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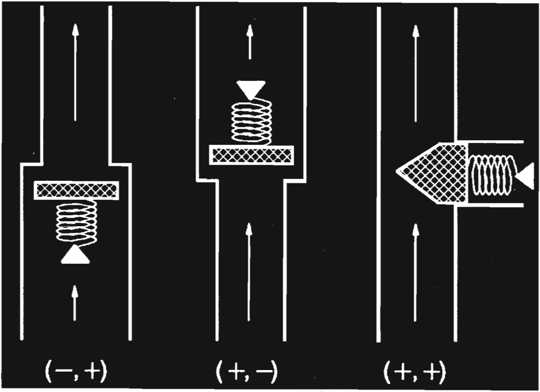

- **Feature Extraction**
- **Didjeridu**
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Australian Acoustical Society

Vol. 24 No. 1 April 1996

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ARTICLES

COVER:

Simple pressure-controlled valves – see article by Fletcher.

Acoustics in Education

We are trying to collect information about ANY courses involving acoustics in Australia. This will be published in the next edition of Acoustics Australia and then updated on a yearly basis. We hope that such information will be useful to the many members who get enquiries from people wishing to improve their understanding of acoustics. Often the enquiries are from people about to transfer from one state to another, so please do not rely on local knowledge being sufficient to publicise your course. If you are involved with a number of courses, please send in a copy of the form for each course. *(Requests for information are also being sent to institutions - if you have received a request for information from that source would you please still forward directly a reply to this questionnaire.)*

Return completed forms as soon as possible to:
Acoustics Australia Editors, Acoustics and Vibration Centre, ADFA, Canberra ACT 2600, fax 06 268 8276.

Name and address of organisation running course :

....

....

School or Department:

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Type of course: (Please tick)

- ☐ PhD
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- ☐ Miscellaneous subject ☐ Short Course/Workshop

Subject name : (course code if appropriate)

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General Area of Acoustics: (if title not self explanatory)

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Prerequisites: (if any)

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Duration: (number of weeks, hours per week and time of year)

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Editorial

Many of you will have attended and been stimulated by the 1995 Annual Conference held in Fremantle, W.A. in November. The combination of technical presentations and social events maintained the excellent standard of our past conferences and the Organising Committee are to be heartily congratulated. Please note that we can all look forward to another enjoyable gathering in November this year when the Queensland Division stage the 1996 Conference in Brisbane.

At the Council meetings associated with the Fremantle Conference, Councillors had to tackle an important issue – the selection of a General Secretary. For several years this role had been ably undertaken by Mrs Noela Eddington, who late in 1995 was forced to resign from the task because of other work pressures. While gratefully acknowledging our debt to Noela for a job well done, Council had to find some way of replacing her. It had become apparent that, for the first time, it would be necessary for the Society to make a salaried appointment. To help defray costs, much of the federal work, such as looking after subscriptions, previously undertaken by the Professional Centre in N.S.W. will be transferred to the General Secretary's position. After considerable discussion, Council chose Mr David Watkins, a long standing member of the Victoria Division, to undertake the task. A summary of David's background and future role in the Society is given elsewhere in this issue; however, I would like to take the opportunity to welcome him to the post, which I am confident he will admirably fill with ease.

A year ago, in the April edition of *Acoustics Australia*, I raised the issue of "Acoustics into the 21st Century". While the response was not exactly a deluge of letters – there were at least four – it did stimulate some interest. In particular, I agree that my note under-represented the role of underwater acoustics, which is a valuable technology base for marine life studies, defence, mining and petroleum exploration. It is the feeling of Council that raising such issues is an important part of the role of our Society and it is anticipated that several discussion papers on "hot topics" will appear in future copies of *Acoustics Australia*. If you have an issue involving acoustics which you feel is important and would like it raised, please send a note to the Editor of *Acoustics Australia* or contact your local Division members and, perhaps, we can stimulate others to action.

Often, members of the Society are asked about courses involving acoustics. Attempts were made in 1994 to update an earlier summary of tertiary education in acoustics created in 1984. However, this venture floundered because of incomplete information. So in this edition, there is a short form which we ask ***all members involved with teaching acoustics,*** at any level, to complete and send back. The information will be collated and published in the December issue of *Acoustics Australia*. So if you don't want your course to be left off the list, please send us the requested details.

Charles Don
President.

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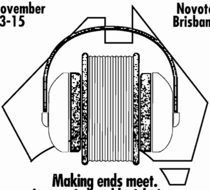

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ACOUSTICAL FEATURE EXTRACTION FROM AIRCRAFT AND TRAFFIC NOISE

R. Mohajeri* and F. R. Fricke**
***Department of Mechanical and Mechatronic Engineering, University of Sydney, NSW 2006 Australia**
****Department of Architectural and Design Science, University of Sydney, NSW 2006 Australia**

This paper was awarded the 1995 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: For the purpose of developing a real-time transportation noise recognition system, a variety of acoustical features and statistical models of signals are reviewed. Finding an appropriate acoustical criteria to discriminate between several types of environmental noise is the goal of the present paper. The main emphasis is put on the discrimination of transportation noise, music and speech. The results could be used in transportation noise activated systems for the "intelligent" monitoring and control of aircraft and motor vehicle noise.

1. INTRODUCTION

The goal of this paper is to find some statistical features from transportation noise signals to be used in a noise activated monitoring and control system. A variety of different parameters and signal processing methods have been examined to distinguish between transportation noise and other environmental sound sources such as speech and music. Some parameters are required to distinguish between the low frequency, random nature of transportation noise and more complex spectra of speech, music and other sources of environmental noise. In this study, aircraft, heavy vehicle and mixture of traffic in dry and wet weather are considered as the transportation noise sources.

A real-time intelligent system requires real-time data acquisition, detection and pattern recognition. The pattern recognition problem can be divided into several stages of which feature extraction and source classification are two of the most important ones.

The feature extraction methods used in seismology, which deal with low frequency vibration recognition, are found applicable to transportation noise recognition. The methods for automatic discrimination between nuclear explosions and natural seismic activity are also worth examining. Speech and speaker recognition systems have employed a variety of signal processing and pattern recognition methods, some of which may be used to identify transportation noise.

The energy of a signal, the zero-crossing rate, the linear prediction coefficients and the autocorrelation function are the time domain functions which have been used for successful waveform recognition in other fields [1,2,3]. The frequency spectrum envelope, averaged-peak frequency, maximum-peak frequency in each band and the plot of the first and second most prominent frequencies are the other features that have already been used for transient events and aircraft type recognition [1,2,8]. The Euclidean distance and the nearest neighbourhood are applied to compare the pattern vector with the sample vector.

In the following sections the characteristics of transportation noise are discussed and a signal modeling procedure is developed. A pattern classification method is then presented together with a recognition algorithm.

2. CHARACTERISTICS OF TRANSPORTATION NOISE

Aircraft noise and traffic noise are non-stationary and time dependent. Transportation noise emitted by cars, heavy vehicles and aircraft is variable in both time and frequency domains. Most of the acoustic energy is concentrated in the lower frequencies. The amplitude and frequency of land transportation noise is strongly dependent on the acceleration, speed, operating mode and the conditions of the vehicle and road. Also, the distance between the source and the observer as well as the weather conditions are very important parameters. Many random parameters such as the noise of vehicle brakes and the sound of car horns and the vibration of trailers are mixed with transportation noise. In the case of aircraft noise, the type of aircraft and propulsion system, load, take off or the landing mode, the angle of flight and the weather conditions all determine the characteristics of the noise heard.

3. TIME VARIATION OF ENERGY AND SOUND PRESSURE LEVEL

In real-time signal processing, one of the most important parameters to be measured is the energy of the signal. This parameter has been used to differentiate between voiced and unvoiced sounds and silence in [3]. Fig. 1(a) is the result of monitoring the energy of the signal from different environmental noise sources. It shows that the energy of background noise is considerably less than the energy of the noise events of interest. When the sensing system is turned off the energy is equal to zero. In the present research an energy threshold level is used to activate the recognition system and discriminate between the "Off" position of sensing system and the "Background" noise. Also, the energy is an indication of the beginning and end points of noise events.The sound pressure level of an acoustical signal is another parameter which can be easily measured Fig. 1(b) shows monitoring of sound pressure level from the same events in Fig. 1(a) under the same conditions. As the logarithmic plot is much noisier than the linear plot, particularly for the values close to zero, the linear plot is more useful for activating the recognition system.

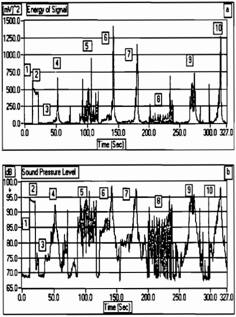

Figure 1a) Energy monitoring of environmental noise, b) Sound pressure level monitoring of the same noise events shown in (a). The sampling frequency was 5 KHz for 512 samples.

In Fig. 1(a) and (b) each number represents a separate class of noise events as follow: 1) the sensing system is off, 2) a B&K 4230 calibrator, pure tone 1 KHz, 3) Background noise, 4) Aircraft noise, 5) A piece of classical music, 6) Aircraft noise, 7) Aircraft noise, 8) Speech, 9) Rock music and 10) Aircraft noise.

4. LINEAR PREDICTION MODEL OF TIME SIGNAL

The "Linear Prediction Model" of time signals is one of the most powerful existing techniques available to discriminate between different waveforms. Different characteristics of this method have been used successfully in the field of speech and speaker recognition [3,4,5]. Also, there is a wide range of applications in the field of seismology to classify the nuclear explosions and earthquakes automatically [1,2,8]. The basic idea of the linear prediction model of a signal is to model the signal as a linear combination of its past and present values with a hypothetical input to the system. The input of such a model is white noise or an impulse and the output is the given signal. In a stationary and invertible process, if x_n is the time signal, the general form of such a statistical model can be represented as:

$$x_n = \sum_{k=1}^{p} a_k x_{n-k} + \sum_{l=1}^{q} b_l w_{n-l} + e_n \quad , \quad 1 \le k \le p, \quad 1 \le l \le q \qquad (1)$$

where, a_k, b_l are the model coefficients, w_n is the white noise sequence, p and q are the orders of model and e_n is the residual error. Thus, the output signal, x_n is a linear combination of past outputs and present and past inputs. The estimated coefficients, a_k and b_l, are useful parameters for pattern classification. The frequency domain representation of equation (1) is:

$$H(z) = G \frac{1 + \sum_{l=1}^{q} b_l z^{-l}}{1 + \sum_{k=1}^{p} a_k z^{-k}} \qquad (2)$$

where G is the system gain. H(z) is the general pole-zero model which is called an autoregressive moving average model ARMA(p,q). Equation (1) can be simplified as an all-pole model or autoregressive model, AR(p), equation (3), when $b_l = 0$. It can be considered as a recursive filter with feedback as follows:

$$x_n = \sum_{k=1}^{p} a_k x_{n-k} + e_n \qquad (3)$$

where, p is the order of the AR model. The most applicable frequency spectral match for the AR model is found by dividing G^2 by the magnitude squared of the FFT from the sequence of $1, a_1, a_2, \ldots, a_p$. Fig. 2(a) is the result of 20-pole fit (AR) to a power spectrum of a signal computed from the noise of an aircraft in landing mode.

5. DISCRIMINATION OF AR COEFFICIENTS

Transportation noise mainly contains low frequency energy and the randomness of the noise is greater than other acoustic sources such as speech and music. A low order AR model for the 1 KHz filtered data from different aircraft, heavy vehicles and mixture of traffic noise has been examined. There is a strong similarity between the plot of the first and second AR coefficients of aircraft and road traffic noise. The same similarity has been found for classical music, rock music and continuous speech. A second order AR model gives a considerable separation between speech, music and transportation noise. In Fig. 2(b) the results of 200 data from two pieces of classical music, a piece of rock music and an interview are compared with the same number of data from aircraft noise and a mixture of traffic noise. Fig. 2(b) shows that the second order AR coefficients are useful in recognising the transportation noise. They also have the potential of dealing with low frequency noise recognition.

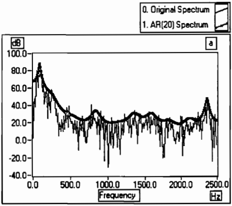

Figure 2. a) Frequency spectrum of the autoregressive model with 20 poles using 512 samples from aircraft noise in landing mode.

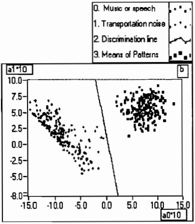

Figure 2.b) Plot of the first and the second coefficients of a 2-pole AR model to discriminate between speech/ music and transportation noise.

6. ACOUSTICAL PATTERN CLASSIFICATION OF ENVIRONMENTAL NOISE SOURCES

After studying different measurable and available features and their abilities to discriminate between different acoustical sources, an attempt was made to combine the extracted features to make a decision system. The energy of a signal is a good indication of the start and the end of noise events. In addition the energy of the signal is a discriminating factor between an "Off" signal and "Background" noise. In the present study the pattern recognition task is divided into two classes of recognition:

1. Short-time acoustical source recognition, which is quick enough not to miss the noise event. This is important as the ultimate goal of source recognition is to activate a system as the noise event starts. The data acquisition, data processing, feature extraction and patten recognition must not take more than a portion of a second. In such a short time extracting the detailed information from the acoustical source is impossible. (Basically a person's hearing system is also not able to recognise similar sound sources in a very short time either).
2. Long-time acoustical source recognition, which does not take more than 50 seconds duration. This case is useful to identify the particular vehicle or aircraft. To differentiate between different types of aircraft, a satisfactory number of data is required to compare with the data base already made from statistical manipulation of data recorded from aircraft noise.

7. SHORT-TIME ZERO-CROSSING OF TIME SIGNAL

The zero-crossing is the number of zero crossings level of signal per duration of sampling. In the case of a pure tone, zero-crossing is a good measurement for frequency, but for broadband signals eg. transportation noise, it can only be a rough indication of frequency content. Direct measurement of zero-crossing for a discrete signal is difficult because the value of the signal is rarely zero. The process of detecting zero-crossing at a given time is based on the sign change of the product of multiplication of one data point value before and one data point value after that time.

8. SHORT-TIME AUTOCORRELATION FUNCTION

The autocorrelation function has a lot of useful properties in real-time signal processing and detection. An important property of the autocorrelation function, for the present study, is the considerable difference in its form for transportation noise and the other acoustical sources. The main reasons for this difference are likely to be the low frequency nature of traffic noise and its randomness. The number of peaks and the number of zero-crossing in the case of speech and music, is considerably higher than that of aircraft and traffic noise. (The number of zero-crossings of the autocorrelation function is totally different with to meaning of the zero-crossing function of time signals). Fig. 3(a) is the result of 200 plots of zero-crossings of the autocorrelation function with respect to the zeroth element of the autocorrelation function.

9. THE LOCATION OF PEAKS

The acoustic energy of transportation noise is mainly concentrated in the low frequencies. It seems to be reasonable to draw the plot of the first and second peak frequencies which usually occur at frequencies lower than 1000 Hz. Fig. 3(b) is the plot of f1 and f2, the first and second frequencies of the most prominent energy peaks in the 200 samples of heavy vehicle noise and the speech and music, that were given in previous sections. The discrimination line shows a good separation between the two classes of acoustical sources.

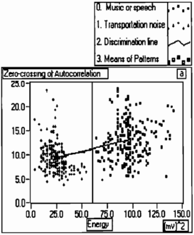

Figure 3. a) Feature extraction from the autocorrelation function for 200 samples of traffic noise and speech/music.

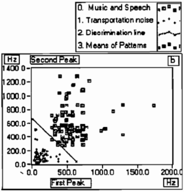

Figure 3.b) A plot of the first and the second frequencies of mixture of heavy vehicle noise compared with speech/ music. The sampling frequency is 5 KHz with 512 samples used.

10. EUCLIDEAN DISTANCE AND NEAREST NEIGHBOURHOOD

In the case of short-time data acquisition and pattern recognition the features (eg. AR coefficients or f1 vs f2 from sample data) have to be compared with the related features in pattern space. By considering the discrimination line, which has the same distance from the means of two classes of noise, the distance between the feature from the sampled data and the mean of the feature from each pattern can be used to discriminate between different types of sounds. The closest distance indicates the type of sample data statistically. One of the simplest distance measurements is the Euclidean distance. If the coordinates of the sample feature is *(x, y)* and the means of the feature from source-1 and source-2 are located at, (μ_{1x}, μ_{1y}) and (μ_{2x}, μ_{2y}), respectively, then the sample belongs to source-1 if the following condition satisfied:

$$[(x-\mu_{1x})^2 + (y-\mu_{1y})^2]^{0.5} < [(x-\mu_{2x})^2 + (y-\mu_{2y})^2]^{0.5} \quad (4)$$

In equation (4) the Euclidean distances between sample and patterns are compared. This method is implemented to discriminate between speech and, music and transportation noise based on AR coefficients and zero-crossing rate in the autocorrelation function.

The pattern vectors made from the acoustical signature of the environmental sources can be compared with the sample vector made in the same manner. The statistical pattern recognition finds the nearest neighbourhood between the sample vector and pattern vector. If the reference pattern of m types of noise source is represented as a vector [6,7]:

$$P_i = (P_{1i}, P_{2i}, ..., P_{ni}) \qquad i=1,2,..m \quad (5)$$

and the sample pattern of noise character is represented as:

$$S = (s_1, s_2, ..., s_n) \quad (6)$$

then the sample vector and the reference pattern vectors can be compared. To evaluate the similarity between a sample and references, the following set of conditional distances has to be computed:

$$D(S,P_i) = [\sum_{j=1}^{n} (s_j - P_{ji})^2 . W_{ji}]^{0.5} \qquad i=1,2,..m,\ j=1,\ 2,..n \quad (7)$$

where W_{ji} is the weight of nth parameter for a noise source type and can be defined as the estimated variance of the nth parameter for the ith source. The sample is assigned to a type of noise source using the condition that the distance score is a minimum. The pattern made by the averaged spectrum from 5 types of aircraft have 256 elements per spectrum. The mean and variance of the data can be calculated and compared with the same parameters in sample vectors based on equation (7).

11. FREQUENCY SPECTRAL PATTERNS

A short-time data acquisition cannot provide enough information to discriminate between different types of aircraft and vehicles. The averaged frequency spectrum is a feature for long-time acquisition. An averaged spectrum has been used successfully to identify 5 different types of aircraft (after detection of transportation noise, 5 types of aircraft will be identified when the noise event is finished). The main feature used to identify the type of aircraft is the minimum Euclidean distance between the averaged frequency spectra of the sample and the patterns. The averaged spectrum of noise can be expressed as follows:

$$X_m = x_{m1}, x_{m2}, ...x_{mn} \quad (8)$$

$$Y_j = \frac{\sum_{i=1}^{m} x_{ij}}{m} \qquad i = 1,2,..m, \quad j = 1,2,..n \quad (9)$$

if the averaged frequency spectrum array is $Y_j = y_1, y_2, ...y_n$, n is the number of data in each spectrum array and m is the number of spectra. Fig. 4(a) illustrates the averaged frequency spectrum pattern made from the overflight duration of aircraft VH-TAD with 512 samples and a 2 KHz sampling frequency.

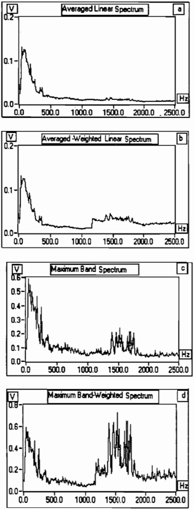

Figure 4. Comparison between different spectral patterns of an aircraft noise, a) A pattern of averaged frequency spectrum, b) A pattern of linear average-weighted frequency spectrum, above 1200 Hz, c) A pattern of linear maximum frequency spectrum, d) A pattern of linear maximum-weighted frequency, above 1200 Hz.

A further indicator of the source of noises, particularly aircraft, is the pattern of the maximum amplitude in each frequency band. This pattern is comparable to the averaged spectrum pattern but the maximum spectrum pattern captures the peaks of short-duration frequency components, which are not observable in the averaged spectrum.

$$Y_j = Max.X_{ij} \quad i = 1,2,...m, \quad j = 1,2,..n \tag{10}$$

The major problem with this feature is its large number of spikes and its instability. We can put emphasis on crucial parts of the averaged or maximum spectrum by weighting the frequencies of interest, eg. Fig. 4(c) shows the growth of frequencies higher than 1200 Hz and Fig. 4(d) shows the multiplications of those frequencies by 3.

12. DECISION MAKING AND AIRCRAFT RECOGNITION

The order of various feature extraction stages and classifiers is crucial in making a right and quick decision about the type of acoustical source. The first thing to know is the correlation between features and sources and realising the stage of decision making based on the extracted feature. The best method is to move from general criteria for a rough classification to specific criteria for a fine classification.

A decision making algorithm based on the discussed features, is presented in Fig. 5. The level of energy in short intervals is measured and compared with the threshold levels of background noise and noise events. When a noise event starts, the system will change the sampling rate and start to measure the zero-crossing rate of time signal, autocorrelation function and the FFT. Then the AR model of the signal is determined. All information from these features is compared with some selected threshold values. After evaluating the type of noise, if it belongs to the transportation noise class, the monitoring system will be activated and then the spectral features will be calculated. They are compared with the patterns in the data base to find whether they are matched to a recognisable aircraft. The acoustical sources to be classified in the present research are: a) Sensing system Off, zero voltage acoustical input, b) Background noise, c) B&K 4230 calibrator, 94 dB, 1 KHz, d) Traffic noise in rainy weather, e) Music and speech, 2 pieces of classic music, 1 piece of rock music and one piece of reading the news by male speaker, f) Transportation noise in dry weather including 5 types of aircraft, a mixture of traffic, a sample of heavy vehicles and a mixture of traffic, train and aircraft noise together.

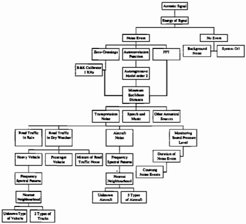

Figure 5. Decision tree for transportation noise recognition and monitoring.

Traffic noise in rainy weather contains a lot of high frequency signals that makes it easily identifiable from the other transportation noise. The high rate of zero-crossing in the time signal is the main characteristic of this signal. The 4230 B&K calibrator gives a constant zero-crossing rate and sound pressure level.

There are two major stages in the algorithm; the first is training and the second is operating. Both stages are adaptive and will be activated only by transportation noise. The main reason that they are made adaptive is that the duration of overflight is different for different aircraft noise events. Therefore, finding the exact start and end points of the event can avoid interferences caused in the subsequent stages due to incorrect data. An example of that is the process of averaging the frequency spectrum which has a crucial role in aircraft noise recognition.

13. INTELLIGENT TRANSPORTATION NOISE MONITORING

A sound pressure level monitoring system can be activated when the traffic noise or aircraft noise dominates the background noise. Such a recording and monitoring system can automatically record the desired noise. The described program is able to calculate the time duration of an event and the maximum and the mean of the sound pressure level during an event. In a quiet environment this program counts the number of vehicles and aircraft with a noise level more than a selected threshold. The results of operating an intelligent noise monitoring system for the noise given in Fig. 1, are presented in Fig. 6. The monitoring system is activated only by transportation noise. When the nature of sound changes or the level of energy and sound falls to less than some particular value, the system stops monitoring.

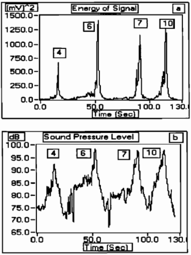

Figure 6. a) The energy monitoring of transportation noise by an intelligent noise monitoring system for the same noise events shown in Fig. 1, b) Sound pressure level monitoring of transportation noise by an intelligent noise monitoring system for the same noise events as in (a).

14. CONCLUSION

In this paper some useful features for discriminating between the transportation noise and other environmental noises, such as music and speech, have been introduced.

The features used to discriminate the transportation noise from the other sounds are the energy of the signal, sound pressure level, linear prediction coefficients, autocorrelation function, peak frequency and zero-crossing. The AR coefficients and the autocorrelation function provide reliable criteria to discriminate between transportation noise, and music and speech in short-time data acquisition. These features have been used successfully to activate an intelligent noise monitoring system. There is also some false recognition when the speech segments are not continuous.

Spectral features for long-time data acquisition are used to recognise the type of aircraft. The result of this research is likely to be applicable to other acoustical noise recognition, such as intelligent noise control [9], counting vehicles, acoustical diagnosis of defects in machines and even to medical diagnosis systems.

Further development of the model is planned. This will include the recognition of other environmental noises such as bird and animal noises, wind and thunderstorm sounds. Techniques will also be developed to recognise sounds when they occur concurrently with other noises in the environment.

ACKNOWLEDGMENT

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THE DIDJERIDU (DIDGERIDOO)

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ABSTRACT: The didjeridu of the Australian aboriginal people is an ancient and deceptively simple instrument, consisting of a length cut from a narrow tree trunk or branch and hollowed by the successive action of fire and termites. Skilled players, however, are able to produce a wide repertoire of interesting musical effects including a rhythmic drone, striking timbre changes, and sounds that are voiced as well as played. This paper outlines the passive acoustics of the didjeridu tube, the active acoustics of the sound-production process, and the mechanisms by which the various musical effects are produced.

1. INTRODUCTION

The didjeridu (commonly spelt didgeridoo) or yiraki of the Australian aboriginal people is a very ancient instrument with considerable acoustic interest, despite its extremely simple construction. It consists of a more-or-less straight piece of tree trunk or branch, hollowed out by the successive action of fire and termites to produce a gently flaring tube. Didjeridus from Central Australia are typically about one metre in length, while those from Arnhem Land are usually about 1.5 metres long. The longer didjeridus are now generally preferred because they allow a greater range of musical effects. In each case the blowing end is about 30 mm in internal diameter and the free end about 50 mm, though all these dimensions vary significantly from one instrument to another, even among those by the same maker. The average wall thickness is usually 5 to 10 mm. At the blowing end, the walls are coated with a rim of resinous gum, to improve playing comfort, and the free end is often given a slight extra flare by internal scraping. The outside of the instrument is smoothed and painted in geometrical totemic designs, usually in black, white and orange.

To play the didjeridu, the musician seals the narrow end of the tube around his mouth, blows, and vibrates his lips under muscular tension in very much the same way as used in playing a brass instrument such as the tuba. The didjeridu uses air at rather a high rate so that, to play a sustained tone, the player adopts the technique of "circular breathing". After playing normally for a few seconds, he expands his cheeks with air, seals off his mouth from his throat with the back of the tongue and, while using the stored air to maintain the tone, takes a quick breath through his nose. This technique is common on certain other instruments, such as Indonesian flutes, and is now used routinely by oboists and even flute players to play without breath breaks for as long as several minutes. In these instruments, with their much smaller breath demand, the objective is to maintain an even tone and cover up any effect of the breathing. With the didjeridu, however, the player makes a virtue of necessity and emphasises the rhythmic breathing cycle to produce a pulsating drone. The pulsations are usually further decorated by tongue vibrations, so that the player effectively says unvoiced words such as "ritoru" or even "didjeridu", with the final "u" sound prolonged. The westernised name "didjeridu" for the instrument perhaps arises from this circumstance, though it may perhaps be a word from some aboriginal language, now extinct.

There has been only a little written about the acoustics of the didjeridu [1,2] or about its playing techniques [3,4]. The instrument itself, however, has become increasingly used in popular music by groups such as Gondwanaland, and was earlier made widely known on television through the efforts of Rolf Harris. A few simple calculations and measurements, however, allow us to understand a good deal about this interesting instrument.

2. PASSIVE ACOUSTICS

It is a good approximation to treat the didjeridu as a truncated conical horn of length L. Suppose that the diameter of the smaller end is d_1 and that of the larger end d_2. Then if we imagine the cone to be continued to its apex, the distance from this apex to the smaller blowing end of the instrument will be $x_1 = d_1 L/(d_2 - d_1)$. Since the players' lips form a pressure-controlled valve, the preferred sounding frequencies are those at which the acoustic pressure at this end, and thus the acoustic impedance, is a maximum. These frequencies f_n can be shown [5] to be the roots of the equation

$$k_n L' = n\pi - \tan^{-1} k_n x_1 \qquad (1)$$

where $k_n = 2\pi f_n / c$, c is the speed of sound in air, and the acoustic length $L' = L + 0.3 d_2$ includes the end-correction at the open end.

If the flare is extremely small so that the horn is nearly cylindrical, then x_1 becomes very large and $\tan^{-1} k_n \pi$ approaches $\pi/2$. The resonance frequencies are then $f_n = (n - \frac{1}{2})c/2L'$ which form the series of odd harmonics that we expect, for example as the playing frequencies of a clarinet, starting with a quarter of a wavelength equal to the tube length. More generally, if the flare is fairly small, we can expand the result (1) to arrive at the approximate expression

$$f_n = (n - \tfrac{1}{2})\frac{c}{4L'}\left\{1 + \left[1 + \frac{4(d_2 - d_1)}{\pi^2 d_1 (n - \frac{1}{2})^2}\right]^{1/2}\right\}. \quad (2)$$

We can see that the frequencies of the lower modes, and particularly that of the fundamental, are raised relatively more than those of the higher partials, so that all the mode intervals are compressed. For moderate flare, only the lowest mode frequency is significantly affected. For the range of end diameters found in the typical didjeridus of Table I, this fundamental-mode frequency is raised by a factor between about 1.06 and 1.38 relative to a cylindrical tube of the same length. The ratio of second to first mode frequencies, which would be a perfect twelfth (1.50) for a cylindrical pipe, ranges from about 1.30 (about a tone flat of a perfect twelfth) to about 1.43 (a little less than a semitone flat). The greater the flare, the flatter the second mode appears relative to the drone fundamental.

TABLE 1. Typical didjeridus [1]

Length L (cm)	159	144	149
Diameter d_1 (mm)	31	26	30
Diameter d_2 (mm)	36	60	40
Frequency f_1 (Hz)	60	80	64
Drone pitch	B_1	E_2	C_2

These mode-frequency predictions are confirmed by the measured drone frequencies of three typical didjeridus from Arnhem Land as listed in Table I. The effect of flare is easily seen in the case of the second and third instruments—the second is only 3 percent shorter than the third, but its fundamental frequency is 25 percent higher because of its large flare. Unfortunately the second-mode frequencies were not recorded, but the pitches agree qualitatively with the theoretical predictions [1].

It is interesting to note that traditional makers and players seem to have little concern with either the drone frequency or the interval to the second mode—the first two instruments in the table are actually by the same maker. Indeed, a good player can produce most of the nuances of traditional performances on a piece of plastic pipe of appropriate diameter and length! When used in popular Western music, however, it is necessary to select a didjeridu of appropriate pitch to match the keyboard instruments, though in some multi-track recordings the didjeridu is actually recorded first and then pitch-shifted, the player having made some adjustment for the associated change in tempo. Breaking with tradition, Graham Wiggins has made the perhaps obvious extension of building a didjeridu with keys to open one or more holes near the foot and so allow the drone pitch to be changed.

3. SOUNDING MECHANISM

While much of our understanding of the sounding mechanism of wind instruments dates back to the time of Helmholtz a hundred years ago [6], it is only recently that these mechanisms have been studied in detail. There is a clear distinction between three types of pressure-controlled valves, as illustrated in Fig. 1. In the first two types, air pressures acting on the two faces of the valve have opposite effects, tending to either open or close the valve, while in the third type excess pressure on either face tends to open the valve. If we represent a closing action of excess pressure by the symbol $-$ and an opening action by $+$, then the first two valves have classification $(-,+)$ and $(+,-)$ respectively, and the third has classification $(+,+)$.

The familiar reed valves of oboes and clarinets are of the $(-,+)$ type, as also are the metal reeds used in organ reed-pipes. The human vocal folds are usually modelled as having the configuration $(+,+)$, as are the vocal organs of birds (the syrinx), though the models used are generally more complex than this. The lips of players of brass instruments, such as the trumpet or tuba, and of the didjeridu, are either of configuration $(+,-)$ or $(+,+)$, and possibly change character between different playing regimes [7]. It is probably necessary to use a rather complex model for the vibrating lip valve, such as has been developed for the human vocal folds [8], but this has not yet been attempted. We must therefore be satisfied for the present with simpler models.

If we define the acoustic admittance of a pressure-controlled valve under blowing pressure, as viewed from the instrument, to be the ratio of the small-signal acoustic flow out of the instrument to the small-signal acoustic pressure in the instrument mouthpiece, then there is the possibility of self-sustained oscillation if the resistive part of this impedance (the acoustic conductance) is negative, to overcome the losses in the system, and if the reactive part can be balanced by the reactive admittance of the instrument tube and the players mouth, taken together. In all cases, the first condition requires that the blowing pressure should be greater than some threshold value determined by the tension of the lip muscles, which itself depends on the pitch of the note being played [9,10].

Provided a blowing pressure greater than this minimum is used, then the acoustic admittance of a lip-valve generator

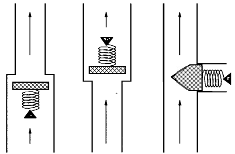

Figure 1. The three types of simple pressure-controlled valve. Air flow direction is shown with an arrow.

can be shown [9] to have a form like one of those shown in Fig. 2. For such a $(+,-)$ or a $(+,+)$ valve, the acoustic conductance—the real part of the admittance—is large and negative at a frequency either just above or just below the resonance frequency of the lip-valve, which is determined by lip mass and muscular tension. At other frequencies the conductance is relatively small and may be either positive or negative. The magnitude of this peak negative conductance is sufficiently large that it is able to overcome the positive conductance losses in the rest of the system and force it into oscillation. While this can happen over a considerable frequency range if the lip resonance frequency is adjusted—a skilled trombone player can play a glissando without moving the instrument slide—the oscillation is most easily sustained near an impedance maximum of the tube, where its positive conductance is least. The acoustic impedance of the player's mouth also plays an important role in sustaining the lip oscillation—a role that can be appreciated when we realise that it is possible to buzz the lips at their resonance frequency even in the absence of any instrument tube [10].

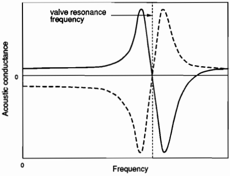

Figure 2. Acoustic conductance of a $(+,-)$ valve (full line) and of a $(+,+)$ valve (broken line). The resonance frequency for free vibration of the valve is shown.

This is the operating regime for a didjeridu—the player adjusts lip tension so that the lip resonance is close to the first tube resonance. To produce the second mode, the player must use a much higher lip tension to raise the lip resonance frequency, and this requires, in turn, a greater threshold blowing pressure. The actual pressures used are, of course, well above the threshold value. Measurements [1] show that a didjeridu player typically uses a pressure of about 1–2 kPa (10–20 cm water gauge pressure) for the drone note and about 4–5 kPa to produce the second mode. Some players can produce the third mode and even higher modes, but they are rarely used. Indeed, even the second mode is only employed for brief accents, and not as a sustained tone.

4. SOUND QUALITY

The discussion above is essentially linear and expressed in terms of linear quantities such as acoustic admittances. Sound production in wind instruments, however, is a nonlinear process [5,11], and this nonlinearity is responsible for generating the upper partials of the tone. The process has been examined for brass instruments such as the trumpet [12] and trombone [13] and much of this discussion can be applied to the didjeridu.

Because, unlike the reed valve in a clarinet, the lip valve operates at very nearly its resonance frequency [7,9,10], the motion of the player's lips is nearly sinusoidal. The average lip opening is determined by the blowing pressure, and the amplitude of the lip vibration is such that the lips just about close once in each cycle. If p_0 is the steady blowing pressure, p the pressure just inside the mouthpiece of the instrument, and $x = a_0 + a \sin 2\pi f t$ the lip opening, then the volume flow U through the lip valve is

$$U \approx \gamma x (p_0 - p)^{1/2} \tag{3}$$

where γ is a constant. The pressure p inside the instrument mouthpiece is approximately RU, where R is the acoustic resistance of the instrument tube at the resonance frequency f_1, and we can substitute this back into (3), along with the expression for x, to find, after a little algebra, that if $a < a_0$ the flow has the form

$$U \approx \frac{p_0}{R} - \frac{p_0^2/R^3}{(a_0 + a \sin 2\pi f t)^2}. \tag{4}$$

This expression cannot be taken too literally in the limit as $a \rightarrow a_0$, but the shape of the flow waveform is essentially as shown in Fig. 3.

Clearly such a waveform has many harmonics, and this accounts for the rich sound of the didjeridu, and of lip-excited instruments in general. The relative strengths of the upper harmonics are not well predicted by this simple flow waveform, however, for several reasons. The flow waveform gives a spectral envelope which is initially nearly constant and then declines at about 12 dB/octave. The assumption that R is constant, however, is not very good, and this resistance is less for the upper harmonics than for the resonant fundamental, except for accidental near-coincidences with higher horn resonances. Finally, the transfer function between flow spectrum and acoustic radiation rises at 6 dB/octave at low frequencies and is then flat above about 3 kHz for the didjeridu horn. Despite these reservations, however, this simple treatment does give a fair idea of spectral behaviour.

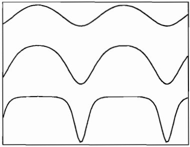

Figure 3. The flow waveform through a lip-valve at several amplitude levels, as given by Equation (4).

Note that the sound spectrum of the didjeridu, as for all sustained-tone instruments (except when playing "multiphonics" or other special effects), is strictly harmonic. The fact that the upper modes of the pipe are not in harmonic relation to the fundamental affects only the strength of certain harmonics. If one of the upper pipe modes is sounded instead of the fundamental, then this sound will itself be accompanied by its own set of harmonics.

We should now consider the effect of the player's mouth cavity on sound quality. The player's lip opening varies nearly sinusoidally with time, as we have seen. The time spent at each opening is inversely proportional to the lip speed at that opening. If the lips just close each cycle so that $a = a_0$, the fraction of time spent at opening x can then be shown to be proportional to $[x(2a_0 - x)]^{-1}$ which is sharply peaked at $x = 0$ and $2a_0$, so that the lips spend most of their time either nearly fully open or nearly closed. Seen from the instrument tube, therefore, the player's mouth is mostly either blocked off by the closed lips or else forms a Helmholtz resonator consisting of a closed volume vented by the lip opening. The resonance frequency of this resonator can be estimated from our experience with whistling, in which the whistle frequency is the resonance frequency of the same Helmholtz resonator. Since the lip opening is similar, within a factor of less than ten, in the two cases, the attainable resonance frequencies should be the same within about a factor three. We therefore expect that it should be possible to vary the resonator frequency over a range from about 500 Hz to about 3 kHz by changing the mouth volume with the tongue.

It is fairly easy to understand the effect of such a resonator on the lip-valve flow and hence on the radiated sound spectrum. The resonator is rather highly damped by the flow resistance through the lip valve so that its bandwidth encompasses the frequencies of several harmonics of the drone frequency. The acoustic flow through the lip valve will be enhanced for these harmonics, so that the acoustic spectrum will exhibit a "formant band" rather like those of the human voice and, indeed, arising from similar causes. Details are more complicated than this, of course, because the opening from the mouth to the instrument is changing with time.

While the didjeridu can be played with a dull drone, lacking obvious formants, this is not usual for good players. Fig. 4 shows two examples of such formants, which play an important role in producing the characteristic sound of the didjeridu. In the first example, there is a pronounced formant band at about 1500 Hz, while in the second example the player has reduced the volume of his mouth so as to raise formant frequency to about 2.2 kHz. In each case there is some evidence for a lower vocal-tract formant at about 500 Hz. Because the frequency range of these formants is similar to that of human vowel formants, they have a similar aural effect. In normal playing, using circular breathing, these formants are produced in a rhythmic manner as the mouth volume changes, but they are often made a tonal feature of the performance.

These formant phenomena are much more pronounced in the didjeridu than in Western brass instruments, principally because trumpets, tubas and the like have a cup-shaped mouthpiece with a narrow constriction between it and the main bore of the instrument. This mouthpiece, as well as providing a comfortable support for the lips, functions as a Helmholtz resonator in its own right, and its resonance produces a broad formant band, typically with a centre frequency around 500 Hz for a trumpet [5]. The mouthpiece cavity also functions as a filter which reduces any influence that mouth resonances might have on upper partials of the sound.

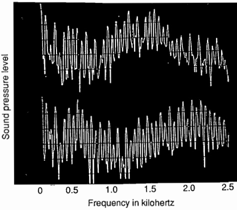

Figure 4. Formant bands in the didjeridu sound. In the upper trace, there is a mouth-cavity formant at about 1.5 kHz, while in the lower trace this has been shifted to about 2.2 kHz by constricting the mouth.

There is one other aspect of performance technique that deserves detailed acoustic comment. This is the use of vocal sounds to augment the drone of the didjeridu. Because of the acoustic coupling between the vocal folds in the throat and the player's vibrating lips, the interaction is quite complex. Suppose that the player's vocal folds vibrate at a frequency f_V. Then this produces pulses of flow in the same way as described for the lip valve and illustrated in Fig. 3. The flow entering the mouth, and therefore the mouth pressure p_0 of (4), thus contains all harmonics nf_V of the vocal-fold frequency. When this flow is convolved with the nonlinear flow through the lips, which are vibrating with frequency f_L, as in (4), the result is the production of all frequencies $nf_V \pm mf_L$, those with greatest amplitude having small integer values (1 or 2) for m and n.

The simplest example of this frequency mixing occurs when the player sings a steady tone at a frequency simply related to the drone frequency. A typical example is the singing of a note that is a just major tenth (frequency ratio 5/2) above the drone fundamental. The cross term $f_V - 2f_L$ then has a frequency $f_L/2$ and this is accompanied by all its harmonics from the other cross terms. The sound is therefore an octave below the original drone frequency. There is not be much radiated energy in this sub-octave fundamental, but the subjective pitch is generated strongly from the sequence of harmonics. Because of the low pitch

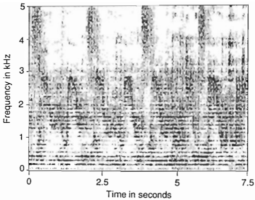

Figure 5. Time-frequency display of the sound of a didjeridu during a typical playing sequence. Note the harmonics of the drone frequency, the shifting formant bands, and the articulation noise.

and the strength of the higher harmonics, the sound has a rough rasping quality which is very effective. A rather similar result can be obtained by singing a note a perfect fifth (frequency ratio 3/2) above the drone fundamental.

Finally, we should remark that players of the instrument often use it to accompany traditional songs or stories and, to this end, embellish their playing by adding the sung sounds of barking dingos, brolgas and other animals. The pitch of these vocal sounds is rather high so that frequency mixing does not have such a pronounced effect, and the sounds can be made easily recognisable.

Fig. 5 shows a spectral display of a short passage of didjeridu playing. In this representation, time is along the horizontal axis and frequency on the vertical axis, with the density of shading indicating the sound pressure level. Two things are immediately obvious. The first is that the harmonic structure of the sound is clearly evident in the closely spaced dark bands running horizontally in the figure. The second feature is the formant bands, which show up as darker regions on the plot and vary with time. Articulation and circular breathing divide the time record into repeating segments. Features of this type will be familiar to anyone involved with human speech analysis.

5. CONCLUSION

Although the didjeridu is physically a simple instrument and its makers appear to accept wide variations in its physical dimensions and therefore in its tuning, it supports a wide variety of subtle performance techniques. We have considered here the acoustics of only the most important of these, but it is clear that there is a great deal of interesting understanding to be derived. I hope that this paper may serve as an example of the sort of results that can come from cooperation between acousticians and musicologists.

Acknowledgments

The work on which this paper is based was completed a long time ago and has, for the most part, already been published elsewhere [1]. It is a pleasure to acknowledge the help I have received from conversations with Trevor Jones, a distinguished musicologist and expert didjeridu player, and with Graham Wiggins, a physicist turned didjeridu virtuoso. Some of the analysed examples were played by Trevor and some were collected in the field by linguist Bill Hoddinott. I would also like to thank Suszanne Thwaites for assistance with the measurements.

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LITERATURE REVIEW OF IMPACT NOISE REDUCTION IN THE SHEET METAL INDUSTRY

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Abstract: In the sheet metal industry, high levels of impact noise are associated with the frequent occurrence of noise induced hearing loss in workers. A literature review is presented of research on impact noise from punch and power presses in this industry. The review shows that considerable work has been done, and that much is understood about, the noise generation mechanisms in these machines. While more fundamental research will undoubtedly produce greater insight, there is a need for much more design and development work to produce quieter machines and processes for the sheet metal industry.

1 INTRODUCTION

Most recent data from the Australian Bureau of Statistics [1] suggests that 185,000 workers are employed in the metal products manufacturing industry in Australia. A large proportion of these people probably work in environments where high levels of noise are generated by impacts which occur during the processing of sheet metal products. Potentially damaging impact noises occur in many operations in the sheet metal industry such as shearing, punching, piercing and forming. Materials handling often produces significant impact noises as well, for example, when sheet metal products are stacked or moved on roller conveyors. In many instances noise enclosures do not provide a practical noise reduction strategy, and personal hearing protectors provide less than ideal protection for the workers. These factors give a strong motivation for developing sheet metal machinery in which impact noise is controlled and reduced at the source.

Since 1991, the Acoustics and Vibration Centre has had a major research program on the reduction of impact noise in the sheet metal industry. This research has been sponsored by Worksafe Australia, the Australian Research Council and BHP Building Products. This literature review, which has been prepared as a part of this program, and which concentrates on punch and power presses, shows that a considerable body of knowledge exists regarding the fundamental nature of impact noise. While the principles of impact noise generation in these machines are relatively well understood, much work remains to be done in designing and developing sheet metal machinery which is inherently less noisy.

2 IMPACT NOISE FROM PUNCH AND POWER PRESSES

Many researchers have studied impact noise from punch, power presses [2–49] and other impact noise sources [50–110], although relatively few significant articles on noise reduct ion from punch and power presses have been reported in the last ten years. In more recent times, world-wide research funding has been directed into noise reduction and modelling of complex structures such as automobiles and aeroplanes, and noise reduction using active noise control; rather than practical solutions to common manufacturing noise related problems for which there is little financial incentive. During the 70s and early 80s, when occupational health and safety first became topical, several studies on the reduction of press noise were conducted.

Sallee and Guy [37] in an early study on punch press noise control noted, contrary to popular belief, that the contact of the punch and the die was not always the most significant noise source. Frequently other components were responsible for equal or greater sound pressure levels, particularly with automated units. They were able to achieve a noise reduction of greater than 8 dB at the operator station by: isolating the die from the main press frame; adding a cover to close the space, in the main frame, under the die; substituting rubber washers on the stripper bumpers; and modifying the end ejector cam to reduce the sharpness of the kick.

In a review of noise and vibration control for impact machines, Bruce [53] concluded that: absorptive treatment of the factory surfaces can only achieve a maximum noise reduction in the order of 3 dB(A) at the operator station; partial enclosures of machines can yield as much as 10 dB(A) of noise reduction; total close-fitting enclosures can achieve up to 20 dB(A) noise reduction; well-designed large total enclosures can achieve as much as 30 dB(A) noise reduction, as they can be constructed of heavier materials with no openings for stock, product or scrap; and operating the punch in shear can reduce the noise levels by about 15 dB(A). These claims appear to be well above other published data and the authors' personal experience.

Studies by Shinaishin [41, 42] on punch press diagnostics, noise control and impact-induced industrial noise note that it is necessary to have a thorough knowledge of the noise generating mechanisms in the press. He used a combination of waveform analysis, frequency analysis, time-frequency analysis and cross-correlation analysis; with the objective of identifying the causes of sound generation and selecting the components to be treated. The analysis included extensive simultaneous measurements of sound levels, acceleration and positions of moving parts. He advised that in all cases the sound spectra were broad and exhibited little or no sharp peaks, indicating that the excited structures were vibrating in many modes. He also advised that a 70% increase in machine speed raised the overall noise level by 5–10 dB(A), and that hard steel feedstock generated about 5 dB(A) more noise than mild steel feedstock. In experiments with high speed stamping presses, Shinaishin achieved noise reductions of 12 dB(A) by reducing the maximum blanking force through shearing the die. He noted that the application of this method should be used with care, since it may affect the product quality.

Shinaishin [41] also tabled the following explanation for the mechanism of press noise generation. During the cutting operation a large force is developed and stress builds up in the feedstock material, with an equal force in the opposite direction building up in the press frame. Upon fracture of the feedstock the two opposing forces set both the feedstock material and the press frame into transient motion. He emphasised that the noise thus produced could be lowered by reducing the vibration amplitude, it's frequency, or reducing the radiation.

This explanation of strain energy generated noise by Shinaishin was recently discussed by Williamson [48]. Williamson developed the concept of this noise as *spring-back noise* from the machine components. Williamson noted in a report on the reduction of impact noise in the sheet metal industry that in the cutting process strain energy builds up in the press components as the forces increase leading up to the cut. This strain energy is suddenly released when the cut or *break-through* occurs. The physical effect of the fracture is to force the press components with a negative step function of amplitude to virtually equal the maximum force. Impulsive motion of the press components following this sudden release was defined as spring-back, hence spring-back noise was the noise generated by such a motion.

Allen and Ison [2] identified and outlined the principal noise sources on a number of punch presses of varying capacity. They noted that although the relative importance of each source varied from press to press, and job to job, they were able to rank them as follows: impacts associated with the die; turbulence noise due to air ejection; metal-to-metal impacts of feed and ejection components; stop start impact of automatic feed mechanism; vibration from the flywheel and sheet metal fastened to the press; clutch and brake mechanism; and vibration of the press surface. On a 50 ton press Allen and Ison achieved a noise reduction of 13 dB(A) by enclosing the die area. This was achieved by making a cardboard mock-up enclosure and then using this prototype to design an operational enclosure from metal and plexiglass.

In an investigation to locate the major noise radiating areas on a 4 ton punch press, Koss and Alfredson [25] located the sources of transient sound through the use of multiple-input correlation theory. The inputs were acceleration, measured at the die, the support plate and the crankshaft collar; while the output was the sound pressure level measured at the operator station. They showed how sound was radiated due to changes in the force-time curve.

Koss [26] also used a conventional vibrational shaker to simulate the frequency response of the above punch press. A comparison was made between the experimental results obtained from the shaker analysis and the blanking operations for mild and stainless steel.

An experimental evaluation of several commercially available mufflers to reduce air exhaust noise from clutch and brake activation was conducted by Daggerhart and Berger [14]. They advised that the peak sound pressure level of pneumatic exhausts could be reduced by as much as 34 dB(A) by the installation of an appropriate air exhaust muffler.

Petrie [33] concentrated his efforts on obtaining an optimum tool alignment and made simple press tool modifications in order to reduce the noise due to the blanking operation of a 15 ton C-frame punch press. Several operational parameters were considered, such as: clearance between the punch and the die; the location of the workpiece on the travel of the punch with its resultant impact velocity; the angle of the shear on the punch and die; and shear area. Petrie noted that the minimum punch impact velocity compatible with sufficient punch travel through feedstock resulted in a reduction of up to 8 dB(A).

Stewart *et al.* [44] in a comprehensive report on the noise parameters influencing a 60 ton power press studied the effects of the feedstock shear strength, hole punch diameter, feedstock thickness, punch impact velocity and the punch and the die clearance, on the peak sound pressure level. They observed a reduction of 15 dB(A) as the percentage clearance between the punch and the die was reduced from 20% to 6%. *Percentage clearance* was defined as the difference in punch and die diameters, multiplied by 100 and divided by the feedstock thickness. They also noted that for percentage clearances less than 6% the noise level was relatively constant for a given thickness, while at percentage clearances above 8% the noise level increased proportionally with increasing punch to die clearance.

Strasser [46] believed that a selective combination of several simple measures, based chiefly on common sense and sound engineering knowledge, would yield highly satisfactory noise reduction results. He noted that the noise produced by a press increased as the load approached the nominal capacity of the press. Therefore, to reduce the noise level, it is important to select a press with ample capacity, approximately 50% to 100% above that required.

Cook [12] discussed his experience in reducing noise on a wide range of power presses using various types of barriers with different materials, mufflers, vibration isolators and absorptive silencers. He advised that the most common design problem associated with applying noise control principles to power presses was the need to make allowance for frequent access to the machine. Cook also stated that it is possible to reduce the overall noise in a crowded press shop from 7–10 dB(A) by the use of absorption treatment. The authors believe these figures to be unlikely in practice due to vast area of panels that would be required and the associated high cost of implementation. The previously considered figure by

Bruce [53] of 3 dB(A) is more plausible.

A mathematical 2-dimensional model of a punch press frame vibrations and acoustic power output was formulated by Brickle [6]. This model was used to determine the relationship between structural dimensions and generated noise levels. He stated that in most cases analysed, the third vibrational mode was predominant and that it was sufficient to take only the first three modes into account in the calculation of the acoustic power, the fourth mode contributing very little.

In a study of three punch presses with different capacities, Koss [27] compared the sound radiation for the same loading. He standardised the characteristic shape of the fall-off regions for the force-time curves. This was achieved using plexiglass as the feedstock, since it was brittle and produced fracture at the maximum load, resulting in fall-off of load similar to a step decrease in the force. The force history was also statistically repeatable. A least squares fit of the peak sound pressure level associated with each transient sound to the peak force was found to be of the form: $L_{peak} = a + b\log_{10} P_{peak}$ where; L_{peak} was the peak sound pressure level (dB(A)), and P_{peak} was the peak force (kN).

Chee [7] also conducted a research survey of punch press noise. He concluded that there was insufficient data available either to construct a general model which would predict press noise from a wide range of machinery, or to assist with a reliable noise reduction program. He later published [8] a comprehensive review of punch press noise characteristics. In summary these were: the sound pressure level was proportional to shear area of the feedstock; and the sound pressure level dropped as the cutting-blade shear angle was increased until it reached a minimum at 12°, thereafter no benefit was measured. For practical angles of shear, in the region of 2–4°, a noise reduction of about 8 dB(A) was noted; the punch to die clearance was more critical with thicker feedstock; the punch to die clearance was related to the feedstock material properties and the type of fracture taking place; and the sound pressure level increased with punch impact velocity until a maximum sound pressure level was reached.

Koss and Moffatt [29] studied the structural response of a 170 kN C-frame punch press. They studied the first mode shape and concluded that it was responsible for a significant portion of the sound radiation. They also concluded that it was very difficult to dampen the press frame due to its large mass and stiffness. Koss [31] later reported overall noise reductions of 1–2 dB(A) using a tuned mass absorber and constrained layer damping treatments applied to the press frame. He achieved this by attaching sets of tuned absorbers to the press bed. A constant mass of 40 kg and varying thicknesses of neoprene rubber were combined to create spring mass systems.

In a follow up study Koss and Moffatt [30] reported mode shape, radiation ratio (σ_{rad}) and damping as a function of frequency for the same press. They concluded that a value of unity could be assumed for σ_{rad}, for machine structures with frequencies above 1000 Hz. For frequencies below this, σ_{rad} could have almost any value and the value was dependent upon how well the structural mode shape was matched with the wavelength of sound in air at the modal frequency and upon air transmission paths through the machine. They also reported that the damping ratio values were operation dependent.

Jeyapalan and Doak [74] showed that σ_{rad} can be used for accurately predicting the noise radiated by a decaying oscillator if the mean square velocity of the oscillator and σ_{rad} are known in the frequency band of interest. This result is specifically of interest for expanded-metal press noise predictions as the press frame vibrations decay rapidly between cuts.

In a report on machinery noise Jeyapalan and Halliwell [75] used acoustic modelling to predict the equivalent sound pressure level at the operator station. This method provided a quick and easy method of accurately predicting overall root-mean-square sound levels given a force input to the machine and the subsequent vibrational response. The method is applicable to any machine which can be identified as a combination of separate sound sources.

Coleman [9] investigated the sound radiated by a hand-operated punch by combining experimental measurements with sound radiation and classical vibration theories. The predicted sound pressure levels from acceleration data and σ_{rad} were within 5dB of the experimental results.

Finite-element modelling of punch presses and forge hammers was performed by Al-Sabeeh [111]. Sound radiation at modal resonance from a punch press frame was predicted using classical structure-borne radiation considerations. He noted that the press structure was responsible for a large portion of the overall noise radiation. He concluded that a much better structure-borne noise prediction could be made if σ_{rad} of steel plates were known. He suggested that an experimental study on steel plates of various thicknesses and boundary conditions be undertaken to yield a set of empirical relationships that approximated σ_{rad}.

Coleman and Hodgson [10] demonstrated the benefits of acoustic intensity contours by mapping the sound field around a 350 kN punch press. All three events of the punch press cycle were analysed individually by partial-coherent residual spectra-analysis techniques to help rank the noise sources per event. Also, the transient response of a single-degree-of-freedom system, subject to the actual punch press forcing function, demonstrated the response to be stiffness controlled rather than mass controlled.

Coleman [11] later studied the sound radiation from repetitive transient vibrations using multi-channel digital signal processing with an emphasis on transient impact machinery. He showed that the partial-coherent residual spectra-analysis technique failed to accurately identify and rank acoustic sources on complex machinery, characterised by omni-directional energy flow and/or high spatial coherence throughout the structure. He concluded that ringing noise was not generated solely by resonant frequencies, therefore techniques that affect the entire frequency range were preferable for reducing noise. He demonstrated that increasing the stiffness of the punch press reduced both the resonant and non-resonant sound radiation. Coleman also successfully employed the use of cepstral analysis to separate overlapping pressure waveforms. This allowed him to separate events within transient machine cycles and reverberant conditions.

Significant pioneering research by Richards *et al.* has led to a better understanding of impact noise mechanisms. Richards *et al.* [35, 85–94] published a comprehensive series of papers based on extensive experimental and theoretical studies conducted at the Institute of Sound and Vibration Research, University of Southampton. Since their publication these papers have served as the definitive reference on impact noise throughout the world.

Like Shinaishin, Richards and Stimpson [35] advised that the force within the punch press body builds up and the whole machine is strained until the feedstock material fractures. At this stage the strain energy in the press body and the feedstock material must be redistributed. This redistribution leads to vibration of the whole press body and subsequent noise radiation. The paper also describes work carried out on passive and active cancellation systems used to arrest the spring-back of the press body following feedstock fracture and explains the limitations of such systems. Richards and Stimpson stated that well designed shear and/or cutting with low percentage clearance was superior to active cancellation. They also used the Energy Accountancy Equation to relate the noise radiated directly to the squares of the large rates of change of force against time; where $f(t)$ was defined as the force pulse shape. This illustrated clearly the way that noise control, with the use of passive or active methods in designing the punch tooling, can be related directly to the one parameter $10\log\sum\left[\dot{f}(t)\right]^2_{\max}$.

Most recently Lam and Hodgson [77] used a numerical technique to predict the ringing noise from a $\frac{1}{3}$ scale model drop hammer, in a rectangular room. The technique was based on the Helmholtz integral equation with a modified Green's function to account for the effects of the enclosure. The vibration data required by the noise prediction technique was obtained by finite element predictions and impact response measurements. It was found that the noise prediction showed good general agreement with measurements, but at certain frequencies noise other than the ringing noise was found to contribute significantly towards the measured noise levels.

3 CONCLUSIONS

It can be seen from the above discussion that there is no single method of reducing noise from punch and power presses. A common conclusion to most articles is that there are generally several noise sources, each requiring separate and individual treatment. The following is a summary of the noise sources, reduction methods and techniques tabled by the various authors that are relevant to the present study:

1. The noise level is directly related to the impact intensity, that is, the sound pressure level is greater with higher forces acting over shorter periods of time; the time element is a very important factor;
2. Strain energy spring-back of the press components is a major noise generating mechanism;
3. Lowering the machine operating speed can reduce the overall sound pressure level by as much as 10 dB(A);
4. The cutting-blade characteristics are important and the following points should be considered when designing for minimum noise emission: provide rake to the edge of the cutting-blade so that the cutting is performed progressively in a smooth shearing action; stagger the cut by performing the cutting operation progressively instead of in one hit; extend the duration of the cutting action; employ the smallest blade clearance consistent with product quality; use clean and sharp cutting edges as higher forces are required to cut with dull cutting edges; and employ anything that makes the cutting action easier, such as lubrication. For punch and die sets a percentage clearance $\leq 6\%$ appeared to be optimal;
5. Absorptive treatment to factory surfaces will only yield a noise reduction in the order of 3 dB(A) at the operator station;
6. Effective inlet and exit treatment to a press enclosure is very important and usually difficult to achieve;
7. Partial enclosure of the press, such as enclosing individual noise sources, is not effective;
8. Increase the mechanical impedance of all moving parts by increasing the mass, stiffness, or damping;
9. Increase the stiffness without changing the mass is more effective than increasing both the stiffness and the mass together;
10. Radiation from impact tends to be broad-band noise, so techniques that reduce noise over the entire spectrum are preferable. Stiffness controlled noise reduction techniques reduce both resonant and non-resonant sound and vibration.
11. Where possible, decouple the energy source from the radiating source;
12. A press capacity of at least 50% and up to 100% above that required is suggested; and
13. The most common design problem associated with applying noise control principles to presses is to under estimate the necessity for frequent access to the various components of the press.

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UNDERWATER ACOUSTIC NOISE LEVELS IN LAKE CETHANA

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This paper describes the noise measurements made in Lake Cethana, Northern Tasmania, as the first step in establishing the suitability of this lake as a possible site for a proposed towed array test facility and gives the noise spectrum results obtained. The results are compared with typical ambient noise data for Australian waters.

1. INTRODUCTION

Lake Cethana is a long deep artificial lake which is managed by the Hydro-Electric Commission (HEC) of Tasmania as part of the State's hydro-electric generating network. The lake, situated approximately 80 km west of Launceston, is one of the sites used by the Australian National Underwater Training Centre Ltd (ANUTC), a company established to train surface supported air and mixed-gas divers.

Lake Cethana is being investigated as a potential site for a towed array testing facility under an Australian Maritime Engineering Cooperative Research Centre (AMECRC) project. As a first step in assessing the suitability of the lake for this role, underwater acoustic noise measurements have been carried out with and without the HEC generators in operation. Depth soundings of the lake have also been made. A map of the northern end of Lake Cethana is included.

This paper outlines the equipment and measurement techniques used to obtain these noise data and gives noise spectral density curves for the lake.

2. UNDERWATER ACOUSTIC NOISE MEASUREMENTS

2.1 Equipment and Measurement Techniques

An ITC 1042 hydrophone with a 9m lead was used, either directly connected to a 20 Hz to 22 kHz digital tape (DAT) recorder or via a 90m long coaxial cable system suspended by floats. A FET voltmeter was also used to record noise voltage readings and headphones were used to monitor the signals being recorded.

The hydrophone was lowered into the water to a depth of approximately 7.5m when directly attached to the DAT recorder. The full 9m hydrophone cable length was used when the 90m coaxial cable was added in line with the hydrophone. The latter arrangement was used to minimise the noise generated by waves lapping against the 18 foot aluminium outboard boat used, however most measurements were made with the hydrophone directly connected to the recorder as this method provided the best sensitivity.

The recorded acoustic noise was analysed by a Rockland System/90 Signal Analysis Workstation. The FFT spectrum was computed from this using the sum fast average function. This required the least processing time enabling analysis to be made between the periods when the sound of waves was acting on the boat. Uniform weighting was used in accordance with the Rockland recommendation for the analysis of acoustic noise measurements.

2.2 The Noise Spectrum Level

This section shows graphs of the sound spectrum level in the lake with and without the HEC generators in operation. Figure 1 shows the spectrum level at different positions in the lake with the generators running. Refer to the map in Figure 2 for the location of the various measurement positions.

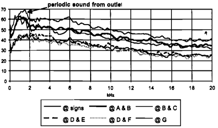

Figure 1 : Spectrum level for Lake Cethana with generators in operation

The arrow points to the water intake's periodic 'roar' sound, the energy of which is mostly below 2 kHz. The spectrum level increases in magnitude as the hydrophone is moved towards the dam wall. In the absence of the 'roar' sound, the spectrum at the warning signs, between points A and B and between points B and C is a similar shape to that between points D and E. The rapid decrease in the ambient noise levels below 1 kHz in the above results is because the measurements were made with the hydrophone directly connected to the DAT recorder. The low input impedance of the DAT acts, with the sum of the hydrophone and cable capacitance, to produce a lower cutoff frequency of about 1kHz with a low-frequency roll off of 20dB per decade.

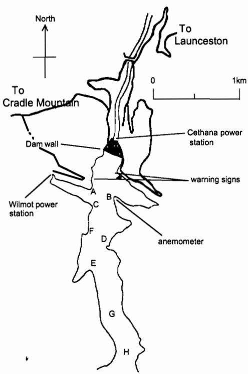

Figure 2. Map of Lake Cethana

Figure 3 contains the spectrum levels with and without the generators running. The top curve is for measurements made between the warning signs near the dam wall. This particular spectra shows the 'roar' from the water inlet. The combination of curves, for the case where the generators were not running, is shown for measurements made from the dam wall (between the signs) to point G.

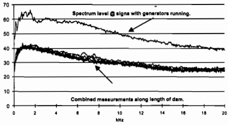

Figure 3. A combination of spectra with and without the generators in operation

Figure 4 shows the noise level at point G with and without the generators running. Between the frequencies of 2 kHz and 13 kHz there is approximately 5 dB difference between the two levels. For comparison, the two upper curves show typical ambient noise data for Australian waters for the wind speeds shown. These data have been taken from Figure 1 of a paper by D Cato [1].

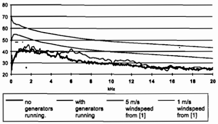

Figure 4. Measurements made at point G with and without the generators running

2.3 Wind speed recorded during measurements

As the wind speed over a body of water affects the ambient sound level in water an anemometer was used, in combination with a data logger, to record wind speeds when noise measurements were being recorded.

It was not feasible to mount the anemometer on the boat so this was placed in the position indicated on the map of Lake Cethana. While this location was generally clear of vegetation, it was felt that the wind speed on the water was marginally greater than the figures recorded in this location. For the measurements made the wind was found to be from a northerly direction. In general the size of the waves were greater further away from the dam wall.

The wind speed was averaged over a 5 minute period before being recorded.

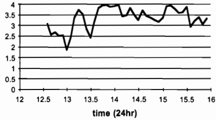

Figure 5. Wind speed measurements taken on 24 March 1994 when the generators were off

Figure 5 shows that the wind speed for measurements made when the generators were off was 3± 1 m/s.

3. DEPTH SOUNDINGS

Depth soundings of the lake were made with a narrow beam echo sounder along the approximate centre line of the lake from the dam wall to point H. The water level in the lake was then approximately 2m below the dam spillway. The deepest recording was 90m at a point between the signs in front of the dam wall. The lake depth varies mainly between 60 and 80m with the shallowest point being 52m approximately between points D and E as shown on the map in Figure 2.

4. DISCUSSION OF RESULTS

The reason for the rapid decrease in the measured ambient noise levels below 1 kHz has been explained previously. For frequencies above 1 kHz the ambient noise levels are encouraging. The recorded Cethana measurements are significantly less than the typical results for Australian oceanic waters at similar wind speeds, and similar in level to those recorded in Woronora Dam [2], which is used by the DSTO Aeronautical and Maritime Research Laboratory for acoustic experimentation.

5. SUMMARY

Lake Cethana is a long deep lake which is acoustically quiet when the HEC generators are not running. With the generators in operation, the lake spectrum noise level between points D and E and at point G are marginally increased compared to the case when the generators are not running. Lake Cethana is one of the sites used by the ANUTC and a 22m x 11m barge carrying diving support gear is already in place at the dam wall end of the lake which could be used as a winch platform for a towed array test facility. Basic accommodation is available at the old HEC camp at Gowrie Park which is a 20 minute drive from the lake site. It now needs to be established whether or not there is sufficient interest in developing such a facility at Lake Cethana.

6. ACKNOWLEDGMENTS

The authors thank the Hydro-Electric Commission, Tasmania for their assistance, and particularly for their co-operation regarding the timing of visits to coincide with the generators at Lake Cethana being on or off. They also thank the DSTO Aeronautical and Maritime Research Laboratories for the use of the Rockland Analyser, which is on loan to AMC for a joint DSTO/AMC parametric array research agreement, and Dr Doug Cato for his encouragement and advice regarding this project. The support of Dr Allan Carpenter, Director of Australian Sonar Systems and AMECRC Sub-Program leader for this and other projects is also acknowledged.

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Books...

Noise Control in Russia

O. Rudenko & S. Rybak (Eds)

NPK Informatica, 1994, 263pp, hard covers. Distributed by Int. Sci. Publications, PO Box 13, Auburn AL36831 USA. Price $US70(includes air mail).

This book is the culmination of the idea of publicising the acoustical results obtained in Russia which for many years were not available to the western world. It consists of nine review papers prepared by leading Russian acousticians on a wide range of noise and vibration control problems.

In the review of "Structure-borne sound damping", Professor Nikiforov discussed vibration absorption, vibration isolation and vibration damping. The complexity of the acoustical and vibrational features of ribbed plates was highlighted. Simple but elegant engineering estimates were used in the analysis. This is followed by a paper on "Sound insulation by layered partitions". Dr. Avilova & Professor Rybak showed how the transition matrix method could be applied to determine the sound insulation of plane and cylindrical partitions consisting of elastic and viscoelastic layers.

With the introduction to passive noise and vibration control in the previous two review papers, the paper on "Adaptive systems for noise and vibration cancelling" was given by Drs. Ljubashevsky & Orlov. In this paper, the adaptive control systems were implemented as one-dimensional or multi-dimensional Wiener filters for cancelling random noise and vibration or discrete spectral components.

In paper "Vibrodosimetry: monitoring of labour conditions", Dr. Matveev discussed the vibration dose, the maximum permissible limits of frequency-weighted vibration parameters, risk factor, the physical mechanism of the effect of vibration on the human body, the requirements for dosimetric monitoring, instrumentation and measurement techniques. It is interesting to note that according to Dr. Matveev, among the people suffering from vibration induced diseases, only 5% came from working in industry, compared with 15% from arts and 80% from sports.

Drs. Bazhenov & Bazhenova gave a very detailed review of "Noise and vibration of centrifugal fans". Theoretical and experimental studies undertaken at the Acoustic Institute of the Academy of Sciences of the USSR on the mechanism of generation of tonal components and broadband noise were presented. The operation of reactive muffler in ventilation systems has been analysed. Vibration sources in ventilation systems have been discussed and recommendations were given to reducing the noise and vibration levels caused by aerodynamic sources.

Prof Rudenko discussed a rather new topic: "Nonlinear methods of noise control". The phenomenon of suppressing low-frequency noise by an intense signal at a sufficiently high frequency has been described. The potential applications and the need for further research in this area have been emphasised.

The review paper by Professor Rybak & Dr. Soroka on "Room Acoustics" is primarily concerned with the development of an adequate model of the acoustic field in an enclosure. The statistical energy method, the method of imaginary sources and the method based on wave theory have been examined and compared.

The last two review papers were written by Professor Osipov. In "Ambient noise protection in towns", various noise sources such as cars, rail, ships and industrial machineries were considered. Practical methods for noise calculations involving acoustical screens, green plantations and different properties of building materials were described. The principles of noise level mapping for road networks were also presented. The book concludes with a review paper on the latest "Noise protection standards in Russia".

While the book covers a number of important noise and vibration control topics, these topics have not been arranged in a logical order. The numerous typographical mistakes are unfortunately rather distracting and do not do justice to the high quality technical analyses presented in the book. Nevertheless, it is a good source book for topical research conducted in Russia. The book has certainly achieved its aim of presenting the most interesting research programs carried out in Russia in the last few years. This book should be of interest to postgraduate students and researchers in the areas covered. Some practical noise and vibration reduction methods have been described which would be useful particularly to consultants.

Joseph Lai, ADFA

Joseph Lai is Assoc Prof in School of Aerospace and Mechanical Engineering at ADFA. H was the foundation Director of the Acoustics & Vibration Centre and has a broad experience in noise control.

Music and Schema Theory

Marc Leman

Springer Verlag, 1995, pp 234, Hard Cover ISBN 3 540 60021 3 Australian Distributor: DA Information Services, PO Box 163, Mitcham Vic 3132. Tel 03 9873 4411 Fax 03 9873 5679. Price A$95.

It is an illuminating experience for one trained in the physical sciences to read an allegedly interdisciplinary text which includes, in the word of the author, "results of musicology, psychology, computer science, brain science and philosophy". The author then states that he wishes "to make all this accessible to a general audience". He further states that "the technical language has been restricted to the most elementary concepts".

Somewhat contrary to the stated aims the book is written in a highly technical fashion with a preponderance of terminology customary in musical psychoacoustics. The author no doubt has done some verbal back-pedalling in order to satisfy his aims but has not been able to break out of the terminological strait-jacket in which his field of work customarily operates. It would take an unusually well-informed "general reader" to read more than a few pages before reaching for the nearest technical dictionary. Musicologists and psychologists would fare better as these are the areas in which the book's strengths lie.

The book as a whole is highly ingenious and employs procedures based on the latest developments in auditory brain research and computer programming. But like most computer manuals the material is written by one expert for other experts to read. The art of addressing the general public is one that so far has escaped the majority of scientists, especially those engaged in intensive research. This problem is illustrated by the author's habit of starting to describe a particular effect or phenomenon and then, in his enthusiasm, giving his impressions of the consequences without describing the effect in sufficient detail.Consequently it is necessary to re-read such sections several times in order to interpolate the missing information.

The whole thrust of the book is to process musical sounds using simulations of the appropriate functions of the ear and brain. As the author comments, the emphasis throughout is from the viewpoint of auditory information processing. Signals are analysed in terms of the critical bands of the inner ear, converted into nerve impulse images and then processed using neural networks that endeavour to operate in a manner analogous to the auditory cortex and associated regions. Data reduction techniques used by the brain as at present understood are incorporated.

Compared with the complexity of the mental processes invoked in listening to live music the analysis that can be performed with even such a sophisticated system is still somewhat elementary. The key notes (tonic) for a series of major and minor chords can be identified using pitch perception techniques and a musical score can be scanned with the object of identifying the tonal centres. Some success has been achieved with the application of the same algorithms to the analysis of rhythm and, to a limited extent, timbre. The final two chapters discuss the relations between the computer model, neurophysiology, theories of meaning and cognitive musicology.

The chapter organisation throughout is good with a clear statement of aims at the beginning and a set of conclusions at the end. The book is a summary of research conducted over many years in a difficult and complex intellectual field wherein artificial intelligence tries desperately to compete with the highly developed musical skills and mental processes that are still only partly understood. It is an impressive effort that has a great deal of potential for future extension.

Howard Pollard

Howard Pollard was an Associate Professor in Physics at UNSW until his retirement. He is currently Publications Consultant to AINSE, Lucas Heights and continues his interest in musical acoustics.

Mediacoust - Teaching Acoustics by Computer

01dB, 1995, CD-ROM. Aust Distributor: ETMC Technologies Pty Ltd, 3 Montague St, Balmain, NSW 2041 Tel 02 555 1225, Fax 02 810 4022 Price A$1,485

Mediacoust is a teaching software package using multimedia techniques to offer a combination of sound, text and pictures on a personal computer. It has been developed by scientists, teachers and professionals from l'Ecole Polytechnique de Lausanne, l'Ecole Nationale des Travaux Publics de l'Etat de Lyon, Liverpool University and the companies Acouphen, Estudi Acustic and 01dB. The original was in French and it has recently been translated to English.

It comes as a CD ROM and the minimum requirements are a 486 computer with 4 MB RAM, VGA screen, DOS 3.3, Windows 3.1, Multimedia card, CD ROM drive and loudspeaker. This combination is comparable with that required for many running games on home computers so is not very demanding. The installation is easy and the first screen comes up without any problems. However no obvious choices for directories are given during the installation process. Once commenced, it is easy to move around with arrow forwards and backwards and bookmarks.

Mediacoust is based on a central core containing the fundamentals along with specialist modules. The user is really only aware of the four main groups in the central core of the software which is used as the starting point and the main menu.These groups are: Basic Physics; Noise and Man; Room Acoustics and Noise Control.

The graphics are quite eye catching with the regular appearance of cartoon characters based on an ear shape. The other graphics are either technical with graphs, spectra, diagrams etc or relevant photos. For example in the community noise section there is an aerial view of a city and then small sections can be selected for zooming, such as a factory or houses near a busy road. The actual text is necessarily brief to fit onto each screen page but the use of hypertext links on highlighted words, in a similar manner to use on the internet, allows the user to seek more information.The complimentary graphics and sound mean that material can be presented with a minimum of words.

When running conventional classes in acoustics it is often difficult and time consuming to set up the appropriate demonstrations for the topics discussed. This package offers audio demonstrations whenever possible. Some of these are interactive with movable controls for various effects.

The package takes some hours to work through and is very comprehensive. It would be ideal as an aid to teaching but it is not a course in itself. Just as one can move around the chapters of a text book one can move around in the package - going along branches (hopefully first using a bookmark to allow return to the starting point). So although it is structured itself, it does not force the user to work through all the elements in a particular manner. But then this is part of the appeal of the package. Someone wanting to know about any one of the topics can find that area easily and quickly. The limitation is the lack of references should the user require yet more information on that topic.

This package would be of use in conjunction with conventional classes for students from high school level to university. Even primary students would find it interesting (the four year old son of a colleague quickly found how to make the sounds and to find all the interesting cartoons). Enquiries from the general public could also be answered by reference to the package if it was available for consultation in a library or similar access area.

Marion Burgess

Damage Your Hearing and It Won't Come Back

Australian Hearing Services, 1995, video. Distributor: Marketing Section AHS, 126 Greville St, Chatswood NSW 2067. Tel 02 412 6825, Fax 02 413 1571 Price A$20.

This video has been recently released as part of the Prevention Program of Australian Hearing Services. It has been developed for children aged from 6 to 16 years to demonstrate how they can prevent damage to their hearing from exposure to loud noise.

The cover of the video shows a photograph of a young person overlaid with coloured graphics focussing on the ears. This sets the scene for the video which has Jim Pike as the humorous presenter. Bright, catchy graphics are used along with film clips of noisy areas and of short interviews. The audio is used well to compliment the visuals as in the examples of what a variety of sounds are like with hearing damage. An explanation of the mechanism of hearing is simply presented. For example the cochlea is described as filled with fluid and about the size of a pea which the presenter shows and then squashes - a scene sure to maintain the interest of the young.

An important focus of the video is on the damage that can be caused by exposure to loud music. Not only is there an encouragement to reduce the level of the music there is an acknowledgment that this may not be possible and so there is guidance on how to use ear plugs. Interviews with the users of ear plugs show the benefits of reduced noise exposure while still hearing what is going on.

The title - damage your hearing and it won't come back - forms a catchy tune and there are stickers and posters with the title and graphics to reinforce this theme. The video is well presented and should be of great use for educating young people in the importance of protecting their hearing. It is important to get the message through at a young age and hopefully there should be less problems with hearing damage from either recreational or occupational noise exposure in the future.

Marion Burgess

Marion Burgess has been involved with teaching at various levels for many years. In her current position at the Acoustics and Vibration Centre at the Australian Defence Force Academy she is involved with the organisation and presentation of continuing education activities. Assistance with this evaluation was provided by Michael Harrap and his son.

News...

AAS General Secretary

At the November Council meeting Noela Eddington tendered her resignation from the position of General Secretary. Her resignation was accepted with regret and a vote of thanks was made by Council for her excellent work in this position over the last few years.

Council decided that, in view of the increased work load of the General Secretary and the need to appoint a person able to look after the policy and business needs of the Society, the appointee should be paid to undertake the work. In addition, the General Secretary should undertake the tasks performed by the Professional Centre of Australia. This mainly involves preparing subscriptions notices for members and keeping a Register of members. The Society will retain the Professional Centre of Australia as its official mailing address.

Expressions of interest in filling the General Secretary position were received from three persons. David Watkins was the successful applicant and he has initially been appointed to the position for a period of 12 months.

David Watkins has been a Member of the Society for 15 years and a member of the Victoria Division Committee for 7 years. He has held various positions on the Committee including Divisional Secretary and Registrar and is familiar with most of the administrative requirements of the Society. David held a position in the Noise Control Branch of the Victorian Environment Protection Authority for 22 years until he retired last year.

David is looking forward to the challenge of managing the needs of the Society into the 21st Century. He can be contacted at PO Box 4, Tally Ho, Vic 3149, Phone/Fax (03) 9887 9400, email watkins@popa.melbpc.org.au

NSW DIVISION

The NSW Division's first technical meeting for 1996 was held at the NAL auditorium on Wednesday 28 February. The meeting was well attended with about 47 persons coming to hear a panel of two speakers discuss sleep arousal - what really wakes you up. It was noted that all persons that attended were sufficiently aroused that no one was noted dosing off during the excellent presentation.

Dr Norm Carter of NAL presentation was quite educational. He discussed the various traditional methods of measuring sleep and raised a number of questions that still require answers. In summary the measurement of sleep can be conducted either during sleep or the next day. If it is measured during sleep there are three common methods of measurement; polygraphy (EEC eyes chin and scull); actinometry (hand movement); and voluntary response (press a button upon waking). Alternatively, if measured the next day after sleep or sleep depredation there are also three common methods of measurement; polygraphy; performance tests; and subjective reports. Dr Carter suggested that the sleep state change could be a more preferred method of measurement. He stated that there is strong evidence confirming that a reduction in sleep affects performance and health in the following ways: reduction in Stage 4 sleep is related to sleepiness; reduction in Stage 2 sleep injures some type of memory; loss of stage 4 sleep may impact on the immune system (NAL/Uni Newcastle study); and fragmentation of sleep reduces daytime alertness.

Dr Rob Bullen of ERM Mitchell Cotter proposed a method for assessing sleep disturbance due to intermittent environmental noise. It was based on: the number of individual noise events heard; the maximum levels of events; and the 'emergence' of events above the ambient noise. He defined intermittent noise as individual events such as planes, cars and trucks. Dr Bullen stated that the derivation of the method, and hence the 'sleep disturbance index' (SDI), was based on a number of field trials. He presented a number of examples of how the method could be used. A fundamental feature of the method was its use of a weighting factor. The weighting factor was derived from the results of eleven major international studies on the probability of awaking based on the number of events and maximum internal noise level. Dr Bullen plotted these results and put a best fit second-order polynomial curve though this data to obtain the weighting curve. Dr Bullen invited the audience for any comments and/or improvements, noting that this method is more useful than the existing alternative and could form a more solid basis for sleep disturbance assessment.

The two speakers and **Mr Roger Treagus** from the EPA invited questions from the audience. The questions were probing and simulating and highlighted the fact that, like airport noise, sleep disturbance is a very complex technical issue which is difficult to define as a model that covers all the possible variables. Whatever criteria are finally used to define sleep disturbance will need to be a compromise of a more complex set of variables. Following the technical meeting the majority of those in attendance adjourned to the NAL cafe for collegial discussion, light food and refreshments. Some members were noted in deep discussion as late as 9:00pm in the NAL carpark, so by all counts this meeting could be judged as successful.

David Eager.

ASJ 60 Years

The Acoustical Society of Japan (ASJ) was founded on 15 April 1936 and has its 60th anniversary in April 1996. A celebration was held during the spring meeting of the Society. Congratulations from the AAS was forwarded by our President and read at the time of the celebration.

The ASJ was founded on April 15th 1936, by 15 members. By 1994, more than 50 years later, the membership had reached 4,212. In addition the Society is supported by 234 Sustaining Members and 226 Special Members.

Australian Prize

The Australia Prize was instituted in 1989, as an international award for outstanding achievement in science and technology promoting human welfare. The prize consists of $300,000 and an inscribed medal. The field in which the award is to be made in 1997 is Telecommunications.

Telecommunications is generally used to describe both the services offered by the worldwide networks which provide voice telephony facilities, and the technology used to construct and support it. This includes - but is not limited to - transmission systems, switching systems, access techniques, network management software, fibre optics, broadband technology, wireless technology, satellite technology, microwave technology, frequency modulation, packet switching and signal processing techniques.

Further information: Prize Secretariat, GPO Box 9839, Canberra ACT 2601, tel 06 276 1246, fax 06 276 2002, email ausprize@dist.gov.au

FASTS Issues

This past year has been an extremely active one for the Federation of Scientific and Technological Societies (FASTS) and here is a summary of the highlights showing how FASTS effectiveness has improved dramatically:

March - Appointment of a new, full time Executive Director, Toss Gascoigne

June - Release of the FASTS Policy Document at Parliament House

July to Nov - Meetings with Government officials contributing to the Innovation Statement, Meetings with Opposition officials contributing to Coalition Science Policy

November - AGM, and election of new President (Joe Baker) and FASTS Board and Executive

December - Press conference in Parliament House responding to the Innovation Statement

February - Consultations with representatives from the various parties contending the election and regular communication with the media.

The AAS is one of the 6 member societies in the Physical Sciences Group on the FASTS Board (the others being the Australian Institute of Physics, the Australian Optical Society, the Astronomical Society of Australia, the Australian Society of Electron Microscopy and the Society of Crystallographers of Australia). At the November AGM, representatives of of the Physical Sciences Group on the FASTS Board agreed that the President of the AIP should be the Physical Sciences Board member for 1996 (Professor Ron MacDonald). In general it was felt that the Board member should be a society President, in keeping with FASTS policy, in order to place the FASTS Board in direct contact (via active society leaders) with current issues of concern to the constituent societies. However, it was decided that the Board representative should be re-elected each year from the Presidents in the Physical Sciences Group who were willing to take on this role.

In addition, it was requested that the interaction between the Physical Sciences Group Board Member and the other societies in the Group be more regular so that FASTS can truly represent the issues of importance to the member societies. Information on FASTS can be obtained from the Web site http://bimbo.pharmacol.su.oz.au/fasts/fastshome.html. Communication with FASTS can be via the AAS/FASTS liaison officer: Marion Burgess, Acoustics and Vibration Centre, ADFA, Canberra ACT 2600, tel 06 268 8241, fax 06 268 8268, m-burgess@adfa.oz.au

Young Views for Future

Young people want the Australia of the future to be a society motivated more by generosity, and less by greed - one that places less emphasis on the individual, material wealth and competition and more on community and family, the environment and cooperation. Young people want to contribute to the decisions which affect them. Young Australians see science and technology as playing a major role in the type of world in which we live and would like to see more emphasis given to placing it in a social context. These are some of the findings of the recently released ASTEC report titled *"Having Our Say about the Future - Young People's Dreams and Expectations for Australia in 2010 and the Role of Science and Technology."* The study found that young people recognise the value of science and technology in solving the problems confronting society, but are concerned about some of the consequences of scientific and technological advances. The ASTEC report is the result of a major foresight study that comprised a series of eight workshops, involving 150 young people from a variety of backgrounds, and a national opinion poll of 800 young Australians aged between 15 and 24.

Future Needs for Networks

As part of the Australian Science and Technology Council (ASTEC) study on "Future Needs - 2010" a report entitled "Surf's up: Alternative Features for Full Service Networks in Australia" has recently been released and is available from the Australian Government Publishing Service. The report contains 12 recommendations, developed as part of a foresighting process, related to Australia's telecommunications systems. Analysis of various scenarios leads to the view that the main driver of change will be the demand for new services.

Primary Investigations

The Federal Minister for Schools, Vocational Education and Training, Mr Ross Free, launched the Primary Investigations program by interactive satellite television in August, 1995. This program has been produced by the Australian Foundation for Science for use in primary school education. A database has been set up to keep track of schools that have been trained on a whole-school basis. More than 360 schools comprising about 4000 teachers are now trained to use the program in their science classes. In December Primary Investigations was shortlisted for the Centre for Australian Cultural Studies Award for an outstanding contribution to Australian culture. This is in addition to it being commended for the Australian Book Publishers Association's Book Design Awards for excellence in Education Publishing. Information about the program is available on the World Wide Web on the Internet. The URL is: http://www.asap.unimelb.edu.au/aas/foundati/primaryi.htm.

Video Histories

The Australian Foundation for Science has initiated the Video Histories of Australian Scientists program to record interviews with outstanding Australian scientist for this and future generations. Initial funding to establish the program was provided by the Fenner Fund. The video interviews emphasise the human dimension and interaction in science, as a counterbalance to the formality of scientific publication. They recount the individual frustration and triumph that are part of scientific advancement. The Foundation has produced a promotional video tape with excerpts from several of the interviews; its theme is the early influence of parents and teachers on scientists' careers. Photos and excerpts from some of the eight interviews are now available on the Internet World Wide Web at URLhttp://www.asap.unimelb.edu.au/aas/foundati/fhp_vide.htm. The foundation is seeking financial support from government, foundations, corporations and scientific societies to interview between 35 and 40 additional scientist. Copies of the interviews are available for loan from the Basser Librarian, Rosanne Clayton, tel 06 247 3966.

OHS Internet

National Occupation Health and Safety information is now available on the Internet. The Prime target in the transition to the technological age by (Worksafe Australia) small businesses across Australia. "This is a very grey area, so we have taken an innovative approach," said chief executive, **Dr Ted Emmett**. Initially, Worksafe information available through the Internet will include media releases and library and information services. Instant access to other Australian and international OHS bodies will also be provided. Worksafe's homepage address is: http://www.worksafe.gov.au/~wsa1.

STANDARDS

Regional Standards

In the first of a significant series of meetings for the region, ACCSQ (ASEAN Consultative Committee on Standards and Quality) and the CER (Closer Economic Relations) countries of Australia and New Zealand met in January to discuss Standards and conformance issues involving the two groups. The meeting was a significant first step towards the sharing of information for the mutual benefit of the countries involved. Later meetings will identify areas for future cooperation and delve into these specific subject areas more fully. The primary benefit is, because Australia and New Zealand are not members of ASEAN (Philippines, Malaysia, Brunei Darussalam, Indonesia, Singapore, Thailand and Vietnam), the Standards conformance bodies of both groups can talk together and look at rationalizing what they do in terms of harmonizing Standards and conformance regimes, thus ensuring the greatest business opportunities for all countries. Ease of trade, lower costs and added convenience will be some of the direct spin-offs to flow from multilateral recognition among the group of foreign certification systems. A Memorandum of Understanding is to be developed between ACCSQ and the CER countries to formalize the cooperation program.

ISO Publications

The International Organisation for Standardization (ISO) has recently released a two-volume compendium containing over 80 international Standards on mechanical vibration and shock.

Vol. 1 - Terminology and symbols, tests and test equipment, balancing and balancing equipment ($250).

Vol. 2 - Human exposure to vibration and shock, Vibration in relation to vehicles, specific equipment and machines, buildings ($160).

ISO has published a two-volume compedium containing over 110 Standrds from various fields relating to acoustics.

Vol 1 - General aspects of acoustics, methods of noise measurement in general and noise with respect to human beings ($260).

Vol. 2 - Noise emitted by vehicles, noise emitted by specific machines and equipment and acoustics in building ($310).

Further information Standards Aust. freecall 1800 808 242

Quality Assurance

Standards Australia is committed to assisting small and medium sized businesses in implementing quality systems. In many small and medium sized businesses, resource and time constraints mean that an ISO 9000 quality system is implemented over an extended period and while this is occurring, there is no recognition for the parts of the quality system which have already been implemented. A subcommittee has been formed to consider possible approaches and to come up with a workable scheme acceptable to the business community. The broad basis of the phased approach adopted by the Subcommittee is provided by distributing the requirements of AS/NZS ISO 9001 over three modules. A draft for comment is to be issued shortly. It is seeking specific comment on concept of three modules. A section of the draft discusses the risk management aspect from both the supplier's and purchaser's perspective.

NATA Alone

The Federal Government has announced that the National Association of Testing Authorities (NATA) is to be Australia's only Government-recognised national laboratory accreditation authority. This means that NATA is the only agency able to accredit a laboratory for its technical competence to carry out specified tests. NATA will continue to represent Australia at overseas laboratory accreditation forums and at international conferences. The Government's recent announcement followed the recommendations of the Commonwealth Inquiry into Australia's Standards and Conformance Infrastructure, chaired by Bruce Kean. Although a private organisation, NATA receives Government funding for its international work.

Glossary

A draft glossary of terms used in noise control engineering has been produced by editorial staff of Noise/News International. Most of the definitions have been taken from American National Standards on Acoustical Terminology. Additional definitions have been taken from a variety of sources. The draft is subject to comment and a questionnaire is provided. Copies can be obtained from editors of Acoustic Australia or directly from Noise/News, fax +1914 473 9325, email INCEUSA@aol.com

Working Party Report

Reports from Working Parties established by International Institute of Noise Control Engineering have recently been published. The report on "Upper Limits to Noise in the Workplace" by the convenor, **Tony Embleton**, has been published in Canadian Acoustics, 23(2), p13-20,1995. This report summarises the legislation and compensation for a number of participating countries. The four recommendations include basic 8-hour exposure level of 85dB(A), limiting value of 140dB linear peak, 3dB exchange rate and engineering controls. It is interesting to note that all of these recommendations are in conformity with the Worksafe Australia Codes.

The report on "Effects of Regulations on Road Vehicle Noise" by the convenor **Ulf Sandberg**, has been published in Noise/Noise International 3(2) p85-113,1995. The study has included assessments of the development of vehicle noise emission limits over the past 25 years and the reasons why the effectiveness of the regulations has been less than intended.

Spinal Ultrasound

The American Institute of Ultrasound in Medicine's (AIUM) released a statement concerning the value of diagnostic spinal ultrasound. This states that :

"the AIUM recognizes that diagnostic ultrasound is a valuable tool in certain neonatal, fetal, perinatal, pediatric, neurologic and muscuolskeletal disorders. Intraoperative spinal ultrasound is valuable in selected clinical situations. There is insufficient evidence in the peer-reviewed medical literature establishing the value of diagnostic spinal ultrasound. Therefore, the AIUM states that, at this time, the use of diagnostic spinal ultrasound (for study of facet joints and capsules, nerve and fascial edema, and other subtle paraspinous abnormalities) for diagnostic evaluation, for evaluation of pain or radiculopathy syndromes, and monitoring of therapy has no proven clinical utility. Diagnostic spinal ultrasound should be considered investigational. The AIUM urges investigators to perform proper double-blinded research projects to evaluate the efficacy of these diagnostic spinal ultrasound examinations."

Rocla Move

From February the Rocla accounts, administration and business section moved form Frankston Road, Dandenong to Sandown Road, Springvale with postal address: PO Box 67, Springvale, Victoria 3171, tel 03 9549 4530 fax 03 9574 1483.

Ship Gets a Noise Job

Ships are too big to hide, but not too large to disguise from radar. This is what is happening to the HMAS Canberra, one of Australia's six guided missile frigates and the first to be fitted out with radar-absorbing technology developed by DSTO. After much research and testing with its industry and Navy partners, the DSTO-developed stealth technology has been fitted to the Canberra progressively since July, in order not to interfere with the frigate's operational schedule. Along with the attachment of 'glue-on' cloaking tiles, changes have been made to the vessel's superstructure in order to reduce its radar echo. This includes developing new steels and composites for use in 'high echo' areas such as turrets, as well as developing shipboard management techniques that minimise the ship's radar signature. Localised climatic and sea conditions affect the efficiency of the so-called anechoic tiles. Those used on US ships, for example, are designed to operate best in seawater temperatures of 0°C, while the average seawater temperature encountered by Australian vessels is around 20°C. The stealth technology developed as a result is cheaper, lighter and more effective than similar material in use overseas. Initial tests of ship sections have been successful enough to encourage the Navy to completely outfit one of its leading-edge combat craft permanently.

For further information: tel 03 962 68214.

Acoustics Lens Research

The inaugural RAN Science Scholarship has recently been awarded to **Dr Mark Readhead** of the AMRL Maritime Operations Division for his proposal to investigate "Acoustic Lenses". The Royal Australian Navy has established this scholarship scheme to promote and enhance the profile of enabling research within DSTO. It allows DSTO scientists to initiate and undertake research activities with longer term, more general or speculative naval significance. Dr Readhead's proposal was selected because of its emphasis on enabling research. The main thrust of the research will be to develop acoustic lenses to realise the concept of 'acoustic daylight', a newly emerging acoustic surveillance technique.

The benefit of this area of enabling research to both the Navy and DSTO is that it should provide a new capability for detecting and classifying underwater objects and vessels.

For further information: Dr Mark Readhead, Maritime Operations Division, Sydney, tel 02 692 1422

Noise Solutions

The UK's Secretary of State for Environment, John Gummer, launched a new book on noise reduction in the workplace as part of the UK government's campaign to reduce ill health caused by working conditions. Noise is one of the first health hazards highlighted in the government's campaign "Good Health is Good Business". The three-year programme was launched in May 1995 in an effort to persuade employers that health risks can be managed simply, effectively and at reasonable cost. "Sound Solutions: Techniques to Reduce Noise at Work" is published by the Health and Safety Executive (HSE) and sets out 60 case studies of noise reduction techniques applied in 24 industries. It gives costs and level of noise reduction of each solution, along with the companies involved. The authors note that a large number of the solutions were developed using in-house expertise. In other cases, noise consultants, with wide experience of investigating noise at work, provided the most cost-effective solutions. Most of the cases included in the book show a successful reduction of noise to within permitted levels. A range of solutions is demonstrated, and in some cases the advantages of one solution over another are indicated. The book is available for £10.95 from HSE Books, PO Box 1999, Sudbury, Suffolk C010 6FS, UK.

Proceedings

INTER-NOISE 95, the 1995 International Congress on Noise Control Engineering, was held in Newport Beach, California on 1995 July 10-12. More than 700 Engineers attended the three-day Congress which had as its theme *Applications of Noise Engineering.* The two-volume set of Congress Proceedings contains more than 1500 pages, is available for US$150 (plus US$55 for overseas airmail).

ACTIVE 95, the 1995 International Symposium on Active Control of Sound and Vibration, was held in Newport Beach, California, USA on 1995 July 6-8. More than 325 Engineers and others interested in active control of sound and vibration attended the three-day meeting. The hardcover book contains the papers presented at the Symposium, and each paper averages more than 10 pages in length. These full-length papers make a valuable contribution to the state of the technology in active control of sound and vibration. The Proceedings is available for US$135 (plus US$50 for overseas airmail).

Orders and Payments to: Noise Control Foundation, PO Box 2469 Arlington Branch, Poughkeepsie, NY 12603, USA.

Internet Supplies

LABLINK is a new approach to researching and ordering scientific products. Until now, if you wanted to see who stocked disposables or other laboratory equipment, you had to flick through dozens of bulky catalogues. You can also read suppliers' magazines and flick through company brochures. If you're an experienced Internet user, go straight to http://www.science.com.au for on-screen help.

RION Agency

Acoustic Research Laboratories is happy to announce they now represent RION instruments in Australia. Backup support and service of these instruments will be carried out in their Thornleigh office. See advert in this issue for your nearest representative.

B&K and SDRC

To further strengthen Bruel & Kjaer's position as a supplier of turnkey system solutions, a close working co-operation has recently been established with Structural Dynamics Research Corporation (SDRC®), a leading international supplier of mechanical design automation, testing and product data management software. SDRC has assigned B&K distribution rights for IDEAS Sound Quality Engineering™ Software and related software support. By entering into agreements with companies such as SDFC, B&K is now in a position to offer a complete range of sound quality system solutions ranging from binaural recording systems to state-of-the-art editing and metrics software and high quality headphone playback.

B&K Training Seminars

Due to the large number of new users for the B&K Sound Level Meters, they have commenced regular training sessions. To begin with, these will be held in Sydney and Brisbane. *Further details: B&K , 24 Tepko Rd, Terrey Hills, NSW, tel 02 450 2066 fax 02 450 2379*

Wilcoxon Agent

ETMC Technologies have become Australian Agents for WILCOXON RESEARCH of Gaithersburg Maryland USA, for their range of vibration equipment. This range includes vibration transducers, hydrophones, shakers and associated amplifiers, power supplies, cables, connectors, and mounting hardware plus underwater models as well as intrinsically safe units. *Further information: ETMC Technologies, 3 Montague St, Balmain, NSW 2041, tel 02 555 1225 fax 02 810 4022*

ERM

ERM Mitchell McCotter have announced the opening of a Melbourne Office, headed by **Graeme Dickson**, Regional Manager Victoria. Graeme has a background in project management and negotiation of all types of development approvals including the commercial and industrial sectors and the petroleum industry. He will be offering the full range of ERM Mitchell McCotter services to clients in Victoria and can be contacted on 03 9650 5200. Also ERM are now able to offer Risk Assessment and Management services in association with ERM Four Elements, ERM's internationally recognised specialist risk company. **Praneet Mehra** will be responsible for the area and is located in the Sydney office.

Courses in Turkey

There are various courses being organised by the Turkish Acoustical Society in conjunction with ISVR, University of Southampton. In May the topics will be Muffler Design and Principles of Active Control. For details of these and future courses: Cuneyt Ozturk, TEE AS R&D, Davutpasa, Litros Yolu, Topkapi 34020, Istanbul, Turkey Fax + 90 212 5442256

ABB Fans

The formation of ASEA and Brown Brown into ABB has combined the strengths of two large organisations into a single engineering based company that is capable of designing and offering any technical solution. That formation brought together a vast number of small specialised companies, each with their own infrastructures. In the next step to better serve markets, ABB Fans and ABB Industrial Systems Pty. Limited. ABB Fans has now become a division of ABB Industrial Pty. Limited. *Further information: ABB Fans, 50 Bertie Street, Port Melbourne, Vic. 3207, Australia. tel 03 9248 8500 fax 03 9248 8686*

Acoustics Centre in WA

A Centre of Acoustics, Dynamics and Vibration (CADV) has been set up within the Department of Mechanical and Materials Engineering at The University of Western Australia. The primary objectives of the Centre are to actively undertake collaborative contact research, to encourage postgraduate research, to act as a focal point for the advancement of acoustics, dynamics and vibration in the region, to manage short courses and conferences, and to undertake collaborative research and teaching exchange with overseas affiliates. Current industrial partners in the centre are BHP Engineering, Lynx Engineering, SVT Engineering Consultants, and Worley Engineering. The Director of the Centre is Associate Professor Michael P. Norton, University of Western Australia, Nedlands, WA 6009 email mpn@uwa.edu.au.

INTERNOISE 96

Planning is proceeding well for INTER-NOISE 96, 30 July to 2 August, to be held at Britannia Adelphi Hotel in Liverpool, UK. Over 850 offers of papers have been accepted for inclusion in the Formal and Poster sessions of the Congress. This means ten parallel sessions running continuously throughout the three main days. An innovation this year is the inclusion of a Summaries Handbook. This will be in A4 format and each first-named author has been asked to submit 100 words to indicate the sort of things delegates will hear about – the Congress Proceedings may be a little heavy for delegates to carry around with them! There will also be a technical exhibition and a comprehensive social program including Conference Dinner and a Jacobean Banquet. The registration brochures are now available. *Further information: Institute of Acoustics, 5 Holywell Hill, St Albans AL1 1EU, UK tel +44 1727 848195 fax +44 1727 850553 email Acoustics@clus1.ulcc.ac.uk*

New Products...

CEL

Sound Level Analysers

The CEL 573 and 593 Real-Time Analysers provide flexibility, speed and real-time measurement power. Equipped with the processing capacity equivalent to multiple lap-top computers, these compact, hand held instruments make dramatic improvements in operational efficiency by reducing the time taken to measure and evaluate noise problems. The analysers offer users the choice of "Front-End" modules, functional software and interfaces which means that an instrument can be specified to suit applications or budgets. Each can also be specified to include octave band, or octave and third octave analysis modes and each is available in either Type 1 or Type 2 versions. The CEL-593 adds time history profile, additional period times and event data to the features found in the CEL-573.

Building Acoustics

The CEL Building Acoustics system takes reverberation time and transmission loss measurements in buildings into a new era. The processing power and speed of a CEL analyzer, the core of the system, gives the operator the kind of freedom and flexibility in a hand held instrument that would normally only be associated with much larger and heavier laboratory equipment. The application is easily and quickly installed in any of the CEL-573 models as no hardware changes or accessories are needed. The only other main requirement for a complete building acoustics system is the noise source. The analyzer also has the ability to be powered by mains or battery power. A remote radio link is available to trigger the noise source which eliminates the problems that long cable connections can present.

Further information: Hearing Conservation Services of Australia Pty Ltd, 139 Ormond Road, Elwood, Vic. 3184, tel 03 9531 8911 fax 03 9525 6155

BRUEL & KJAER

Proximity Probe

Proximity probes are the 'finger-tips' of machine condition monitoring and protection systems, providing vital information for both machine operation and maintenance. They measure shaft vibration and shaft position on industrial machinery and, until now, their operation has depended upon the type of the shaft material to be measured. UniProbeTM "breaks-through" this limitation, as it uses both the amplitude and the phase information to produce an output voltage that is independent of the target material. The UniProbe driver is insensitive to variations in capacitance due to changes in cable length. It is also fully EMC compliant with the major European and US Standards.

Microphone Preamplifier

The new FalconTM Range 1/4-inch Microphone Preamplifier Type 2670 provides additional state-of-the-art technology and functionality. The built-in Charge Injection Calibration is highly sensitive to the condition of the microphone and so provides a convenient verification of the entire measurement set-up. It has excellent phase linearity, which is designed to have an optimised phase characteristic for intensity measurements. The 2670 offers a very flat low-frequency amplitude response, so avoiding 'gain peaking' when making low frequency measurements.

Positioning System

Automatic positioning and scanning of the sound intensity probe can now be done by using Microphone Positioning System Type 9664. Noise Source Location Software Version 1.10 now includes a generic robot driver and a point-table that contains information about the robot position and the name of the relevant analyzer-file for each measurement direction at each measurement point. The automated microphone positioning option will not only increase the cost-effectiveness and the repeatability of measurements, but allow for measurements in environments where access is impossible for humans.

Further Information: Bruel & Kjaer Aust. PO Box 177, Terrey Hills, NSW 2084 tel 02 450 2066 fax 02 450 2379.

KINGDOM

PCMCIA FFT Analyser

ACE is the fastest, smallest PCMCIA FFT analyser and will fit inside a notebook PC. The result is a laboratory standard FFT Analysis instrument capable of refined measurements, data acquisition and report preparation literally anywhere. ACE squeezes two input and two output channels on a| PCMCIA card with 20 KHz real time tri-spectrum average (cross spectrum and both auto spectra) with multiple bandwidth steps and a dynamic range in excess of 100 dB. It provides a true 32 bit WINDOWS95 analyser including a full 32 bit 50 Mhz floating point DSP processor. A full array of measurements are provided including Power Spectrum Density, Frequency Response Function, Coherence, Correlation, Real time Zoom, Disk Throughput, Replay Analysis and Disk Playback. With additional memory, ACE can be used for frequency spectra with up to 50,000 lines or for high performance Rapid Waterfalls storing up to 125 scan of 900 lines.

Further information: Kingdom Pty Ltd, PO Box 75, Frenchs Forest, NSW 2086 tel 02 9975 3272

NORSONIC

Building Acoustics

By implementing the Maximum-Length-Sequence (MLS) measurement technique in a user-friendly real-time analyser, Norsonic has overcome many of the problems for in-situ measurements of sound insulation and reverberation time. The combination of the Real-Time Analyser type 840 and the MLS measurement technique brings new important features to help. The MLS technique overcomes the problem of external impulsive noise, of insufficient noise energy from source loudspeakers and of measuring very short RTs. Facade insulation may be measured without a cable connected between the noise source and the measuring instrument. The RTA 840 and its option 7 MLS combined with the internal PC with the Windows based NOR-SIC post processing software, is a powerful single instrument for in-situ building acoustic measurements.

Further information: ETMC Technologies, 3 Montague St., Balmain NSW 2041 tel 02 555 1225, fax 02 810 4022

PCB

Vibration Calibrator

The PCB model 394B06 is an ideal tool for carrying out quick checks on the calibration of accelerometers. It gives a controlled vibration level for verifying sensors weighing up to 85 gm. Battery powered, this electromagnetic exciter has a built-in reference accelerometer to maintain a constant 1.0g rms amplitude at a fixed frequency of 79.6 Hz.

Further information: MB & KJ Davidson Pty Ltd, 17 Roberna Street, Moorabbin Vic 3189 tel 03 9555 7277 fax 03 9555 7956. email info@davidson.com.au

SNAP-TEX

Fabric Mounting

The Snap-tex acoustical Fabric Mounting for walls and ceilings has gained wide acceptance by the architectural, design and acoustics communities for combining measurable noise reduction with the aesthetic qualities of fabric panels on walls and ceilings. The system comprises of the track, a PVC extrusion with patented locking jaw, flexible hinge and adhesive strip to align fabric before setting into the jaw for perfect tension. These three features combine to eliminate fabric creep and sagging, as well as effecting significant savings on installation cost.

For further information: 17 Fencourt Avenue, Roseville NSW 2069 tel 02 415 3541, 1800 634 676 fax 02 411 4553

AAS CONFERENCE

The 1996 Conference will be held in Brisbane from 13-15 November at the Novotel Brisbane Hotel which is located in the heart of Brisbane. The papers will be presented in parallel technical sessions from Wednesday through to Friday. A technical exhibition will be open for the duration of the conference for manufacturers and suppliers to show and demonstrate their latest products.

The **Presidents Prize** will be awarded for the best paper presented by an AAS member.

The **Excellence in Acoustics Awards** will be made on entries from around Australia.

An information brochure is included as an insert in this journal.

For further information contact: Ross Palmer tel 07 3279 3745 fax 07 3376 2360.

New Members...

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

N.S.W.

Member: Prof. J Wolfe, Mr F Weatherall, Mr P Banks, Mr R Roper, Mr S Suine, Dr H Williamson

Associate: Mr J Basset, Mr K Williams

Subscriber: Mr W Oosterhuis, Mr N Koikas, Mr P Thomas

Student: Mr S Demasi, Mr P Conroy, Mr R Mohajeri

QLD

Member: Ms G Adams, Mrs C Richardson

Subscriber: Mr M Lanchester, Mr W Wright, Mr S Carter, Mr R Hunt

S.A.

Subscriber: Mr S Kanev

Letters...

Further to the Australian Acoustical Society Conference held in Fremantle during November, 1995, on Acoustics Applied, at which the paper, "Appropriate Standards" was presented, outlining the need for a Standard for the method of measurement of noise from LARGE earth moving machines, a questionnaire has been prepared on the subject to assist those interested in the design of the Standard.

We are hopeful that, in addition to Acoustical Society members, the Environmental Section of the open-cut Mining Industry and suppliers of LARGE earth moving machinery will take up this Questionnaire and, by their response, give us the opportunity to provide a workable Standard of general agreement. Copies of the Questionnaire are available to all interested persons from: *Caleb Smith Consulting Pty Ltd, PO Box 306, Toronto, NSW 2283, tel 049 505 833 fax 049 504 276.*

Courses...

1996

May 9-10, Sydney
B&K Noise at Work Training Course
Details: B&K, PO Box 177, Terrey Hills NSW 2084,
Tel: 02 450 2066 Fax: 02 450 2379

15 July, CANBERRA
Noise and the Acoustic Environment
Details: John Bromilow, CIT, PO Box 226, Jamison, ACT 2614, Tel: 06 207 4444; Fax 06 207 4343; john-bromilow@cit.act.edu.au

Dec 3-5, CANBERRA
Machinery Vibration: Cond Monitoring & Vib Isolation
Details: Acoustics & Vibration Centre, School of Aerospace & Mechanical Eng, Australian Defence Academy, Canberra ACT 2600, Tel: 06 268 8241 Fax: 06 268 8276, avu@adfa.oz.au

Multisensor Data Fusion (21-23 May),
Multiple Target Tracking (in Melbourne11-13 June), Pattern Recognition (25-27 June), Adaptive Signal Processing (in Melbourne 2-4 July), Introductory Signal Processing (29-31 July), Advanced Signal Processing
(1-2 August), Multisensor Data Fusion or Bayesian Methods (24-26 September), Wavelet Transforms (1-3 October), Digital Image Processing and Target Recognition (12-14 November), Sonar Signal Processing (3-5 December)
Details: Mary Ayre, Continuing Education Manager, Cooperative Centre for Sensor Signal & Information Processing (CSSIP), SPRI Building, Technology Park Adelaide, SA 5095 Tel: 08 302 3928 Fax: 08 302 3124 mayre@postoffice.cssip.edu.au

Various Times and Cities.
Media and Presentation Skills for Scientists,
Details: Econnect, PO Box 464, Paddington, QLD 4064. Tel: 07 3367 2646 Fax: 07 3217 6376; jenni.econnect@bozz.aone.net.au

Diary...

CONFERENCES and SEMINARS

* Indicates an Australian Activity

1996

January 10-11, SINGAPORE
Annual Meeting, Society of Acoustics
Details: Dr W S Gan, c/o Acoustical Services Pty Ltd, 209-212 Innovation Centre, NTU, Nanyang Ave, Singapore 2263, Fax +65 791 3665, Tel +65 791 3242

May 13-17, INDIANAPOLIS
131st Meeting Acoustical Soc of America
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, USA.
Fax +1 516 576 2377, email elaine@aip.org

May 20-23, LONDON
Low Frequency Noise
Details: Dr G. Leventhall, Stewart House, Brookway, Leatherhead, Surrey KT22 7NA, UK

May 21-24, AUTRANS
4th Speech Production Seminar
Details: ICP-INPG, 46 ave Felix Viallet, 38031 Grenoble cedex 01, France. Fax +33 76 57 47 10, email etrwspm@icp.grenet.fr

May 23-25, MOSCOW
Acoustical Measurements
Details: Russian Acoustical Society, 4 Shvernik St, Moscow 117036 Russia, Fax +7 095 126 8411

May 27-31, MOSCOW
Intl Symposium on Acoustic Remote Sensing of the Atmosphere and Oceans.
Details: Secretariat ISARS'96, 3 Pyzevsky Line, Moscow, 109017 Russia. Fax +7 095 233 1652, email postmaster@iaph.msk.su

May 28-31, PISA
Noise and Planning '96
International Conference on Acoustics applied to planning: from technical standards to environmental standards
Details: Guido Lombardi, via Bragadino 2, 20144 Milano, Italy. Tel +39 2 48018833, Fax +39 2 48018839

June 16-20, BARI
13th Intl Congress of Audiology
Details: Audiology and Otology Centre, University of Bari, 70124 Bari, Italy.
Fax +358 460224, email nam96@hut.fi

June 17-21, NANJING
14th International Symposium on Nonlinear Acoustics
Details: Ronjue Wei, Nanjing University, Institute of Acoustics, Nanjing 210008, China. Fax +86 25 360 5557, email postndi@nju.edu.cn

June 24-28, HERAKLION, CRETE
3rd European Conference on Underwater Acoustics
Details: J S Papdakis, Foundation for Research & Technology, PO Box 1527, 711 10, Heraklion, Crete, Greece.
Tel +30 81 210034, Fax +30 81 238868, email conference@iesl.forth.gr

June 24-28, ST PETERSBURG
4th Int Congress on Sound & Vibration
Details: M Crocker, Mech Eng Dept, 201 Ross Hall, Auburn Uni, Auburn, AL 36849-3501, USA. Tel 334 844 3310, Fax 334 844 3306. email mcrocker@eng.auburn.edu

Jul 16-18: SHEFFIELD, UK.
Condition Monitoring & Diagnostic Eng. 96
Details: Dept Mech & Process Eng. Uni of Sheffield, Mappin St, Sheffield S1 3JD, UK.
Tel: +44 1142 825 169
Fax: +44 1142 753 671

July 30-August 2, LIVERPOOL
INTERNOISE 96
25th Anniversary Congress
Noise - The Next 25 Years
Details: Institute of Acoustics, Agriculture House, 5 Holywell Hill, St Albans, Herts AL1 1EU, UK. Tel +44 727 848195, Fax +44 727 850553

September 2-6, CHRISTCHURCH
ROADS 96 - Joint Aust/NZ Conference
Details: ARRB Transport Research, 500 Burwood Hwy., Vermont Sth, Vic 3133.
Tel +61 3 9881 1555, Fax +61 3 9887 8104

September 9-12: OXFORD, UK
Vibrations in Rotating Machinery
Contact: 1 MECH E, 1 Birdcage Walk, London SW1H 9JJ, UK Tel: +44 171 973 1249 Fax: +44 171 222 9881.

September 18-20, LEUVEN
Noise & Vibration Engineering Conference
Details: L Notre, K.U. Leuven-PMA, Celestijnenlaan 300B, 3001 Heverlee, Belgium. Fax +32 16 32 29 87, email lieve.notre@mech.kuleuven.ac.be

September 23-25, ST PETERSBURG
FASE Symposium: Transport Noise
Details: FASE Secretary, K.U. Leuven-ATF, Celestijnenlaan 200D, 3001 Leuven, Belgium. Fax: +32 16 32 79 84, email jan.thoen@fys.kuleuven.ac.be

September 29-October 2, BELLEVUE
NOISE-CON 96
Visions for the Next 25 Years
Details: NOISE-CON96 Conference Secretariat, Engineering Professional Programs, 3201 Fremont Avenue N., Seattle, WA 98103. Tel +1 206 543 5539, Fax +1 206 543 2352

October 3-6, PHILADELPHIA
4th Conf. Spoken Language Process
Details: ICSLP96, Sci & Eng Labs, AI du Pont Institute, PO Box 269, Wilmington, DE 19899 USA, Fax +1 302 651 6895, email ICSLP96@asel.udel.edu

November 3-6, SAN ANTONIO
1996 IEEE Intl Ultrasonics Symposium
Details: J S Schoenwald, Rockwell International Science Center, Mail Code A9, 1049 Camono dos Rios, Thousand Oaks, CA 91358, USA. Fax +1 805 373 4810

November 13-15, BRISBANE
*1996 AAS Conference
Making Ends Meet. Innovat. & Legislation
Details: Ross Palmer, Tel 07 3806 7522, Fax 07 3806 7999

December 2-6, HONOLULU
3rd Joint Meeting of the Acoustical Society of Japan and the Acoust Society of America
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, USA.
Fax +1 516 576 2377, email elaine@aip.org

1997

April 21-24, MUNICH
International Conference Acoustic, Speech & Signal Processing
Details: H. Fastl, Technical University Munich, 80290 Munchen, Germany.
Fax: + 49 892 105 8535, fas@mmk.e-technik.tu.muenchen.de

August 19-22, NEW ZEALAND
Diennial Conference - New Zealand Acoustical Society
Details: NZ Acoustical Society, PO Box 1181, Auckland, NZ

August 25-27, BUDAPEST
INTERNOISE 97
Details: OPAKFI, H-1027, Budapest FO U68 Hugary, Tel/Fax: +36 1202 0452

1998

June 20-28, SEATTLE
16th International Conference Acoustic
Details: Applied Physics Lab, University Washington, 1013 NE 40th St, Seattle 98105-6698 USA

November 16-18, CHRISTCHURCH
INTERNOISE 98
Details: NZ Acoustical Society, PO Box 1181, Auckland, New Zealand

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* Notification of change of address
* Payment of annual subscription
* Proceedings of annual conferences

General Secretary
AAS– Professional Centre of Australia
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Tel/Fax (03) 9887 9400
email: watkins@popa.melbpc.org.au

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email D.Eager@uts.edu.au

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email: CQHOWARD@edison.aelmg.adelaide.edu.au

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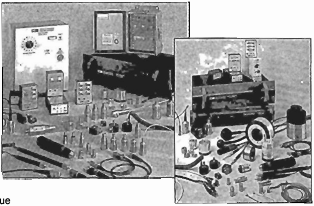

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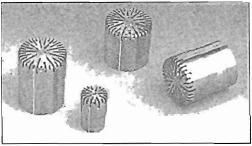

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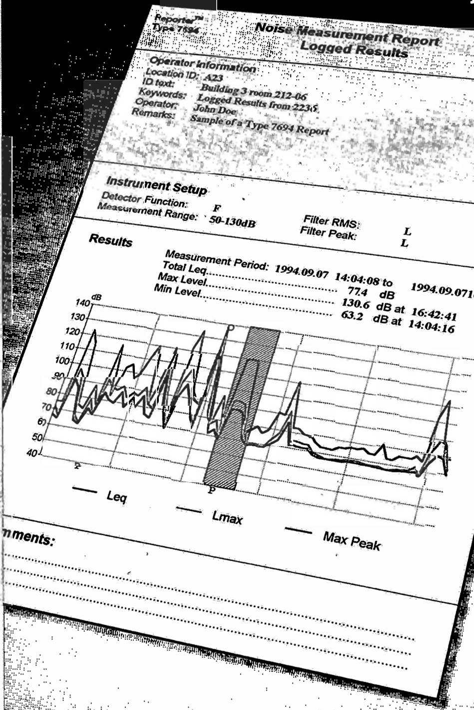


Reporter™ Type 7694

Noise Measurement Report
Logged Results

Brüel Kjær

Operator Information

Location ID: A23
ID text: Building 3 room 212-06
Keywords: Logged Results from 2236
Operator: John Doe
Remarks: Sample of a Type 7694 Report

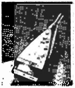
Instrument Setup

Detector Function: F
Measurement Range: 50-130dB
Filter RMS: L
Filter Peak: L

Results

Measurement Period: 1994.09.07 14:04:08 to 1994.09.0716:43:27
Total Leq.................................... 77.4 dB
Max Level.................................... 130.6 dB at 16:42:41
Min Level.................................... 63.2 dB at 14:04:16

Comments:



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