried Objects by an Acoustic Impulse Technique" was co-authored by A.J. Rogers and C.G. Don.

Conference Proceedings

The following papers were presented at the conference and are printed in the proceedings.

Peter Swift (l) congratulated by David Bies on being awarded the David Bies Prize (S.A. Division)

Costs for copies of the Proceedings, inclusive of packaging and postage are:

within Aust A$50 b) overseas A$60

Orders with payment in A$ should be forwarded to: Aust Acoustical Society, c/- Dept of Mechanical Engineering, University Adelaide, South Australia 5005.

• Keynote paper

Psychological perspectives on regulating noise emissions, *Prof Dr Bernd Rohrmann*

• Measurement and Control of Noise

A technique for measuring installed silencer performance, *B Martin*

Use of polyurethane dampers to reduce noise from a roll-form shear, *HM Williamson & CG Speakman*

MS-DOS based systems for airport noise control, AD Wallis & R Thorne

• Acoustics in Solids

Sound attenuation, enhanced by forced resonance, of elastomer layers containing resonating air inserts, *BCH Wendlandt*

Location of buried objects by an acoustic impulse technique, *AJ Rogers & CG Don*

Attenuation and dispersion measurements in porous materials, *DEP Lawrence & CG Don*

• Sound Propagation, Transmission and Attenuation

The volume velocity method for determining the specific normal impedances of acoustical materials, *K Byrne*

Sound power determination in the geometric near field of a source by pressure measurements alone, *DA Bies & GE Bridges*

Single and double pulse propagation in a turbulent atmosphere, *ID McLeod, GG Swenson & CG Don*

Charles Don (l) receiving President's Prize from John Lambert.

Transmission of sound through apertures, *KA Burgemeister & CH Hansen*

Sound propagation in ducts - modal scattering in rigid walled ducts of arbitrary axial curvature, *GE Bridges, DA Bies & CH Hansen*

• Vibration Monitoring and Isolation

Surface excitation: surface mobility, *JY Zhao, H Williamson & J Baird*

Four pole parameter characterisation of isolator acoustic transmission performance, J Dickens, C Norwood & R Juniper

Use of the cepstrum to separate source and transmission path effects, *RB Randall*

Active Control of Noise and Vibration PVDF noise control source in liquid filled pipes, *M Podlesak & RG Juniper*

Sensing vibration to control structural radiation, *SD Snyder*

Genetic algorithm adaption of nonlinear filter structures, *CT Wangi & CH Hansen*

Active control of aircraft interior noise with a view to application in light aircraft, *MT Simpson & CH Hansen*

Commercial application of active noise control in ducted systems, *PB Swift*

• Noise Ratings and Management

Establishment of an outdoor learning environment for young deaf children in an acoustic climate dominated by traffic noise, *J North & S Samuels*

Attitudes of residents, currently exposed to aircraft noise, to amelioration measures, *MA Burgess & RB Zehner*

Criteria for rail traffic noise, *R Bullen & SE Banks*

Noise management in the workplace, *W Williams*

Public policy and prevention of industrial deafness amongst Australian farmers, *I Eddington, D Moore & P Rooney*

Low Frequency noise due to HVAC systems and its assessment, *N Broner*

Applications of Numerical Analysis prediction of road barrier insertion loss by the boundary element method, *X Du & RJ Alfredson*

Numerical acoustics - what are its applications?, *JCS Lai*

• General

Monitoring of the support conditions of buried and sub-sea pipelines using a vibrating PIG, *UG Kopke*

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Science Centre Name Change

As of October 1993, the Science Centre Foundation has changed its name to the **Professional Centre of Australia.** This change should be noted in your record of the address for the General Secretary of the the Society and for the NSW Division.

Award For Anita Lawrence

Congratulations are due to Professor Anita Lawrence, a recipient of one of Standards Australia's inaugural **Standards Awards.** These special annual awards, decided by the Executive Board and the Standards Australia Directorate, are for those who have made major contributions to standardization. Eligible for awards are Technical Committee and Executive Board members who, through the years, have distinguished themselves in devoting their time and resources to the development of standards for the benefit of the nation.

Public Relations Officer

The NSW Division of the AAS welcomes **Matthew Harrison** as the new Public Relations Officer. Matthew is an acoustical consultant with Eden Dynamics Pty Ltd. He has enthusiastically accepted the role of Public Relations Officer and hopes to make a significant impact during his term of office. As the title suggests, his duties will involve promoting our Society and increasing the public's awareness on acoustic issues in general. Matthew is keen to hear from anyone who has ideas on how we could promote our field of interest and anyone who has contacts in the media world. He can be contacted during business hours on (02) 579 5566 by phone, or (02) 580 9755 by fax. After hours phone/ fax (02) 427 6031.

NEW MEMBERS

The following are new members of the Society, or members whose grading has changed.

New South Wales

Member
Mr P F Alway — Mr G A Leembruggen
Dr J A Ogilvy — Mr K F S Wong

Student
Mr A Appleby

Subscriber
Ms S E Banks — Mr M B Pettigrew
Mr C G Speakman — Mr J H Wasserman

Queensland

Student
Mr D J Davis

South Australia

Subscriber
Mr K A Burgemeister — Mr J Woolley

EXCELLENCE IN ACOUSTICS

National Awards 1994

The Australian Acoustical Society is now inviting entries for the 1994 Excellence Awards. A Call for Entries is included as an insert with this edition of Acoustics Australia.

Further information:
Dr Stephen Samuels, UNSW.
Tel (02) 697 5094
Fax (02) 663 2188

FASTS

The AAS is a member society of FASTS and the following has been extracted from an article by Peter Pockley published in Search, vol 25, p.13.

The new President of the Federation of Australian Scientific and Technological Societies (FASTS), Professor Graham Johnston, is planning a shift in emphasis from a largely reactive to a predominantly proactive organisation. Johnston's mission for Australian Science, in a nutshell, is 'to help make it part of the real world and to establish a broader base for the science and technology agenda'. Johnston said he is keen to apply the lessons from his contacts with business and government to his work as leader of one of the most influential bodies in Australian science.

Prominent on Johnston's agenda are:

• Making FASTS 'a more responsible, apolitical body, generating its own policies and not just criticising government'.

• Focusing political attention on 'big picture items'. The chemical and pharmaceutical industries should be targets for major growth in exports, for instance.

• Promoting the Science Ministry to Cabinet level, as in the UK, USA and France.

• Supporting FASTS' existing lobbying activities with the Federal Government and forming strategic alliances with State Governments and major representative bodies.

• Challenging the 70 member societies comprising FASTS (total individual membership about 70 000) to nominate issues in their discipline areas that, if supported, would have a high likelihood of producing export income for the nation.

- Getting more practising scientists on to science policy and advisory bodies like ASTEC and the Prime Minister's Science and Engineering Council.
- Improving public and political understanding of science and technology.
- Simplifying the government rules that industry has to contend with in becoming more innovative.
- Focusing scientists' minds on the social and economic impact of their work by requiring them to answer question on these points in applications to research funding bodies.

DSTO Laboratory Opening

On 15 February 1994 a new Australian research facility for the study of ship noise and vibration was opened. The facility is part of the Ship Structures and Materials Division of the Defence Science and Technology Organisation's (DSTO) Materials Research Laboratory (MRL) located in Melbourne. Its mission is to help reduce and control the acoustic signatures of Royal Australian Navy vessels with the view to enhancing the Navy's operational capabilities. Research already underway within the facility is targetted at developing a better understanding of ship noise and of its sources, transmission and radiation into the sea. The associated work program involves theoretical analyses, numerical modelling, laboratory experiments and onboard measurements and trials. Well equipped laboratories are housed within the facility to undertake this research and include the following.

- water tank with interchangeable side wall.
- vibration isolator test rig.
- 25 kN force vibration system.
- anechoic chamber
- 20 t seismic block on an airbag suspension.

The facility is known as the Leonard Samuels Laboratory, named after Dr L.E. Samuels AM, a former Director of MRL and an internationally acclaimed metallurgist. It was officially opened by Senator the **Honourable John Faulkner,** Minister for Defence Science and Personnel, during a ceremony attended by present and former MRL staff and invited guests. Appropriately representing the Society was **Dr Stephen Samuels,** a Federal Councillor from NSW and the elder son of Leonard Samuels.

Speech Science & Technology

The Australian Speech Science and Technology Association (ASSTA) has a growing membership with wide ranging interests in all aspects of speech. Audiologists, biologists, computer scientists, engineers, linguists, mathematicians, phoneticians, physicists, psychologists, speech pathologists etc come together with the objective of advancing and promoting speech research. A comprehensive directory of Australian Speech Science & Technology Research has been published by the association. Further information: *ASSTA Inc, GPO Box 143, Canberra, ACT, 2601.*

Quality Assurance

Standards Australia has just produced an important interim handbook: *HB66 Quality Assurance Explained - Small Business Handbook for Quality Systems (AS3900 Series).* This handbook provides guidance for small business on quality systems. It explains what quality systems are and how they apply to small business, together with relevant examples. As the quality standards AS 3901, 3902, and 3903 are due for revision later in 1994, this handbook is an interim measure and will be revised following revision of the relevant Standards. Comment is requested on this handbook to assist with the future revision. Details from any Standards Aust Office, cost $37.00.

ASA New Acoustical Standards

The Standards Secretariat of the Acoustical Society of America (ASA) is releasing three new sets of acoustical standards. They focus on sound from portable electric power tools, stationary and fixed electric power tools, and gardening appliances (ANSI S 12.15 1992); guidelines for obtaining noise level data from manufacturers of stationary equipment (ANSI S 12.16 1992); and the second part of a series concerning the description and measurement of outdoor environmental noise (ANSI S 12.9 1992/Part 2). Inquiries should be directed to Avril Brenig, Office of the Standards Secretariat, Acoustical Society of America, 120 Wall Street 32nd Floor, New York NY 10005-3993, USA. Fax (212) 248 0146.

In the facility's anechoic chamber are (from left) Dr Tony McLachlan, Chief of MRL's Ship Structures and Materials Division, Senator John Faulkner, Dr and Mrs Leonard Samuels.

AUSTRALIAN ACOUSTICAL SOCIETY

1994 INTERNATIONAL CONFERENCE ON

UNDERWATER ACOUSTICS

"Acoustic Imaging and Remote Sensing"

5 - 7 December 1994
University of New South Wales

TOPICS:

- Sonar & Ultrasonic Imaging
- Remote Sensing
- Acoustic Vision
- Seabed Characterisation
- Fisheries Acoustics
- Biological Noise

Details:
Dr J I Dunlop, School of Physics, University of New South Wales
PO Box 1, Kensington NSW 2033.
Tel (02) 697 4575,
Fax (02) 663 3420
email: jid@newt.phys.unsw.edu.au.

SAS (Singapore) Conference

To be held January 11-12 1995, the topics of interest under the theme NOISE are: Active control of noise and vibration; Sound intensity applications; Structural intensity measurement; Noise and vibration measurement; Construction noise; Assessment and regulation of community noise; Architectural acoustics; Speech communication; Physical acoustics; Ultrasonics and bioacoustics; Underwater acoustics; Transduction and measurement. The proposed venue is the Novotel Orchid Singapore.

The reader is referred to Vol 21 No 2-65 "Inter-Society Collaboration", where Dr Gan, President of the Society of Acoustics (Singapore), invited Australian acousticians visiting Singapore, particularly Members of AAS, to address the SAS on any topic of their choice related to acoustics. Reciprocally of course, AAS welcomes visiting acousticians from Singapore to arrange for presentations to our Society.

Further information: Dr Gan (see Diary section of this issue) or Donald H Woolford, GPO Box 278, Sydney NSW 2001 (Tel/Fax (02) 363 2554).

Synaesthetica '94

A Symposium on Computer Animation and Computer Music will be held 1-3 July 1994 at The Australian Centre for the Arts and Technology (ACAT), Australian National University, Canberra. The symposium will bring together researchers, developers and practitioners involved in the theory, practice, and analysis of computer-based animation and music composition as well as real time performance systems. This three day program is designed to encourage the interaction between researchers and the interchange of work and ideas in the areas of computer music and computer animation. The symposium will provide a mix of innovative technical sessions and cultural events to promote the understanding and development of both computer music and computer animation and will provide a forum for exploring the technical and aesthetic similarities and differences in these two fields. Original papers, live performance works, works for screenings and poster presentations are sought on a wide range of topics.

Further information: Julie Fraser, ACAT, GPO Box 804 Canberra, ACT 2610, Australia Email: cat691@anu.edu.au

Computational Acoustics

Conference to be held 5-7 April 1995 in Southampton, UK. The need for accurate prediction of noise in different types of environment has resulted in a growing awareness of the power of computer codes to monitor acoustic problems which are of primary importance in industry, architecture and the environment. This conference aims to bring together all who are concerned with the study of acoustical problems and are interested in their accurate modelling. Further information from COMACO95, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO4O 7AA UK, Tel 44 703 293223, Fax 44 703 292853, email CMI@ac.rl.ib.uk

Inter-Noise 94

This conference is being held in Yokohama, Japan August 29 to 31 and is sponsored by the Int Institute of Noise Control Engineering. The theme is Noise Quantity and Quality. Over 500 abstracts have been received for contributed papers and there will be three invited lectures. The reduced rate for registration fees applies to 31 May 1994. Contact details in Diary section of this issue.

Westprac V

The registration details for the Fifth Western Pacific Regional Acoustics Conference,Westprac V, are now available. This conference will be held in Seoul, Korea during August 23 to 25 (immediately preceding Inter-noise in Japan). The conference will include invited and contributed papers on a range of topics. Contact details in Diary section of this issue.

Euro - Noise 95

The second European Conference on Noise Control will be held in Lyon, 21-23 March, 1995 with the theme "Software for Noise Control". The aim is to provide a meeting point for software developers, researchers and end users. Two types of oral presentation will be organised. One will be devoted to original aspects from current research in the field of computation for noise control. The second will allow software developers and users to provide product presentations. Workshop sessions and manufacturer's exhibition will also be part of the Conference. Contact details in Diary section of this issue.

AUSTRALIAN ACOUSTICAL SOCIETY
1994 CONFERENCE

NOISE AND SOUND: *Nuisance and Amenity*

9-11 November 1994 in CANBERRA

All those wishing to present papers at this Conference are reminded that titles and abstracts should be submitted to the Conference Organisers by April 15 1994.

The brochure for expression of interest and call for abstracts has been distributed. Additional copies and further details on the Conference are available from:

Marion Burgess,
Acoustics and Vibration Centre,
ADFA, Canberra, ACT 2600.
Tel (06) 268 8241 Fax (06) 268 8276
email m-burgess@adfa.oz.au.

SHORT COURSE ON

BASICS of ACTIVE NOISE CONTROL

8-9 November 1994
(preceding AAS Conference)

Acoustics & Vibration Centre
ADFA, Canberra, ACT 2600

Oticon A/S of Denmark has recently purchased the Hearing Care Division of Angus & Coote Pty Ltd and International Acoustics Manufacturers and is now strongly represented in Australia. The new Company has its headquarters in Sydney's west and will provide hearing aid technology, manufacture and supply throughout Australia. The old Angus & Coote Division will trade under the name of "AudioClinic". Also see item in New Products, this issue.

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Bryan Vanderstelt has recently joined Acoustics Research Laboratory as its product development engineer. His experience in hardware and software will fit well with ARL's current and planned system development strategies.

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The English-language Proceedings of the Russian Acoustical Society 1993 conference "Acoustical Media Monitoring" are available for US$45.50 from the Russian Acoustical Society, Shvernik Str.,4, Moscow 117 036, Russia. The topics covered include acoustical monitoring of seas and oceans, the earth's crust, the atmosphere, and applications of acoustical monitoring in industry, medicine and other areas.

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The February meeting of the ACT Group for 1994 was held at the the Film and Sound Archive of the Australian War Memorial. The curator of the collection, **George Imashev**, outlined the extent of the collection and the approach taken to its preservation. A tour of the facilities included demonstrations of the range of items in the collection.

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In response to the need for advanced skills in acoustics, **TAFE NSW** has joined forces with acoustical consultants **Eden Dynamics Pty Ltd** to offer short courses designed for personnel required to assess the impact of environmental and occupational noise.

Books...

ACEL OHS Yearbook 1994

ACEL Information Pty Ltd, 1993, pp408, soft covers. Distribution by ACEL, PO Box 471, Crows Nest, NSW 2065, Tel (02) 906 5566, Fax (02) 906 6096. Price A$115.

This is the first Edition of what could be a most useful information resource on OH&S supplies, suppliers and information. The promotional literature promises that 'ACEL scours the world for the very latest information relevant to the needs of Australian occupational health and safety professionals' sadly this and the other claims regarding the quality of information provided are not fulfilled, however later editions may improve.

The Yearbook is laid out in clear and helpful sections to enable a quick search for information. The sections are; PRODUCTS - which lists suppliers of a product or reference to a more appropriate product section eg Ear protection lists suppliers of Ear muffs, Ear plugs and Ear testing equipment with a reference to Audiometric testing equipment, COMPANIES & BRAND NAMES - which lists brands, agents suppliers and manufacturers overseas and in Australia, SUBJECTS - this is potentially the most useful and sets itself the task of providing a publication listing on all OHS issues ranging from Abandoned vehicles through many chemical and physical agents to Zoonoses, ADDRESSES - which lists the address in Australia and overseas of suppliers referred to elsewhere in the yearbook.

The question which needs to be asked is: Will this yearbook give me the information in less time than other sources and is it complete? To establish the answer some sections on acoustics were checked with the following results.

Acoustic consultants were not listed. Noise measurement lists only 4 suppliers of dosimeters, noise level meters and other equipment - my personal records show 10 in Sydney and this is probably still not complete. Noise reduction lists 7 suppliers of barriers, hoods and partitions - my personal records show more than double this number in Sydney alone.

The subjects index, whilst performing better with some interesting references to pamphlets fact sheets and other relevant data, omits important facts. For example the Asbestos section omits NH&MRC recommendations, the Noise section omits references to current NSW noise regulations with the exception of the Factories (Health and Safety Hearing Conservation) Regulations and the previously mentioned Abandoned Vehicles section refers to the section on Refuse and Waste which gives no information on abandoned vehicles.

The yearbook is unfortunately incomplete and in fact falls far short of providing the information promised. At this stage it can provide some information to the novice OHS professional, but should not be relied upon for a full and complete listing as promised in the promotional brochure.

Ken Mikl

Ken Mikl is the Section Leader of WorkCover Acoustics which provides research and acoustic services to the Inspection, Compensation and Risk Management areas of the Authority. The section also provides a commercial noise assessment and control service principally to industrial clients.

Obituary

Edward Thomas Weston B.E. M.A.A.S.

On 19 February 1994, Edward Thomas Weston, known by his family, friends and associates as Ted, died in hospital after a short illness. The loss of a colleague who made numerous contributions to the development of acoustics and was a great friend of many of us is deeply regretted.

Ted was born in Perth in 1916 and educated in WA. Ted moved on to the University of WA in 1935 and after studying science for a short while switched to electrical and mechanical engineering. At the university he resided at St George's College, the only residential college for students at that time and became Senior Student and President of the College Club in his final year.

About two years before the World War II, Ted was among eight of two hundred applicants who were selected to learn to fly at the Royal Australian Air Force Academy at Pierce. He joined the Citizen Air Force and became a flying officer. During the war, he was a training officer at Sommers Air Base in Victoria and worked with the Munitions Supply Laboratories in Melbourne.

Following the war Ted joined the Commonwealth Experimental Building Station at North Ryde (National Building Technology Centre). This position involved consideration of thermal conditions, lighting, ventilation and acoustics in building design. It particularly suited him because at university he was interested in engineering relating to personal comfort and the environment although this was long before courses were available

Ted commenced working in the field of acoustics some time during the middle 1950's when there was little expertise in Australia and probably no more than a handful of people working on building acoustics. At this time noise from ventilation of buildings, traffic and machines in offices and factories was increasing and at the same time building construction practices were moving away from solid brickwork which was a good barrier to noise, to light weight structures which were often fairly transparent. The overall effect was often an undesired increase in noise levels and or a reduction in privacy. People were beginning to demand solutions to these problems.

The Station was part of the Commonwealth Department of Works which was responsible for the design and construction of Commonwealth buildings throughout Australia. This led to the building at the Station of a special laboratory for acoustic tests on building elements which was completed in 1964. Some of the work Ted and his group carried out during these years included consultation on the design of the new International Terminal and Operations Towers at Sydney Airport. Ted also contributed significantly to the publications entitled Notes on the Science of Building which were produced to give practical guidance to designers and builders.

Because of Ted's considerable expertise in noise measurement and building acoustics he became a very valuable member of Committees of the Standards Association of Australia involved in drawing up standards for instrumentation and acoustical testing of various building elements.

Ted became involved in the Australian Acoustical Society during its earliest days. He was among a small group of enthusiasts who met in 1964 to consider the formation of a Society to promote the science and practice of acoustics. He worked on various committees established to organise meetings and arrange for the Society to be incorporated. He was a foundation member of the Society, a councillor and General Secretary for two years from 1973. One of his most significant contributions was his work with Peter Knowland and John Irvine in the production of a Newsletter for the NSW Division which developed into The Bulletin and subsequently became "Acoustics Australia".

The organisation of meetings and the journal played a very significant part in the development of acoustics in Australia through the transfer of information in which all acousticians wholeheartedly participated. Ted and his group actively participated in these activities and thereby played a very important part in the practical application of acoustics. In addition Ted passed on a lot of his knowledge by lecturing to students at the Universities of Sydney and New South Wales.

Throughout most of his life Ted retained a love of flying and for many years owned his own aircraft. Several members of the AAS have on occasions appreciated air transport to Society conferences and have interesting stories to tell about these flights with him. Everyone agreed, however, he was a superb pilot who was unflappable in all circumstances.

Ted was a highly respected and popular member of the Society. Many regarded him as one of the gentlemen of this world. He had very warm friendly relationship with people, he was always helpful to the best of his ability, never denigrated others and was most professional in his work at all times. We are grateful for his immense contributions to the practical application and knowledge of acoustics in building design and construction in Australia.

As well as flying aircraft, Ted dearly loved playing tennis. until he became ill late last year he was playing at least once and often twice a week in an over 60's tennis group. Anyone who played tennis with him and knew him well would realise that his attitude to tennis was the same as his attitude to life which is perhaps not surprising. He enjoyed the game at all times; He was always enthusiastic in participating; He had a good style: He always played the shots to the best of his ability; He was always fair in his decisions on line calls; And whenever the call went against him he played to equalise the deficit.

Ted is survived by his wife, Joan, and his daughter Marion.

Ted was a great friend and colleague who will be sadly missed.

Ray Piesse

Letter...

Dear Editor,

I have decided to write to you with the aim of obtaining information about Postgraduate Study in Australia. At present I am a Final Year undergraduate at the University of Southampton, studying Acoustics and Vibration at the ISVR. I will graduate July 1994 and anticipate obtaining an Upper Second class degree. After graduating, I am required to work for Rolls-Royce as part of a sponsorship arrangement. This will take me to December 1995, and thus I would be interested in starting study again in early 1996.

I would like to continue along research lines, leading preferably to a PhD, or a Master of Engineering or Science. My main areas of interest are fairly varied - my Final Year options this year include: Engineering Acoustics, Automotive Engineering, Acoustic Technology and Society (basically an Environmental Acoustics type-course), Underwater Acoustics (including many parallels with Human Body and Medical Applications) and Music Performance-option allowing links between ISVR and the Music Dept.

I would like to continue my studies in the area of Environmental Acoustics, and Transportation Noise, If anyone reading this can help me, please contact me at

Chris Dobson,
110 Ashdown Road, Chandlers Ford, Hampshire. SO51QG. (0) 703 269341
email:C.J.Dobson@southampton.ac.uk

New Products...

QUEST TECHNOLOGIES
Quest Q-500 Noise Analyser

The Q-500 Noise Analyser, a Type 1 analyser, has two independently programmable channels. By setting each channel to a different set of parameters, the user can get accurate comparisons between two different weightings, threshold levels between 40 and 140 dB, selected exchange rates, fast and slow response rates, a security code to protect user-selected parameters and data, and storage of up to 999 separate events in memory. The Q-500 has menu selectable instructions. The large display has a zoom feature which makes for easy comprehension of data. The interface enables the user to print reports and download data into a PC for further manipulation. The Q-500 is intended for industrial noise, community noise, or any other application requiring accurate noise measurement and documentation.

Further information: Selby Scientific Instruments, Private Bag 24, Mulgrave North, Victoria 3170. Tel 132990.

MONITRAN
Vibration Sensor

The MTN/1185cm has internal electronics to give a direct velocity output of 4 - 20 mA. Three standard velocity ranges are available for 0-5 mm/sec through to 0-50 mm/sec rms with special ranges available for specific needs. Frequency response is from 2Hz to 8kHz with an operating temperature range of -25 to 100 deg C. The unit operates using the standard two wire control loop requiring a 10-32 volts unregulated supply. The sensor is constructed in stainless steel, weighs only 150 g and is sealed to allow use in dirty, dusty and wet environments.

Further information: Vipac Engineers and Scientists, 275-283 Normanby Road, Port Melbourne, Victoria 3207. Tel (03) 647 9700, Fax (03) 646 4370.

CSR GYPROCK
Acoustic Design Manual

The updated version of the Manual provides a comprehensive guide to the acoustic performance of an extensive range of Gyprock plasterboard wall and ceiling systems. It also includes a fully-detailed ready reference of plasterboard building systems which comply with the Building Code of Australia. The Manual includes a wide range of test results issued by CSIRO or other NATA-registered laboratories.

Further information: CSR Gyprock (Wendy Kelly) Tel (02) 332 3088.

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MultiFocus is the first fully automatic hearing aid which constantly adapts to the users sound environment and compensates for the specific nature of the hearing loss. When soft sounds are detected, such a quiet conversation, the amplification is increased to make them more audible, even in background noise. Yet loud sounds are never uncomfortably loud. A nonlinear low frequency channel is based on loudness recruitment compensation and a linear high frequency channel is controlled by active output limiting.

Further information: Oticon Australia Pty Ltd, P.O. Box 661, Paramatta, NSW 2124. Tel (02) 635 8878, 008 816 825, Fax (02) 633 4021.

TEAC
DAT Data Recorder RD145T

The RD145T is a 16 channel DAT data recorder featuring double-speed mode which increases tape transport and head rotation speeds to twice the standard, thus increasing the total bandwidth to twice that of conventional DAT data recorders. The RD145T has a recording frequency response of DC to 20 kHz in 4-channel mode, DC to 10 kHz in 8-channel mode and DC to 5 kHz in 16-channel mode. Data processing time can be halved by using the double-speed mode to reproduce data recorded in standard mode. The recorder is switchable for 2, 4, 8, or 16 channel operation. Signal-to-noise ratio is more than 75 dB, and phase difference between channels is 2 degrees or less. An independent memo channel and a built-in microphone enable hands-free recording of surrounding environment during data recording. Computer control is possible via the optional GPIB interface.

Further information: AWA Distribution, 112-118 Talavera Road, North Ryde, NSW 2113. Tel (02) 888 9000, Fax (02) 888 9310.

KINGDOM
MIMO for FFT

Kingdom has released Multiple Input Multiple Output (MIMO) frequency response measurements on the DP420 Multichannel FFT Analyser. MIMO improves the accuracy of modal measurements and has only been available with large computer based analysers in the past. The DP420 is the first multichannel analyser to offer this powerful measurement capability.

The DP420 FFT Analyser uses co-processor boards which plug into the PC and provide a powerful DSP engine for data acquisition and high sped digital processing. The modular hardware platform is a natural for MIMO application where the user can choose any combination of DAC output channels and ADC input channels.

Further information: Kingdom Pty Ltd, PO Box 75 Frenchs Forrest, NSW 2086. Tel (02) 451 8131, Fax (02) 975 3819

INTELLIGENT INSTRUMENT
Visual Designer Software

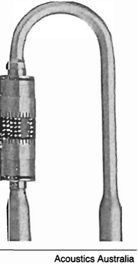
Visual Designer is a powerful yet easy-to-use application generator for PC-based data acquisition, test, measurement and control. It enables custom Windows application software to be created quickly to meet a user's specific requirements, without using a programming language. It can be used to capture, record, manipulate, analyse, display and output data; to control processes and devices; and to create customised instruments. Visual Designer runs on suitably-configured IBM-compatible PCs.

Further information: Kenelec, 2 Apollo Court, Blackburn, Victoria 3130. Tel (03) 878 2700, Fax (03) 878 0824.

BRUEL AND KJAER
Robust Intensity Probes

Bruel and Kjaer's intensity probes have a new mechanical design that makes them as strong as they are sensitive. A new stainless steel alloy brace replaces all the mechanical parts used in earlier probes, so there are no extra adapters or pieces which can be unscrewed or lost. The new probes use a specially designed dual preamplifier connected to a single 18-pin LEMO socket which is screwed directly into the brace. Each probe is supplied with a pair of phase- and amplitude-matched microphones, and 50, 12, and 8.5 mm spacers. The 8.5 mm spacer extends the useful frequency range with 1/2" microphones up to 7.1 kHz. An updating kit is also available for existing probes Type 3545, 3547, and 3548.

Further information: Bruel and Kjaer Australia Pty Ltd, P.O. Box 177, Terrey Hills, NSW 2084. Tel (02) 450 2066, Fax (02) 450 2379.



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* Notification of change of address	General Secretary AAS– Professional Centre of Australia Private Bag 1, Darlinghurst 2010 Tel (02) 331 6920 Fax (02) 331 7296
* Payment of annual subscription	

Enquiries regarding membership and sustaining membership should be directed to the appropriate State Division Secretary as under:

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Diary ...

CONFERENCES and SEMINARS

• Indicates an Australian Activity

1994

May 1-4, FORT LAUDERDALE
NOISE-CON 94
Details: Susan Fish, Department of Ocean Engineering, Florida Atlantic University, 500 NW 20th Street, Boca Raton, FL 33431 USA. Tel (407) 367 3430, Fax (407) 367 3885, e-mail: fish@oe.fau.edu

May 15-19, PERTH
• MECH 94 - Resource Engineering including tri-annual Australian Vibration and Noise Conference
Details: Convention Manager,Mech 94, AE Conventions, Engineering House, 11 National Circuit, Barton, ACT 2600, Tel: (06) 270 6530, Fax: (06) 273 2918

June 5-9, CAMBRIDGE
127th Meeting ASA
Details: Acoustical Society of America, 500 Sunnyside Boulevard, Woodbury, NY 11797, USA

July 1-3, CANBERRA
• Synaesthetica '94 Details: ACAT, GPO Box 804, Canberra ACT 2601 email: cat691@acat.anu.edu.au.

July 3-7, HALIFAX, NOVA SCOTIA
22nd Int Congress of Audiology
Details: Secretariat, PO Box 2627, Station M, Halifax, Nova Scotia, Canada B3J 3P7. Tel. (902) 461 0230, Fax (902) 465 2233.

July 18-21, SOUTHAMPTON
5th International Conference on Recent Advances In Structural Dynamics
Details: ISVR Conference Secretariat, The University, Southampton, SO9 5NH, England.

August 23-25, SEOUL
WESTPRAC V
Details: The Acoustical Society of Korea, Science Building, Suite 302, 635-4 Yuksam-Dong, Kangnam-Ku, Seoul 135-703, Korea. Tel 82-2-556-3513, fax 82-2-569-9717. email: swyoon @yurim.skku.ac.kr

August 29-31, YOKOHAMA
INTERNOISE 94
Details: Yoiti Suzuki, Sone Lab, RIEC, Tohoku Univ. 2-1-1 Katahira, Aoba-Ku, Sendai, 980 Japan. Tel 81 22 266 4966, Fax 81 22 263 9848, 81 22 224 7889 email: in94@riec.tohoku.ac.jp

Aug 31 - Sept 3, YOKOHAMA
2nd Int Conf: Motion & Vibration Control
Details: Assoc Prof Kazuo Yoshida, Secretary of 2nd MOVIC, Faculty of Science and Technology, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan. Fax +81 45 563 5943.

November 9 -11, CANBERRA
• AAS Annual Conference 1994
Noise and Sound: Nuisance and Amenity
Details: Marion Burgess, Acoustics & Vibration Centre, ADFA, Canberra, ACT 2600. Tel (06) 268 8241, Fax (06) 268 8276, email m-burgess@adfa.oz.au.

November 28 - December 2, AUSTIN
128th Meeting ASA
Details: Acoustical Society of America, 500 Sunnyside Boulevard, Woodbury, NY 11797, USA

1995

January 11-12, SINGAPORE
Annual Conference on Noise
Details: Dr W S Gan, c/- Acoustical Services Pty Ltd., 209-212 Innovation Centre, Nayang Avenue, NTU, Singapore, 2263. Tel 65-791 3242. Fax 65-791 3665

March 21-23, LYON
Euro-Noise 95
Software for Noise Control
Detaills: Euro-Noise 95, CETIM, %2 Avenue Felix Louat, 60300 Senlis, France. Fax (33) 44583400

April 5-7, SOUTHAMPTON
Int Conf on Computational Acoustics Environmental Applications
Details: COMACO 95, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO4 2AA, UK. Tel 44 (0)703 293223, Fax 44(0)703 292853, email CMI@ib.rl.ac.uk

May 31 - June 4, WASHINGTON
129th Meeting ASA
Details: Acoustical Society of America, 500 Sunnyside Boulevard, Woodbury, NY 11797, USA

June 26-30, TRONDHEIM
15th International Congress on Acoustics
Details: ICA'95, N-7034, Trondheim, Norway.

July 10-12, NEWPORT BEACH, CALIF
INTERNOISE 95
Details: INCE/USA, PO Box 3206 Arlington Branch, Poughkeepsie, NY 12603 USA. Fax +1 914 473 9325

Nov 27 - Dec 1, ST LOUIS
130th Meeting ASA
Details: Acoustical Society of America, 500 Sunnyside Boulevard, Woodbury, NY 11797, USA

COURSES

In accordance with the recognition of the importance of continuing education, details of courses held in Australia are included in this section at no charge. Additional details can be given in an advertisement at normal rates.

November 8-9, CANBERRA
BASICS OF ACTIVE NOISE CONTROL
Details: Marion Burgess, Acoustics and Vibration Centre, ADFA, Canberra, ACT 2600. Tel (06) 268 8241, Fax (06) 268 8276, email m-burgess@adfa.oz.au.