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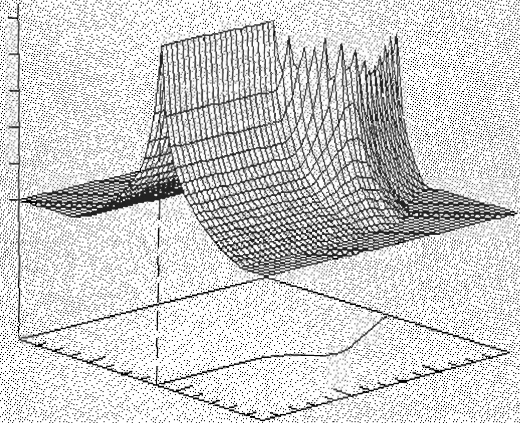

• RAIL NOISE

• ROAD TRAFFIC NOISE

Acoustics Australia

Vol. 18 No. 2 August 1990

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COVER . . .

Three dimensional noise contours generated by NOISEXPT, an expert rail noise system developed by CSIRO Division of Building Construction & Engineering, Melbourne, Australia (see article in this issue).

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See next page for all journal and Society Information

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ACT

February Meeting

On 20th February, a group of eighteen toured the Civil Aviation Authority Laboratories which have only recently been completed. **Colin Gray**, the Manager of the Measurement Laboratory, gave a short explanation in the range of investigations undertaken which have included sonic boom measurements, noise certification tests and follow up of complaints.

The group were then taken on a tour of the various areas and Colin was assisted by **Bob Lam** who conducted one group. The storage and retrieval of data is vitally important to a calibration laboratory, so this information is filed in the Data Storage Room which is located adjacent to the Data Analysis Room. Here the procedure for digital storage of the acoustic data for an aircraft flyover and subsequent determination of the descriptors, EPNL etc, were explained.

The reverberation time of the room, which can be used for tests on the intelligibility of signals, can be changed by the placement of curtains and floor covering. A tape which highlighted the difficulties in understanding speech with a translation error of approx 300 Hz and for an AM transmission with high background noise was played. The Anechoic Chamber, with internal dimensions of the order of 3.5m, is available for investigations requiring such a controlled acoustic environment.

The other areas visited included the screened RF Room, the Electrical and Acoustic Calibration Rooms as well as the Electrical and Acoustic Standards Rooms.

The group was then taken to the special acoustic room in the Communications section. **Max Peace** explained the use of the room for testing broadcast systems. **Eric Taylor**, who was consultant for the acoustic design of the room, summarised the criteria for which the room was designed and described the various types of absorbers which were used to obtain the required reverberation time over the frequency range.

The tour was most interesting and showed the range of work undertaken by the staff at the Laboratory. Over half the group enjoyed a Thai Banquet at a nearby restaurant after the meeting.

April Meeting

Twenty people attended a **Discussion on the ACT Noise Control Act** on 2 April. The ACT Noise Control Ordinance was introduced in November 1988 and, following self government for the ACT, the name was changed to Noise Control Act. The stated intention, at the time of introduction of the Ordinance, was that there would be a review after a twelve month period. This meeting formed one part of this review process and provided the opportunity for all those interested in the area of environmental noise in the ACT to discuss issues related to the Noise Control Act.

Hugh Crawley, the Pollution Control Authority for the ACT, commenced the discussion with a review of the environmental noise aspects of the Act. He advised that the Manual was in the process of being gazetted and should be available within a few weeks. **George Knight**, Officer in Charge of Policy, from the Environment Protection Section, then outlined some of the areas of the Act which, in the light of the experience, needed particular attention during the review. In the vehicle noise area, these included noisy items on vehicles (eg garbage trucks), and extension of the provisions to deal with noise from trains and aircraft, especially helicopters. Problems had been experienced with use of the assessment of annoyance related to background noise levels, particularly when there were special characteristics for the sound.

Ron Manly, Senior Technical Officer, reported that the major number of complaints had been related to amplified sound (> 40%). Following receipt of complaints, it was now general policy to measure the noise. The negotiation was considered to be important and not a lot of Notices had been issued. The officers had to consider that noise may just be one issue in neighbours disputes and in some instances people had unreal expectations of a quiet life in suburban areas.

In the general discussion, some legislative aspects of Acts in the ACT were identified as limiting the extent of the review. In particular this related to the lack of discretionary powers which meant that assessment of annoyance could not be based on consideration of audibility of noise. More cooperation between ACT Government Departments would assist in resolving problems efficiently or perhaps dealing with potential noise problems at the planning stage.

It was agreed that the Society could play a role in encouraging the Government to undertake the review and implement the recommendations as soon as possible. The discussions continued during dinner at a nearby Club.

Marion Burgess

SA

March Technical Meeting

On 14 March **John Lambert**, Manager of the Noise Abatement Branch, Dept. of Environment and Planning spoke on "Annoyance from Noise".

In two recent surveys it was identified that noise is the single most annoying factor that concerns people in the community. Noises ranged from barking dogs to road traffic and aircraft. Despite this do we really understand what noise is and how it differs from sounds that are not noisy?

In almost every text book on acoustics, noise is defined as "unwanted sound". However, the apparent simplicity of this definition is deceiving. The factors that make one sound enjoyable and another unwanted are complex, and vary not only with the volume and characteristics of the the noise, but also with the physical and psychological condition of the person listening. Some of the relevant factors are the mood of the individual, identification with the sound, particular needs (e.g. sleep), existing level of stress and physical conditions such as tinitus or recruitment.

John discussed some of the wide range of factors that cause a noise to be annoying to individuals. He also spoke at the methods applied in legislation that attempt to describe the subjective nature of noise. Included in this discussion was some of the methods being considered for inclusion in the proposed amendments to the SA Noise Control Act which is likely to be amended in the early part of 1990.

May Technical Meeting

Adrian Jones spoke on "Automotive Muffler Design" on 30 May.

The design of mufflers for motor vehicles has traditionally been trial and error based. This is still true of much of the vehicle exhaust industry. Recently, computer-based models have been developed for use in the acoustical gas dynamic segments of exhaust system design. These computer models are generally based on a linear acoustic analysis of the pulsating gas flow in the exhaust system and sound radiation at the tailpipe outlet. The use of one such model is described.

In using the computer model, the insertion loss or muffling effect caused by making a particular change to any part of the complete exhaust system may be predicted. Also an estimate may be made of the absolute level of the noise spectrum radiated by an engine with a particular exhaust system. As comparisons between calculations and measurements from complete vehicle tests show, accuracy is very good and is adequate for design purposes.

David Bies

QLD

Technical Meetings

On 28 February the meeting commenced with dinner at the City Rovers Restaurant which was followed by a visit to Central Plaza 2. **Ron Rumble** and **Ross Palmer** led an examination of some "Innovative acoustic designs in the air-conditioning and emergency generator plant rooms".

A demonstration and presentation on the Bruel & Kjaer Real Time Frequency Analyser, type 2321, was given by **Roger Upton** on 29 March. Roger is from the Acoustics Research Division of Bruel & Kjaer in Denmark.

A discussion on prediction of noise from industrial air conditioners was held on 4 April. It was led by **Terry Connolly**, President of the Qld Air Conditioning Specialists Association and **Warren Renew**, Senior Environmental Officer, Qld Division of Environment.

Warren Middleton

VICTORIA

April and June Meetings

On 9 April, **Mike Gregory** from G.P. Embelton and Co spoke on the design and construction of suspended floor systems.

The June Technical Meeting was held at the CSIRO Division of Building, Construction and Engineering, Highett on 7 June 1990. **Ian Shepherd** spoke on the development of active control for reduction of noise in air handling systems. Active control is similar in principal to active attenuation but applies a small amount of sound power close to the source of the noise, thereby cancelling the noise generation mechanism before large sound powers are developed. In active attenuation, sound power is directed to cancel a noise that is already fully developed and hence often requires large amounts of power.

The talk was followed by a tour of the air flow laboratory where active control and acoustic modelling were demonstrated. The group then split in two to visit either the large air flow rig or the acoustic chambers.

Mike Snell

INCE

At the Annual Meeting of the Institute of Noise Control Engineering (INCE) in Newport Beach, California on 1989 December 03, four new INCE Directors were elected to serve for a three-year term. **William J. Cavanaugh, Robert Hickling, David Lubman** and **Knut S. Nordby** were elected to the Board.

At the Annual Meeting of the INCE Board of Directors, also held on December 03, the Board elected **Nancy S. Timmerman** of MASSPORT in Boston, Massachusetts as President-Elect. She previously served INCE as Vice President for Technical Activities and as Vice President for Membership. She will become President in 1991. **Raymond Cohen**, Professor of Mechanical Engineering at Purdue University was Executive Vice President in 1989 and became the 1990 INCE President. **Stephen I. Roth** of the Aluminium Company of America was re-elected as Secretary, and **James G. Seebold** of Chevron was re-elected as Treasurer.

The Proceedings of **INTER-NOISE 89**, held in California, USA, are now available. They include 262 papers and two distinguished lectures: "Criteria for Controlling Noise and Vibration" by Leo L. Beranek, one of the founding partners of Bolt Beranek and Newman, Inc., and "Noise Control Applications of Sound Intensity" by Jiri Tichy, head of the graduate program in acoustics at The Pennsylvania State University.

Copies of the INTER-NOISE 89 Proceedings are available from Noise Control Foundation. The two-volume set of proceedings contains 1312 technical pages, and is available for US$100.00. Shipped postpaid except that overseas orders must add US$45.00 if shipment overseas is to be by air. Payment must be in U.S. Funds on a U.S. bank or a bank that has a correspondent relationship in the United States. Order from Noise Control Foundation, P.O. Box 2469 Arlington Branch, Poughkeepsie, NY 12603, USA.

NOISE-INDUCED HEARING LOSS — PREVENTION AND REHABILITATION

Worksafe Australia and the University of New England will jointly convene a one day seminar series on the above topic in November 1990.

The speakers will be **Dr Louise Getty** and **Dr Raymond Hetu** (Acoustics Group, Montreal University), **Dr Bill Noble** (University of New England) and **Dr Dick Waugh** (Worksafe Australia).

The seminars will present the results of recent research into psychological and social factors related to hearing impairment and their implications for prevention and rehabilitation programs for noise-induced hearing loss. They will also feature the national strategy and information materials being developed by Worksafe Australia for the prevention of occupational noise-induced hearing loss.

It is planned to hold seminars in Brisbane, northern NSW, Newcastle, Sydney, Melbourne, Adelaide and Perth.

To receive a brochure please telephone (067) 73 2788, fax (067) 73 3204 or write to Hearing Seminars, Department of Continuing Education, The University of New England, Armidale, N.S.W. 2351.

The Victorian Occupational Health and Safety Commission has released their draft Noise Control/Hearing Conservation Regulations and Code of Practice. The Commission closed public comment on the draft on 15th June 1990. Following consideration of public comment and any necessary amendments, it is expected that a final recommendation will be made to the Minister of the Department of Labour, Victoria. The anticipated commencement date for the regulations and code of practice is 1 January 1991.

Perhaps the most significant aspect of the draft is the proposal that from 1 July 1997, engineering design to ensure noise exposure does not exceed an L_{Aeq8} of 85 dB(A) be enforced.

NSW

Technical Meeting

Don Woolford spoke to the June Technical Meeting on the apparent paradox that many musicians whose hearing by normal standards would be considered significantly impaired are still able to perform acceptably, even outstandingly.

Many studies have shown that professional musicians quite commonly have noticeably impaired hearing, sometimes to the extent of 40dB loss at 250Hz. As with other occupations, it is usually difficult to assign a cause of loss with great confidence, though there appears to be little doubt that some of it is due to the occupational hazard of long exposure to high sound levels. Despite their hearing losses, these musicians carry on their profession in a manner judged satisfactory by their colleagues and the public, yet if the ordinary industrial criteria were applied, many of them would become Workers' Compensation cases — a fate which most do not want and a prospect which leads to a certain reticence in discussing the problem.

The speaker did not claim to have an explanation for the phenomenon. As he pointed out, however, the industrial criteria were developed in relation to speech impairment. In the musical situation, the hearing loss may be masked by the operation of other brain functions. Musically important harmonics may fall in a frequency range where hearing loss is less marked. Whatever the explanation, it is clear that the insensitive application of 'objective' hearing loss criteria to musicians will lead to manifestly unjust results when compared with the subjective assessments of their peers.

People

New Members

• Interim Admissions

We have pleasure in welcoming the following who have been admitted to the grade of Subscriber while awaiting grading by the Council Standing Committee on Membership.

New South Wales
Mr L W Mar, Mr K Mikl, Mrs N M Murray, Mr M P Potocki.
South Australia
Mr A C Zander
Victoria
Mr D J Dolly, Mr N A J Goddard

• Graded

We welcome the following new members whose gradings have now been approved.

Student
Victoria
Mr J A Grant, Mr C P Huybregts

Subscriber
Western Australia
Mr T C Reynolds

Member
New South Wales
Mr J C Gray (ACT), Mr G Jenner, Mr M M Poon, Mr G Tanos, Mr Q Wu
South Australia
Mr P A Heinze, Dr J Pan
Victoria
Mr D M Edwards, Mr M Padalini

* * *

NEW JOURNAL EDITOR

Neville Fletcher has been appointed to the Advisory Board of "Acustica" and to the Editorial Board of "Applied Acoustics". These two well-known journals cover rather different aspects of the subject. Applied Acoustics, as its name implies, is concerned with practical applications of acoustics, and papers should be written with a readership of practical acousticians and engineers in mind. Acustica publishes papers on all branches of the subject, including those with high mathematical content. Neville has no role in accepting papers for publication, but would be happy to provide advice to intending authors of either journal and to pass on reader's comments to the journal management. His address is Department of Electronic Materials Engineering, Australian National University, Canberra 2601. Phone: (06) 249 4406.

OBITUARY
Alec Clemson CLUTTERBUCK 1920-90

Alec grew up on a small farm in the Kiewa Valley and was a motor mechanic's offsider when war broke out. He promptly joined up with the RAAF as ground crew and had gained his 'wings' as a pilot in Canada. As a returned serviceman he commenced a part-time rehabilitation course (for the Communications Engineering Diploma) while working as a mechanic to support his young family. However, poor health prevented completion of the course but left him with a lifelong interest in higher education.

His entry into the field of acoustics came when he was appointed by Insulwool to a new position designing and selling acoustic products, especially duct silencers. He started in Melbourne (1963) and was supposed to go to Sydney to run the operation from there. As it happened, the field grew enough to support another person, and Caleb Smith filled the NSW post. Alec and Caleb became close friends.

Alec started his own firm, Applied Acoustics, in 1972. The main interest of the firm was originally design and construction of duct silencers; acoustic enclosures and booths, but gradually became directed towards background sound conditioning. Alec's pioneering spirit let him into commissioning a chip to control the output devices so that individual projects could use standard components. Ill health prevented full exploitation of this technology.

Outside of his work, he was also enthusiastic in supporting the industry as an affiliate member of the Acoustical Society. He was a driving force behind the Personal Emergency Service and often a member of his church's Board. He rediscovered his love of horses and the high country and went on roughriding trips into the bush for a week at a time.

For his last few years his health went downhill due to bone cancer, but he still gave all his interests all the time and energy he had. He passed away on 26/2/90 after three months hospitalisation.

* * *

Wendy Saunders from Gippsland Institute joins the three students, announced in last issue of Acoustics Australia, in being awarded the H. Vivian Taylor Memorial Prize for excellence in studies in the field of acoustics. Each of the recipients will receive a cash prize of $150, one years student membership to the society and a certificate.

As of 1st July 1989 **Pryce Goodale and Duncan** (Adelaide) merged with the national consulting engineering company **Bassett Consulting Engineers**. The combined Adelaide office is now referred to as **Bassett PGD Consulting Engineers**.

Several changes have also occured in the Adelaide office with Michael Pryce retiring but still acting in a consultative role to Bassett PGD. Just prior to the merger **Dr Peter Swift** was appointed a director and put in charge of the acoustics section.

Dr Peter Swift, whilst attending the 1990 Australian Acoustical Society Conference in Perth, officially opened the Bassett's Perth Office acoustical section which is headed by Perth based engineer, **Tim Reynolds**. The opening was attended by government personnel, architects and other clients.

NEWS . . .

WA
March Technical Meeting

About 17 members and friends disturbed their sleep on 22 March to attend a breakfast meeting on Sleep Disturbance! The speaker was Prof. Ragnar Rylander, from the Department of Environmental Hygiene, University of Gothenburg, Sweden. His talk on "Recent Advances in Environmental Noise Annoyance" contained an interesting dose-response relationship between extent of annoyance and number of heavy vehicles; in which the percentage of people highly annoyed increased with the number of heavy vehicles up to a point, then flattened out. This provoked some healthy debate. The breakfast format worked well, with the meal at 7.00am, and talk from 7.30-8.00am, leaving attendees time to go to work.

John Macpherson

"Interior Noise Climates"
AAS 1989/90 National Conference Perth, 19-20 April, 1990

About 75 delegates enjoyed two pleasant days at the Cottesloe Beach Resort absorbing the fine acoustical work of some twenty authors and two exceptional keynote speakers, **Prof. Harold Marshall** (New Zealand) and **Mr Louis Challis** (Sydney). Highlights included **Mike Norton** winning the inaugural President's prize, the Focus Groups and the splendid conference dinner. After the disappointment of postponing last year's conference (due to the airlines dispute), the success of this conference was sweet indeed, and this committee wishes to thank members and helpers for their support.

A full report will appear next issue.

John Macpherson

A Knowledge-based System for Rail Noise

Professor Qian Chen*, Dr John F. Brotchie, Dr Ron Sharpe and Miles Anderson
CSIRO Division of Building, Construction and Engineering
P.O. Box 56
Highett, Vic. 3190, Australia

ABSTRACT: High-speed rail systems operate in two countries whilst other countries are planning for them. The technology of knowledge-based or expert systems provides a powerful aid in resolving environmental problems such as noise from fast-rail networks which are becoming more and more attractive. In order to estimate the likely impact and to establish guidelines for noise control in fast-rail design, an expert system called NOISEXPT has been developed to assemble and extrapolate relevant sources of information, including experience from Shinkansen (Japan), Train à Grande Vitesse (TGV, France), InterCity Experimental (ICE, Germany) etc. The system is composed of five modules, including one in which more than 400 paper and book references form an extensive knowledge base. Standards from more than 10 countries and international organisations, noise source information, several prediction methods and guidelines for noise control measures can be examined in other modules.

1. INTRODUCTION

The development of knowledge-based systems is an emerging technology which has wide application in engineering. Already several acoustic projects have explored the use of expert systems. A system called CHINA (Computerised HIghway Noise Analyst) was developed by Harris et al [1] and Cohn et al [2] from the USA to estimate highway noise and to address the problem of designing highway noise barriers. It is a rule-based system written in FRANZ LISP to run on a VAX 11/780 computer using an inference engine called GENIE. Fung Fai [3] in Hong Kong and Yanagida et al [4] in Japan have investigated knowledge-based systems for room acoustics. The latter involved a conceptual design for an acoustic field simulator and an expert system for auditorium acoustics (ARDEX) and was developed in Prolog and FORTRAN to run on a mini-computer (DG MV/7800 XP). Fung Fai reports that a demonstration prototype using Prolog has been developed but no technical details are given. In the USA, another expert system called SKUA has been developed by Stanford University [5] to interpret vibration data for the acoustical analysis of machinery.

A Very Fast Train (VFT) system is planned to travel from Sydney to Melbourne (via Canberra) with one of the highest operating speeds in the world — 350 km/h. Train noise output is usually considered to be proportional to the third power of the speed and, hence, the noise issue must be closely examined by all concerned in the project. After decades of effort in reducing railway noise, considerable expertise has been developed to ensure that high-speed trains can be acceptable and sometimes quieter than the conventional low-speed trains. A knowledge-based system, called NOISEXPT, has been developed in CSIRO and includes five modules as follows:

- **Standard.** This explores acceptable train noise tolerance levels for the community based on synthesis of the existing relevant regulations and standards, especially the ones for fast rail, from various countries and international organisations.
- **Source.** Component noise sources and their characteristics can be examined to see the effects of various parameters on noise emission so that possible noise countermeasures can be derived.
- **Prediction.** This provides several prediction methods for noise impact on the environment and includes a graphics package enabling noise contours to be drawn which take into account noise propagation corrections such as ground effect, screen effect, view angle correction, track condition effects and so on.
- **Control.** This provides advice for noise control engineering design based on cost-efficient, user-optional and feedback concepts.
- **Reference.** This provides ready access to an extensive literature on railway noise.

Figure 1 shows the structure of the system indicating the relationship between these modules.

Although NOISEXPT is developed mainly to meet the requirements of engineers who are interested in fast-rail noise and may have little knowledge of acoustics and lack of easy access to the small number of local and international railway noise experts, it can be used as an adviser for the conventional railways as well.

2. DEVELOPMENT ENVIRONMENT

The extent and complexity of railway noise expertise makes knowledge acquisition and representation a major problem to be resolved and this is closely coupled with the choice of a suitable expert system shell. There are now many commercial expert system shells to choose from, so many in fact that it is too time-consuming to evaluate them all before making a choice. Since extensive experience had previously been obtained using a shell called CRYSTAL in another engineering project [6], it was decided to use it in this project since it had most of the features desired. These included an ability to handle very large knowledge bases quickly on a PC, a good development environment, user-friendly displays including menus and character graphics, an ability to handle complex mathematics, and an interface to a database system as well as to Lotus files. The main shortcoming is that CRYSTAL is limited to production rule knowledge bases and does not permit frames or object-oriented programming. It is also limited to low resolution

* On leave from Beijing Municipal Institute of Labour Protection, China.

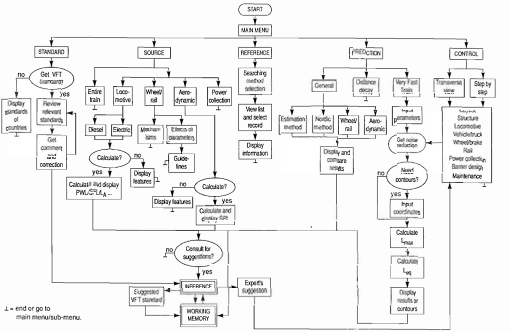

Figure 1: NOISEXPT modular structure.

graphics which are unsuitable in many applications, but this can be overcome by external higher resolution graphics, as will be seen later.

3. THE HIGH-SPEED RAIL NOISE PROBLEM

Although several hundred papers on railway noise have been published, the number of experts in this area is very few. When it comes to high-speed trains, the number is even less and there may not be any experts at all in some countries.

Acoustics is a difficult science involving complex theories. The computing and modelling of sound fields needs very powerful computers and is time-consuming. In practice, wide-ranging engineering experience is the only basis that can be used for noise control design. This usually means a lot of knowledge from different specialties has to be combined to solve a single problem. To establish a standard for environmental noise from railway traffic, disciplines such as law, psychology, statistics, medical science, and ergonomics, as well as engineering, need to be combined with acoustics so that a subjective assessment of railway noise can be developed. To control the noise from railway traffic not only requires knowledge about sound emission and propagation, but also expertise on mechanics, material science and so on.

Over $160 billion of investment in fast trains is now being planned in Europe over the next decade in addition to extensions to Shinkansen in Japan and the Los Angeles–Las Vegas and Florida trains in the USA. Recent symposiums have been held in Seoul, Taipei, Montreal and Canberra. At present, commercially available high-speed trains can be found only in Japan and France, thus limiting the availability of noise data. Even worse, noise data for TGV have seldom been published. In Germany, the InterCity Experimental (ICE) train has made great progress and 430 km of railway track is being built for it, but it will not be operating commercially until 1991. This means that some expertise on fast-rail noise can be acquired only through international exchange and through the literature.

4. SYNTHESIS OF STANDARDS

At present no international standards for acceptable noise levels for either general rail traffic or high-speed trains have been established. The railway noise assessment task facing regulation makers is very complex.

Firstly, argument about which quantity, i.e. L_{eq} or L_{max}, should be used to estimate the probable response of the community is continuing. Secondly, the variation between the proposed noise standards of different authorities in different countries is quite large. Thirdly, the variation of reactions of people at the same noise level is very large.

Some of the relevant standards have been collected and inserted into NOISEXPT. The user can interact with NOISEXPT to develop a local standard in two different ways:

- Based on the users' reactions to the existing standards:
  - Select L_{eq} as a rating quantity since this is the general trend. As railway noise is composed of a series of individual events, each of which can be measured with L_{max}, and since there is a relation between L_{eq} and L_{max}, all measures can be based on L_{eq} and then converted to L_{max} using practical data such as train speed, train number in a certain time period, train length and distance from track to receiver.
  - A subjective assessment is then made of each standard as to its suitability. There are four options to be selected: (1) accept unconditionally; (2) it is probably acceptable; (3) it may be applicable; and (4) unknown. Each option corresponds to a weight factor (w_i): 1.0, 0.8, 0.6 and 0.
  - A suggested correction (δ_i) for the standard value is then requested. These are different for each subjective judgment, as shown in Table 1.
    In the Japanese standard for extreme cases, two more types of comments are available: "it's really too low" and "it's far too low". Corrections of +8 and +10 are set up to meet these reactions.

- A weighted average of the corrected values is then recommended as the local noise standard. The equation is:

$$L_{eq} = [\Sigma w_i(L_{eq,i} + \delta_i)]/\Sigma w_i \qquad (1)$$

- Based on a weighted average of the publication year of existing fast rail standards:

  This method is used to emphasise the more recently published standards. With this approach the system suggests an averaged standard varying from L_{eq} = 64 dB(A) to L_{eq} = 69 dB(A).

5. TYPICAL NOISE SPECTRUM AND TYPICAL DISTANCE ATTENUATION

Several noise spectra from Shinkansen, TGV and ICE [7] have been included in the system. Some are shown in Figure 2. Spectra from the various high-speed systems exhibit a similar pattern, i.e. a higher level at low frequencies, a flat feature at mid-high frequencies (250-2000 Hz) and a rapid decrease at very high frequencies (4000-8000 Hz). Although discrepancies for different rail systems occur at low frequencies, an average relative spectrum can be obtained as shown in Figure 3. It is interesting that the averaged relative noise spectrum from dozens of measured spectra is similar to the TGV-A coach noise spectrum at 290 km/h (M. Mauclaire, pers. comm.). The typical spectrum adopted in NOISEXPT is shown in Table 2.

Based on these data and typical Australian meteorological and ground conditions (15°C, 70% RH, grassland), a set of regression equations for the estimation of distance attenuation has been derived to include ground effect, air absorption and geometric attenuation:

$$\Delta L = -0.6\,(d-25)^{0.6} \quad \text{if } d \leqslant 500 \text{ m} \qquad (2)$$

$$\Delta L = 55.6 - 12.9 \ln(d) \quad \text{if } d > 500 \text{ m} \qquad (3)$$

where ΔL is the noise attenuation in relation to L_{eq} at 25 m, in dB(A), due to the distance d, in m.

6. SOURCE INFORMATION

High-speed train system noise comes from power collection devices, power cars, wheel/rail interaction, train body turbulent boundary layer, and excitation of structures. Although very powerful electric motors of the order of 10 MW start-up and 9 MW continuous power rating are used in high-speed trains, power car noise is not important in comparison with wheel/rail and aerodynamic noise at the high operating speeds. However, NOISEXPT provides some information about train engine/motor noise and other noise source data.

It is worthwhile pointing out that as the train speed increases, aerodynamic noise becomes more and more important. As can be seen from NOISEXPT, aerodynamic noise is comparable with wheel/rail noise from the newly developed high-speed train with speeds greater than 250 km/h, for example, comparing SPL_{ae} with L_{maxc} in Table 3.

7. PREDICTION METHODS

Several prediction methods are available in NOISEXPT, the simplest being the "klogU model" (see [8] for example):

$$L_c = 30 \log (U/100) + 89 \qquad (4)$$

where L_c is the predicted train noise at a distance of 25 m from the track.

In more detailed models, a prediction method for wheel/rail noise developed by Peters [9], a semi-empirical equation for aerodynamic noise prediction developed by King et al [10] and the Nordic method for noise propagation calculations [11,12] are combined together to form a recommended method for fast-rail noise prediction:

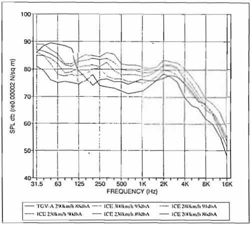

Figure 2: Some noise spectra from measured fast-rail data.

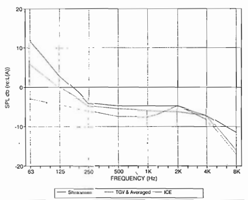

Figure 3: Relative noise spectra and averaged typical noise spectrum for fast rail.

TABLE 1
Corrections for standards

Subjective judgement of standards	Comments on the value	Corresponding correction (dB)
(1)	It is acceptable	0
(2)	It is acceptable	0
	It seems a bit high	−3
	It seems a bit low	+3
(3)	It is acceptable	0
	It may be too high	−5
	It seems a bit high	−3
	It seems a bit low	+3
	It may be too low	+5

TABLE 2
Typical fast-rail noise spectrum

Frequency (Hz)	63	125	250	500	1 k	2 k	4 k	8 k
SPL (dB)	6.0	0	−5.1	−6.2	−6.2	−6.2	−7.2	−15.0

$$SPL_{wr} = L_G + 10 \log (a/N) - 20 \log (l_c) + C_s \log (U) + 10 \log \{2D \operatorname{arctg}(D) + D \sin[2 \operatorname{arctg}(D)]\} \quad (5)$$

$$SPL_{ae} = 57 \log (U/160) + 10 \log \{(H/d)[\operatorname{arctg} D + \sin(2 \operatorname{arctg} D)]\} + 80 \quad (6)$$

$$\Delta L_{ground} = -12 \log \{d/[1 + (d/10)]\} + 3 \log (h_{ave}) + 7.76 \quad (7)$$

$$\Delta L_{screen} = -10 \log d_s - 10 \log \{[e + 1/4(d_s + 1)]/[1 + e/3]\} - 7.54 \quad (8)$$

where

SPL_{wr} = wheel/rail noise level (dB(A));
SPL_{ae} = aerodynamic noise level (dB(A));
ΔL_{ground} = corrections for ground effect (dB(A));
ΔL_{screen} = screen effect (dB(a));
L_G = a constant (dB(A));
a = mean number of axles per coach;
N = total number of individual vehicles in a train including power cars;
l_c = coach length (m);
L = total length of the train (m);
U = train speed (km/h);
C_s = speed coefficient (ten times the power of the train speed to which sound intensity is proportional), taken as 35 ± 5 for most western European trains;
D = L/2d with d being the distance to the near rail (m);
H = height of the sound radiation area of the turbulent boundary layer (m);
d_s = distance from screen to track centreline (m);
d = distance from receiver to track centreline (m);
e = sound path difference (m); and
h_{ave} = average height above ground of the connection line between the receiver and the track (0.5 m above the track surface).

NOISEXPT is designed so that the user can invoke every prediction method in the knowledge base and make an easy comparison for different methods or for different parameters using one prediction method. For example, the results from several methods using typical parameters are shown in Table 3.

TABLE 3
Typical results from several methods [dB(A), at 25 m]

U (km/h)	SPL_{wr}	SPL_{ae}	L_{maxa}	L_{maxb}	L_{maxc}	L_{eqa}	L_{eqb}	L_{eqc}	OASPL
40	71.4	38.4	78.7	71.4	56.4	61.1	54.3	39.3	77.1
80	81.9	55.6	87.9	81.9	67.2	68.1	61.8	47.1	86.1
120	88.1	65.6	93.3	88.1	73.8	72.3	66.2	51.9	91.4
160	92.4	72.7	97.1	92.5	78.7	75.2	69.4	55.6	95.1
200	95.8	78.3	100.0	95.9	82.7	77.5	71.8	58.6	98.0
240	98.6	82.8	102.5	98.7	86.2	79.3	73.8	61.3	100.4
280	100.9	86.6	104.5	101.1	89.3	80.9	75.5	63.7	102.4
320	103.0	89.9	106.3	103.2	92.0	82.3	77.0	65.9	104.2
360	104.8	92.8	107.8	105.0	94.6	83.5	78.4	67.9	105.7
400	106.4	95.4	109.2	106.7	96.9	84.6	79.6	69.7	107.1

where
SPL_{wr} = wheel/rail noise predicted by Peters' [9] method;
SPL_{ae} = aerodynamic noise predicted by King's [10] method;
L_{maxa} = peak noise predicted by the Nordic method [12];
L_{maxb} = peak noise predicted by $SPL_{wr} + SPL_{ae}$;
L_{maxc} = peak noise predicted by (SPL_{wr} – reduction) + SPL_{ae};
L_{eqa} = equivalent noise predicted by Nordic method;
L_{eqb} = equivalent noise by wheel/rail + aerodynamic;
L_{eqc} = equivalent noise by (wheel/rail – reduction) + aerodynamic; and
OASPL = peak noise predicted by the klogU method.

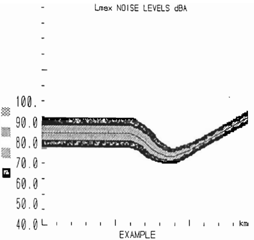

Figure 4: Typical noise contour plot generated by NOISEXPT. This shows a plan view of noise emanating from the train moving along the black line from left to right. The train slows from 350 to 240 km/h as it enters the bend.

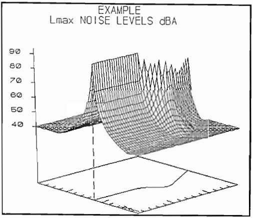

Figure 5: A three-dimensional view of noise for the same situation as in Figure 4.

In this table, all quantities except L_{maxc} and L_{eqc} are for conventional (lower-speed) trains. "Reduction" means noise reduction achieved by the efforts to build advanced high-speed trains.

Predicted noise levels may be displayed as either contours in plan view (Figure 4) or as a three-dimensional image (Figure 5).

8. NOISE CONTROL DESIGN

Information about noise countermeasures from several countries has been collected and included in the knowledge base which can be viewed statically or used interactively in design. Based on a cost-effective concept, the user will be led through each countermeasure option. A scoring system is used to judge the user's selection so that the final achievement can be shown in both dB(A) reduction and total marks. The latter enables the system to advise further treatments.

Countermeasures which have been verified to be effective in the engineering practice of Sinkansen, TGV and ICE, such as reducing the number of bogies, using disc braking systems with computerised anti-locking devices, damping of the wheels (especially tuned damping), truing of the wheels and smoothing of the rails, reducing the number of pantograph and so on, can be viewed in detail in NOISEXPT.

9. LITERATURE DATABASE

More than 400 paper and book references form a database which can be searched through an interface between CRYSTAL and dBASE III plus. A matching technology enables users to find references through Author, Title, Book/Journal Name, Publication Year, Country Name and Keywords.

10. CONCLUSIONS

Rail noise control engineering is a suitable area in which to apply AI technology, especially knowledge-based systems, because of complexity, uncertainty, lack of experts and the lack of internationally agreed noise standards.

A successful way to develop an expert system for noise control is to bring experts on acoustics into the expert system application area. As one keynote speaker put it at the Second Australian Conference on Expert Systems [13]:

> Often the best exploiters of AI technology are people who are not expert in AI but who need AI technology to solve a problem of importance to their work and hence to their careers.
>
> Also, the basic principles of AI can be learned much faster than domain expertise in most cases. A person with some programming experience and skill with computers can do useful AI work in a year, and occasionally less. To become good at anything for which experience counts can take many years.
>
> Consequently, the best people for tackling AI problems are those who cope well with things that lack precise definition.

The use of a suitable expert system building shell such as CRYSTAL makes development more rapid.

The development of NOISEXPT has seen the successful application of a rule-based expert system to rail noise engineering. It provides a powerful tool enabling key international expertise in high-speed train noise impacts to be more readily available to designers, planners and regulating authorities. A rational basis for setting standards and understanding the influence of speed, terrain, observer location, track type, vehicle design and many other factors is provided.

11. ACKNOWLEDGMENTS

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ICA Report

Neville Fletcher

The 1992 conference is confirmed for Beijing. I guess everyone would have been happier if it had been arranged for somewhere else, but the political situation seems to have calmed down (even if it has not really improved), the Chinese hosts have arrangements well in hand, the conference site seems convenient (at the new Olympic village), and there is no pressing reason to call it off. There is a measure of worry about the level of attendance to be expected — the Chinese hope for about 500 overseas delegates and 500 locals, but 500 overseas may be rather optimistic. Local arrangements are expected to be very good.

The 1995 ICA will be held in Trondheim in June. The original bid from Norway was for Lillehammer (Winter sports resort north of Oslo) but no-one was at all keen on that, and they were persuaded to change. The other bid was from Rome, but that would have been in September, which did not please the Americans, and the Italian people were happy to defer their bid to 1998. No decision can be made on 1998 at this time, of course, but Rome looks a good possibility. For the 1995 ICA it has been made clear that Satellite meetings are not a necessity, and indeed the Committee would prefer to see everything at one large meeting. The same message has been given for the 1992 ICA, but it is too late to change some of the satellite arrangements.

My term on the Commission ends at the end of this year and cannot be renewed. It is proposed that the new President will be David Blackstock (University of Texas — nonlinear acoustics etc) and the Secretary Adriano Alippi (Rome — ultrasonics etc). Gunnar Rasmussen (B&K Denmark) will stay on as Vice-President. Of course the Commission membership has to be confirmed at the next ICSU meeting. There was no further nomination from Australia, Henri Myncke (ex-President, Belgium) may stay on for another term, and there will be replacement members probably from UK, France and Japan.

A Prediction Method for Probability Distribution of Road Traffic Noise at an Intersection

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ABSTRACT: The actual road traffic noise which is encountered in daily life usually shows nonstationary fluctuation patterns caused by the temporal change of traffic flow. One of the typical examples can be seen in noise level presented in the area around the intersection. On the other hand, statistical parameters such as median value of the sound level, L_X (X = 5, 10, ...; i.e. (100 − X) percentage point of the level probability distribution), as well as the lower order statistical values as L_{eq} are important for noise evaluation and regulation problems. In this paper, the probability distribution form of periodic nonstationary road traffic noise in an intersection area is numerically predicted, by using digital simulation experiment. The predicted values for the noise level probability distribution are in good agreement with the actually observed data.

1. INTRODUCTION

The statistical evaluation and/or prediction problems of road traffic noise have been considered by many investigators [1-7]. However, in the previous studies, the theoretical consideration was confined to only the noise level fluctuation caused by the statistically stationary road traffic flow [1-4] or limited to the relatively simple traffic flow even if the concrete statistical analysis were carried out for nonstationary road traffic noise [5-8]. Up to now, scarcely anyone has studied the prediction problem of traffic noise in the intersection area, because of the complexity of behaviour of moving vehicles controlled by traffic signals.

When one considers the prediction problems of actual road traffic noise in the intersection area, the following should be taken into account:

- At an intersection existing in the urban district, in general, many high buildings line the street. Accordingly, in the area around the intersection, the sound field cannot be regarded as the free sound field.
- Needless to say, the moving vehicles are direct noise sources and the number of vehicles can be controlled for the purpose of a noise counterplan. Therefore, it is important to consider the relationship between the noise level and the number of moving vehicles, which is usually used in the description of the physical mechanism of road traffic noise.
- The behaviour of the above vehicles moving in the intersection area is very complex. Therefore, it is difficult to estimate the time patterns (fluctuating in the one period time interval of the traffic signals) of an average number of vehicles moving on each lane, by using the usual dynamical traffic theory such as the kinematic wave model or the shock wave model [9].

From the above viewpoints, a method for predicting the road traffic noise in the intersection area based on the digital simulation experiment is proposed by paying special attention to the periodicity of the temporal change of traffic flow. Concretely, we first determine the effective area, the moving vehicles in which affect mainly the noise level fluctuation at an observation point in the intersection area. Next, the noise level probability distribution form is numerically predicted by using the fluctuation patterns of an average number of vehicles moving on each lane in the above area.

The predicted noise level probability distribution form is in good agreement with the actually observed data.

2. OBSERVATION OF NOISE LEVEL AND TRAFFIC FLOW

In order to make a survey of the fluctuation form of the road traffic noise level and the state of the behaviour of moving vehicles in the intersection area, the road traffic noise level and the traffic flow were observed for several hours at the points, A and B, shown in Figure 1 (A: observation point of noise level, B: observation point of traffic flow, a video tape recorder was set on the rooftop of a high building). In this figure, S_A and S_B are synchronous traffic signals with the period T (= 140 s). Figure 2 shows the scatter diagram obtained from N (= 58) sample paths for random noise fluctuation observed in time interval T. Each sample path is sampled every second. The solid line in Figure 2 shows the mean value fluctuation pattern, $\mu_L(t)$, of periodic nonstationary random noise. Figure 3 shows the 15 lanes of vehicles which have been obtained from the actually observed data (recorded simultaneously with noise measurement on a video tape recorder). The experimental values for the average number of heavy vehicles, μ_{N1}, the average number of light vehicles, μ_{N2}, and average speed, v (m/s), for each lane are shown in Table 1. These values were experimentally obtained by using 58 sample paths of the set of photographs of traffic flow condition, each of which has been recorded in time interval T on a video tape recorder.

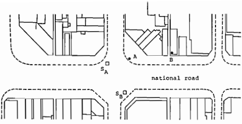


Figure 1: The observation points of the road traffic noise and the number of moving vehicles.

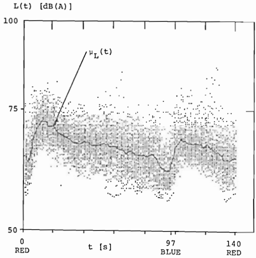


Figure 2: A scatter diagram and temporal change of the mean value for periodic nonstationary road traffic noise.

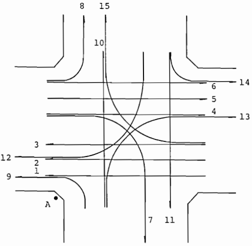


Figure 3: The 15 lanes of moving vehicles in an intersection area which have been obtained from the actually observed data.

TABLE 1

The experimental values for the average number of heavy vehicles, the average number of light vehicles and the average speed on each lane

Lane	μ_{N1}	μ_{N2}	V (m/s)
1	26	191	8.7
2	110	667	10.2
3	66	459	10.7
4	183	525	11.0
5	76	816	11.6
6	5	154	10.7
7	11	368	6.1
8	6	295	6.5
9	18	338	6.1
10	16	485	7.7
11	10	549	10.0
12	8	360	6.8
13	6	68	4.1
14	5	108	8.3
15	0	69	1.8

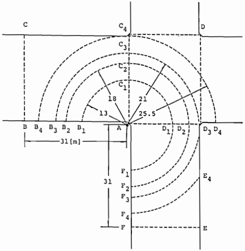


Figure 4: Determination of the effective area.

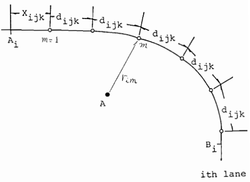
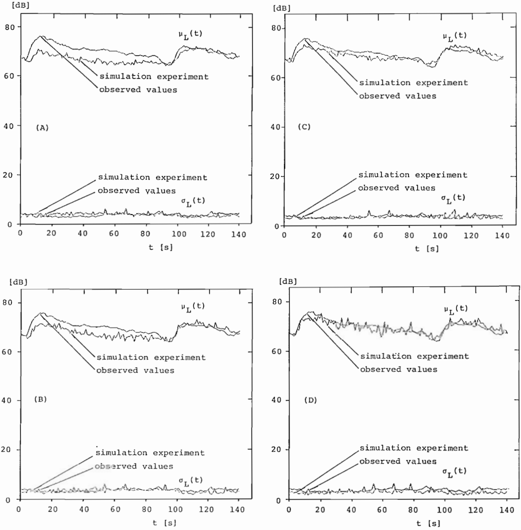


Figure 5: The position of vehicles existing on i-th lane in the effective area.



(A) Case 1 (B) Case 2 *(C) Case 3 (D) Case 4*

Figure 6: Comparison between actually observed data and simulation experiment for $\mu_L(t)$ and $\sigma_{L(t)}$.
(A) Case 1; (B) Case 2; (C) Case 3; (D) Case 4; (E) Case 5; (F) Case 6

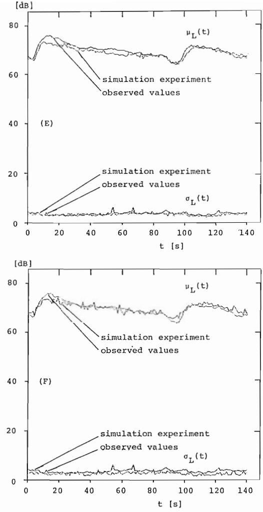
3. DETERMINATION OF EFFECTIVE AREA AND DIGITAL SIMULATION

The traffic noise presented in the intersection area can be divided into the sound intensity due to the direct field and that due to the reverberant field. The latter component is the sound intensity caused by multi-reflection of sound waves. The form of noise level fluctuation pattern shown in Figure 2 may be mainly affected by the direct sound emitted from the vehicles moving in the area near the observation point.

3.1 Set of the effective area

Let us consider the following six cases, in order to determine the effective area (see Figure 4):

Case 1. Area 1 ($A-B_1-C_1-D_1-F_1-A$)
Case 2. Area 2 ($A-B_2-C_2-D_2-F_2-A$)
Case 3. Area 3 ($A-B_3-C_3-D_3-F_3-A$)
Case 4. Area 4 ($A-B_4-C_4-D_4-D_3-E_4-F_4-A$)
Case 5. Area 5 ($A-C_4-D-D_3-A$)
Case 6. Area 6 ($A-B-C-C_4-D-D_3-E-F-A$)



(E) Case 5 (F) Case 6

3.2 Digital simulation

For the purpose for determining the effective area, the fairly conscientious simulation experiment should be carried out by using the actually observed data of the number of moving vehicles. Let n(i,j,k) be the number of vehicles moving on i-th lane (i = 1, 2, ..., 15) in each effective area shown in the previous section, at time j (j = 1, 2, ..., 140) of k-th sample path (k = 1, 2, ..., 58). The value of n(i,j,k) is experimentally obtained from the photograph of the traffic flow condition, which has been recorded by a video tape recorder.

Now, the position of vehicles existing in the certain interval of i-th lane $(A_i, B_i]$ is determined by using an equally spaced model with the space headway (see Figure 5):

$$d_{ijk} = (A_i - B_i - X_{ijk})/n(i,j,k) \quad (1)$$

Hereupon, X_{ijk} is random variable with a uniform distribution in a region $[0, X_{ijk0}]$ $[X_{ijk0} = (A_i - B_i)/(n(i,j,k)+1)]$.

In order to carry out the digital simulation experiment (Monte Carlo simulation) for the road traffic noise fluctuation at an intersection area where the starting and/or stopping of the vehicles is controlled repeatedly by the traffic signals, it is essentially important to consider the effect of the acceleration and/or deceleration on the vehicle noise emission. On the other hand, up to now, the speed dependence of noise emission level of moving vehicles has been considered by some investigators [10,11]. In the previous papers, however, the discussion on the speed dependence was confined to only the case of free flow with a certain constant speed. And we can not find out the study on the mutual relationship between the vehicle noise emission level and the factors of acceleration and/or deceleration (it is very basic and important to consider the speed dependence of noise emission characteristics of vehicles in the acceleration area and deceleration area).

So, as the second best policy, we have used the following models [10]:

A The value of noise level emitted from moving heavy vehicle with speed V (km/h) is Gaussian type random variable with following mean value and standard deviation:
mean value: $\mu(1) = 97 + 0.2\,V$ (dB)
standard deviation: $\sigma(1) = 3.3$ (dB) (2)

B The value of noise level emitted from moving light vehicle with speed V (km/s) is Gaussian type random variable with following mean value and standard deviation:
mean value: $\mu(2) = 87 + 0.2\,V$ (dB)
standard deviation: $\sigma(2) = 3.6$ (dB) (3)

The above vehicle noise emission model may be fairly useful for the purpose of finding the dominant tendency of random noise phenomena. (It should be noticed that we pay our attention to the average quantity of the space headway, speed and number of moving vehicles etc, and we consider the time patterns of statistics such as mean value and standard deviation of the random noise level fluctuation in the next section 3.3.)

Now, if the information on the effective area (see Figure 4), the number of moving vehicles, n(i,j,k) (i = 1, 2, ..., 15; j = 1, 2, ..,, 140; k = 1, 2, ..,, 15) and the average speed of moving vehicles on i-th lane, V(i) (km/h) (i = 1, 2, ..., 15), are given (see Table 1), we can obtain the noise level data L(j,k) (j = 1, 2, ..., 140; k = 1, 2, ..., 58) through the following procedure.

1 Pay attention to the m-th vehicle on the i-th lane at time j of the k-th sample path (see Figure 5).
2 Generate a random number R_1 with uniform distribution in a region [0,1]. Then, determine the type of the above m-th vehicle as follows:
if $0 \leqslant R_1 \leqslant \theta(i)$, the m-th vehicle is heavy type (N = 1),
if $\theta(i) < R_1 \leqslant 1$, the m-th vehicle is light type (N = 2).
3 Generate a random number R_2 with Gaussian distribution of mean value 0 and standard deviation 1. Next, by using the value of V(i) (see Table 1) and Equation (2) (or Equation (3)), calculate $L_{im} = \mu(N) + R_2\sigma(N)$ (N = 1 or 2), which corresponds to a value of noise level emitted from the m-th moving vehicle.
4 Sum up the sound intensity I_{im} ($\triangleq 10^{L_{im}/10}$) over all vehicles existing in the effective area, as follows (see Figures 4 and 5):

$$I(j,k) = \sum_{i=1}^{15} \sum_{m=1}^{n(i,j,k)} I_{im}/(4\pi r_{im}^2) \quad (4)$$

5 Calculate the following equation:

$$L(i,j) = 10 \,.\, \log\,[I(i,j) + I_0] \quad (5)$$

Hereupon, I_0 is the background noise intensity corresponding to the sound intensity due to the reverberant field.

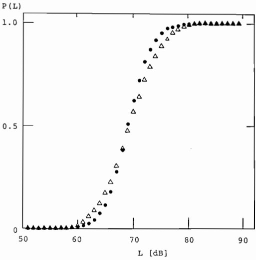


Figure 7: A comparison between predicted values and actually observed data for the cumulative probability distribution of periodic nonstationary road traffic noise (△ predicted value, ● observed value).

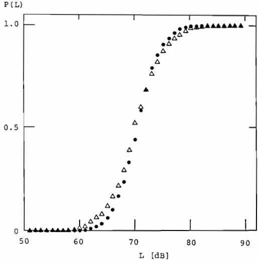


Figure 8: A comparison between predicted values and actually observed data for the cumulative probability distribution of periodic nonstationary road traffic noise (△ predicted value, ● observed value).

3.3 Results

Figure 6 shows a comparison between actually observed data and simulation experiment for the time patterns of mean value, $\mu_L(t)$, and standard deviation, $\sigma_L(t)$, of the periodic nonstationary random noise level fluctuation. Here, the results of simulation experiment for $\mu_L(t)$ and $\sigma_L(t)$ have been obtained by using the simulation data $L(j,k)$ ($j = 1, 2, \ldots, 140$; $k = 1, 2, \ldots, 58$). From this figure, we can find the following three facts: (1) As is shown in Figure 6(A), the time pattern obtained by simulation experiment is rather different from the actually observed values in the case when the effective area is estimated small. (2) The time pattern obtained by simulation experiment is closer to the observed values as the effective area becomes larger and the sufficient approximation, up to the area of Case 4, seems to catch all ups and downs of the actually observed time pattern (see Figures 6(D) and (F)). So, the area of Case 4 can be determined as the effective area (the vehicles existing in which affect mainly the traffic noise level at an observation point). (3) When Figures 7(D), (E) and (F) are observed minutely, it can be found that the values of $\mu_L(t)$ obtained from the simulation experiment are somewhat underestimated at near the first peak ($t = 10 \sim 20$(s)). This underestimate may be caused by the neglect of the vehicle noise emission effect in the acceleration time interval. (It should be noticeable that the observation point A has been set near the acceleration area of vehicles moving on the national road (especially lanes 1, 2 and 3; see Figure 3) with large traffic volume (see Table 1)).

4. PREDICTION OF PERIODIC NONSTATIONARY ROAD TRAFFIC NOISE

In the previous section, the effective area was determined. Accordingly, if the time pattern of average number of moving vehicles on i-th lane, $n(i,j)$ ($i = 1, 2, \ldots, 15$; $j = 1, 2, \ldots, 140$), the ratio of the intermixture of heavy vehicles in the i-th lane, $\theta(i)$ ($i = 1, 2, \ldots, 15$), and the average speed of moving vehicles on i-th lane, $V(i)$ (km/h) ($i = 1, 2, \ldots, 15$) are given, the probability distribution form of periodic nonstationary road traffic noise can be predicted by digital simulation experiment. Figures 7 and 8 show, respectively, the comparison between predicted values obtained by digital simulation experiment and observed data for the probability distribution, $P(L)$, of periodic nonstationary road traffic noise in the different two time intervals. We can find a good agreement between predicted values and observed data. This fact means that the model on the speed dependence of noise emission levels of moving vehicles may be approximately applicable to the intersection area.

5. CONCLUSIONS

Up to now, the prediction problem of nonstationary road traffic noise in the intersection area has not been considered, since the behaviour of moving vehicles in the intersection area is very complex. In this paper, a method for predicting the probability distribution form of periodic nonstationary road traffic noise in the intersection area has been proposed by paying special attention to the periodicity of the temporal change of traffic flow. Concretely, the effective area (the moving vehicles in which affect mainly the noise level fluctuation) has first been determined. Next, by using the fluctuation pattern of average number of vehicles moving on each lane, the ratio of the intermixture of heavy vehicles in each lane and the average speed of moving vehicles on each lane, the noise level probability distribution form has been numerically predicted. The predicted noise level probability distribution form was in good agreement with the experimentally observed data.

The prediction method for the probability distribution form of a nonstationary road traffic noise in the intersection area, based on the information of moving vehicles (time pattern of average number, the ratio of the intermixture of heavy vehicles and the average speed), is still in an early stage of study. Therefore, there still remain important future problems to consider such as the speed dependence of noise emission levels of individual vehicles in the intersection area.

ACKNOWLEDGMENTS

We would like to express our cordial thanks to K. Hironaga, M. Okinaga and M. Mitsumune for their helpful assistance. We also have to express our thanks for many constructive discussions at the annual meeting of the Acoustical Society of Japan.

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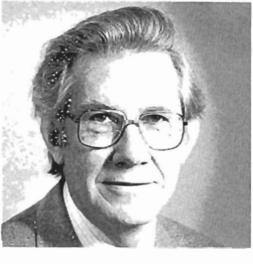
Neville Fletcher

Interviewed by Graham Caldersmith

This is the first interview in a new series featuring currently active acousticians.

Neville Fletcher is a remarkable person and a distinguished scientist in several fields as well as acoustics. He was born at Armidale, NSW, in July, 1930, attended school there and went on to study science at New England University College, then a part of Sydney University. He graduated in 1951 with first class honours in both maths and physics and gained the Sydney University Medal in Physics. He then went to Harvard University gaining an MA In 1953 and PhD in 1955 followed by a DSc from Sydney University in 1973. He was elected Fellow of the Australian Academy of Science in 1976, Fellow of the Australian Academy of Technological Sciences and Engineering in 1987 and was appointed a member of the Order of Australia this year. He is also a Fellow of the Acoustical Society of America and has been a member of the International Commission on Acoustics since 1984. He is Co-ordinating Editor, Special Issues for Acoustics Australia and is currently on the editorial advisory committees of both Acustica and Applied Acoustics.

I worked with Neville as a Research Fellow in musical acoustics in 1977 and have never ceased to be impressed with the breadth and power of his physical insight as well as his experimental acumen and administrative efficiency. I have also enjoyed his friendship since he moved to Canberra and it was a great pleasure to record in the interview below some of the philosophical and personal qualities of a great Australian scientist.



Part A — Personal Aspects

Perhaps we should start with your recollections of schooldays. Can you point to any events or experiences that anticipated a special ability with science?

I was interested in radios at that stage — crystal sets and simple valve radios, some from my uncle, which I took apart and made into different sorts. That was in early high school, and I wanted to be a radio engineer. I also had chemistry sets and electricity sets and enjoyed mucking around with them.

I might have become an engineer but I could only take physics, chemistry, maths and either geology or biology at the University College in Armidale, so I ended up majoring in maths and physics.

I'm trying to get at the origin of the breadth and originality of your approach to physical problems — the origin of your feeling for physics. Did that begin at school or later?

I guess at school I was good at maths, but the careers adviser said I wouldn't be able to handle honours physics (!) so I did honours maths which was probably the best for me then. But ultimately my approach to physics emerged out of an exposure to a range of projects in my formative research years — as many inflicted on me as by choice. I did a fourth year project and then some research in gas discharges at NEUC, then to Harvard for a dose of solid state and transistors which continued when I returned to work with CSIRO until they decided transistors were not a commercial proposition for Australia. So I was given the choice of Radio Astronomy or Cloud Physics, the latter involving the growth of ice crystals. I knew a bit about crystals so I did cloud physics for almost three years at CSIRO but then returned to solid state and gas discharges when I joined the staff at UNE in 1960...

And when did you start your acoustics research?

That wasn't until 1972, almost ten years into my professorship at UNE, though when I learned the flute under Victor McMahon I had dabbled with some blowing pressure measurements which I gave to him — but I didn't follow it up. The ARGS thought my proposal for acoustic research was OK so that's where that strand started.

What about the people who inspired or guided you in your undergraduate and graduate years? What names stand out?

Particularly Jack Somerville who was appointed senior lecturer to inaugurate the maths and physics departments in New England in 1938. I did my fourth year project with him in gas discharges and then worked for a year or so as his research assistant before disappearing off to Harvard. I was with him again at UNE from 1960 until 1963 when he died. I learnt a lot from him - he gave me my first acquaintance with tertiary maths and physics. He had moved from engineering to physics in his own career so that he had himself a broad and applied - or applicable - ability with physics.

When you were in Harvard - did anyone impress you especially?

I did my PhD under Harvey Brooks who was a theoretical physicist - solid - state. My thesis was about two thirds solid state theory. I did metallurgy with Bruce Chalmers in 53-54 in applied physics and with Andrew Lang who did X-ray topography - he was visiting from England at the time. Those three made the greatest impression on me at Harvard, but my thesis was done rather in isolation because my first year was mainly course work, the second year I worked one day a week at a transistor factory, and in the third year I worked four days a week there in the absence of any scholarship support. I actually became assistant director of development while I did my thesis in the remaining three days. So I didn't have a lot of time for socialising at Harvard. But while my thesis was mainly theoretical of necessity, I did manage to incorporate some of the results on power transistors from my work at the company - which also gained me a patent.

Do you have any special affection for authors - physics text etc.?

Phillip Morse stands out from Morse and Fechbach: Methods of Theoretical Physics and also from his book Vibration and Sound. I respect the refinement of his exposition. J.C. Slater also; I attended his lectures on solid state theory and MIT and valued his books on microwave transmission. More generally I had superb lectures from Julian Schwinger who got a Nobel Prize for Quantum Electrodynamics and I heard Fermi lecture on cosmic rays - he was said to be the last person to have known the whole of physics. But in a way I was a country boy from Australia and was probably too retiring to get the most out of the bright lights in physics in America at the time. My main participation in American life was playing flute in the Harvard orchestra and playing the organ in one of the local churches. I had a great time doing that but I suppose I should have put more effort into the physics culture.

When you think of a problem, do you think of a physical system or do you think of a mathematical equation?

I think of the physical system. I visualise it concretely as if I am small, standing inside the system watching what happens. Then

I try to clothe the goings on in some equations to tie down the quantitative elements.

Einstein said he saw physical events as muscular, but you stand inside the system watching the parts interact — like standing inside the flute head joint watching the air jet switching in and out.

Yes, I am smaller than the parts interacting so I can watch the waves going past.

We should talk about your acoustics research. In 1977 I worked with you on plate vibrations, trying to understand the fourth order differential plate equations and applying them to experimental instruments I made at the UNE. But you were supervising Suszanne Thwaites' experiments in flute excitation and in string vibration decay rates.

Yes, I started acoustic research with flute physics because I knew about flute playing characteristics. I worked also with organ pipes because a player wasn't needed and the blowing was reproduceable. At that stage, in the early 1970's, there was a lot of uncertainty about how flutes and organs actually worked even without the nonlinearities in the excitation processes. But right from the start I tried to understand harmonic generation from nonlinear excitation and that has proved to be a unifying theme in my acoustics research.

How did you start your biological acoustics?

I met Adrian Horridge at the Research School of Biological Sciences during a visit to the ANU. He was interested in vision in invertebrates, crabs and things, but he had a project with Ken Hill in hearing and sound production in invertebrates — cicadas and crickets — and also in birds. Talking with them I realised that there were clear ways to explain what was going on with fairly simply physics. So I dived in to interpret physically some of Ken Hill's experiments.

You dealt with phase delays in signals received by the ears on the insects' legs.

Yes. In insects, lizards and birds the two ears are coupled acoustically so you have a tube with a drum on each end, a system which is not hard to analyse. In mammals the Eustachian tubes are small and not acoustically coupled. Later on I saw that it was possible to apply the methods of analysing sound production in wind instruments to birdsong, even though the mechanism there involves vibrating membranes interacting nonlinearly with the air column in the trachaea, resulting in the type of harmonic generation that people measure in birdsong spectra.

What about the strings — harpsichords, clavichords etc.?

I was interested in the linear coupling between the vibrating parts of the instruments and did some work with Suszanne Thwaites on modes in clavichords. With Katherine Legge, who recently completed her PhD, I was looking at nonlinear effects in simple vibrating strings, one-dimensional systems, that showed the effects most definitely. This was the beginning of a planned series of studies in nonlinear vibrating systems which progressed through bent bars to plates and shells. I was captivated by the Chinese gong, a dished plate with bumps in it, that exhibited beautiful nonlinear behaviour. It goes "boom" and then "sshhhh" so that the energy has gone from the low frequency modes to the higher ones through a nonlinear process.

And you are continuing this work by studing the chaotic nature of the transition from linear to nonlinear behaviour in plates and gongs. How did that arise?

That started because Katherine discovered it in a big Turkish gong about 50cm across with a flange around it. She found that, if you excited it at the centre with a sinusoidal driving force, at particular frequencies subharmonic generation occurred and then chaos, resulting in a sound similar to that when you stood off and welted it. We found the same sort of behaviour in cymbals and flat plates — subharmonic generation and chaos, but subharmonics of order 3, 5 instead of 2, 4 etc. as in standard chaos theory. That's interesting and it has practical application in structures subject to periodic impulses like oil platforms. If they vibrate in subharmonics to the wave frequencies and at large amplitude, or if they go chaotic under certain excitations, they might fall to bits.

It's intriguing that you have discovered chaos in fairly well-defined vibrating systems and that you have related onset of chaos to nonlinear response to the energy input. Do you think these sorts of studies will provide some insight into chaotic behaviour in natural and cultural systems like the weather and economies?

Certainly the characteristics of nonlinear systems have been attracting attention for something like fifteen years now. Rene Thom came along first with catastrophe theory, where systems had sudden transitions from one state to another without actually going chaotic — that happens in simple physical systems, like geometrical catastrophies in optical systems where there is a folding of the wavefront. People were optimistic about application of catastrophe theory to social systems and, sure, it did reveal new ways of describing erratic social behaviour, but I don't think it ever reached the stage of being predictive. Then came the focus on nonlinear coupled biological systems — predator-prey relations and so on — just straightforward coupled nonlinear differential equations which gave good predictive explanations of the cycles in lemming populations in Canada etc.

When you get to simple chaotic systems like vibrating objects, some chemical reactions, and fluid dynamics, you can describe some aspects of the chaos structure and onset of chaos, but only on the average: transition to turbulence and drag coefficients in laminar and turbulent flows. We really want to know about the details, like next week's weather, rather than a big average over the summer. So while we have better explanations for why systems are chaotic and how chaos is structured, I don't think we are any closer to predicting the important details of the chaos — other than modelling with a whopping great computer and feeding in a whole range of initial conditions. But even then the sensitivity of the system to minute changes in initial condition makes that sort of analysis very difficult. I think we always knew about small turbulent effects escalating in semi-random patterns — the so-called butterfly effect. Now at least we have a broader framework within which to explain chaotic behaviour and maybe we will proceed to find ways to predict it in the future.

Part B of this interview will be published in the December issue.

BOOK REVIEWS

FLOW-INDUCED VIBRATION, 2ND EDITION
R.D. Blevins

Van Nostrand Reinhold, New York, 1990, pp 451, Hard Cover, ISBN 0-442-20651-8. Australian Distributor:
Thomas Nelson Aust, 480 La Trobe St, Melbourne, Vic. 3000.

Flow-induced vibration (second edition) by Robert D. Blevins is a welcome addition to the vibration and noise literature. The book is authoritative and covers the complete field of flow-induced vibration — there is something in it for anyone who has an interest in the subject. The book also contains numerous very useful up-to-date references at the end of each chapter.

The book contains ten chapters and some very useful appendices. The chapter topics include dimensional analysis, ideal fluid models, vortex-induced vibration, galloping and flutter, instability of tube and cylinder arrays, vibration induced by oscillating flow, vibration induced by turbulence and sound, damping of structures, sound induced by vortex shedding, and vibration of a pipe containing a fluid flow. There are numerous exercises/worked examples sprinkled throughout the text and this is a welcome addition. The appendices include useful summaries of modal analysis, principal coordinates, aerodynamic sources of sound, and digital spectral and Fourier analysis. There is also a very useful and comprehensive author index for cross referencing the various reference lists.

The main strengths of the book are its subject breadth and up-to-date references. Its main shortcoming is that the depth of coverage of certain topics (particularly certain sections in chapters 7, 8, 9 and 10) has been compromised.

Chapter 1 is an excellent summary of the dimensional parameters relevant to flow-induced vibration. It is a good introduction to the book. Parameters such as geometry, reduced velocity, dimensionless amplitude, mass ratio, Reynold's number, damping factor and turbulence intensity are clearly defined.

Chapter 2 deals with ideal fluid models. The fundamentals of potential flow, added mass, fluid coupling, and vortex motion are discussed. Like chapter 1, it is a useful introduction to the rest of the book. The comprehensive reference list is very useful for anybody wishing to delve deeper into the subjects discussed.

Chapter 3 is where the book starts to get really interesting! The subject of vortex-induced vibration is very topical for a wide range of industries. The chapter includes sections on vortex wakes of stationary cylinders, Strouhal numbers, effect of cylinder motion on wakes, analysis, models and reduction of vortex-induced vibration, and specific examples relating to bridge decks, marine cables and pipelines. The flow chart for determining amplitude and drag in vortex-induced vibration and the design guidelines for vortex suppression devices are very useful.

Chapter 4 deals with galloping and flutter. Galloping instability, galloping response, relationships between vortex shedding and turbulence and galloping, flutter, prevention of galloping and flutter are discussed with some authority. Examples of flutter analysis of an aeroplane wing rib section, and galloping of a cable are provided. The chapter contains a lot of very useful empirical and experimental data for design calculations.

Chapter 5 is about the instability of tube and cylinder arrays. It includes a section on the theory of fluid elastic instability, practical considerations for heat exchangers, vibration of pairs of cylinders and a numerical example of tube instability in a heat exchanger. Like the previous chapter, this chapter contains a lot of very useful empirical and experimental data for design calculations, and is largely based on the authors own research and consulting experience. The chapter has significant practical value as fluid elastic instability is a primary cause of heat exchanger tube failures.

Vibrations induced by oscillating flow are discussed in chapter 6. The chapter includes discussions on inline forces, inline motion, fluid force coefficients, and transverse force and response. A brief but nevertheless useful section on the reduction of vibration induced by oscillating flow is also included together with a detailed example of ocean wave-induced vibration of a marine riser. The chapter ends with a detailed section on ship motion in a seaway.

Chapter 7 deals with vibration induced by turbulence and sound. The topics covered include random vibration theory, sound- and turbulence-induced vibration of panels, turbulence-induced vibration of tubes and rods, vibration induced by winds, and the response of aircraft to gusts. A numerical example of wind-induced vibration of a building and some recommendations for the reduction of vibration induced by turbulence is included. The mathematical model developed in the section on sound- and turbulence-induced vibration of panels is elementary and is essentially a single oscillator subjected to broadband noise. The modal overlap situation, which can be of some importance in certain instances, is not discussed. The forced response of a panel to acoustic excitation is also not discussed — it can sometimes have a significant effect.

Chapter 8 deals with damping of structures. Sections in the chapter include elements of damping, fluid damping, structural damping, damping of bridges, towers, buildings, piping and aircraft structures, and material damping and dampers. The techniques for measurement of damping discussed in the chapter are very basic. Recent developments in damping measurement techniques including the steady power flow method, and amplitude tracking using the Wigner distribution (or an FFT algorithm) are not discussed. There are limitations in using the bandwidth or the magnification factor method for estimating structural damping of lightly damped structures. The drive point damping can dominate over the structural damping. Also, sometimes the radiation damping dominates the need to be estimated and subtracted. The results presented in section 8.3.2. could be affected by radiation damping and drive point damping. A discussion on the accuracy of the measurement techniques described and their limitations would have been useful. The section on damping of bridges, towers, buildings, pipings and aircraft structures contains some valuable empirical data for design studies.

Chapter 9 is on sound induced by vortex shedding. Topics covered include sound from single cylinders, sound from vibrating cylinders, sound from multiple tubes and heat exchangers, and sound from flow over cavities. A useful design procedure for the prediction and suppression of resonance in heat exchanger tube arrays is also included. In section 9.3.1. the author states that cut-off or bound acoustic modes in a duct do not propagate energy away from the tube array. This is in disagreement with other works in the published literature (e.g. Shepherd and Cabelli, Journal of Sound and Vibration, 1981, Vol 77, pp 495) where it is shown that acoustic energy does propagate out of the duct due to reflections at duct terminations.

Chapter 10 deals with vibrations of a pipe containing a fluid flow. The chapter covers instability of fluid-conveying pipes, external axial flows, pipe whip, pipe acoustical forcing, and leakage flow-induced vibration. The section on instability of fluid-conveying pipes is excellent, as are the sections external axial flows and pipe whip. The section on piping acoustical forcing is very elementary and whilst the tubes can sustain standing acoustic waves, there are also travelling higher order modes (travelling acoustic waves) that are very important both from a noise and from an acoustic fatigue viewpoint. It is these travelling higher order modes that couple circumferentially to the pipe and excite it. This topic is omitted from the book, and it would have been useful to include it.

The shortcomings mentioned in this review do not detract from the overall value of this very good and useful text. Any book that covers so much breadth is bound to have some limitations and cannot please everyone. The book is useful for postgraduates starting out in the field, researchers and consultants. It could also be the base for a postgraduate course on flow-induced vibration.

Michael Norton

Michael Norton is an Associate Professor in the Department of Mechanical Engineering at the University of Western Australia. His primary areas of research involve noise and vibration. This review first appeared in the Journal of Experimental Thermal and Fluid Sciences.

AN INTRODUCTION TO THE PSYCHOLOGY OF HEARING

B C J Moore

Academic Press, 1989, pp 350,
Soft Cover ISBN 0 12 505624 9,
Hard Cover ISBN 0 12 505623 0.
Distributor: Harcourt Brace Jovanovich, Locked bag 16, Marrickville NSW 2204.
Price: Soft Covers A$33.49.

The book begins with the fundamentals of sound and the structure of the ear and proceeds rapidly to response of the basilar membrane and the hair cells. Neural tuning curves, phase locking and cochlear echoes are discussed as well as processes in the higher levels in the auditory system. Chapter 2 covers absolute thresholds, equal loudness contours, Weber's Law, adaption, damage risk, and loudness recruitment. Chapter 3 considers frequency selectivity, masking and the critical band, phase sensitivity, the shape of the auditory filter, the excitation pattern, masking release, Green's profile analysis, forward and backward masking. Temporal resolution of the auditory system is the subject of Chapter 4. Chapter 5 considers the perception of pure tones and complex tones and the perception of pitch in music; Chapter 6, space perception and auditory localisation, and the perception of distance. The next two chapters draw together much of the information derived from the earlier chapters to discuss sound pattern and object perception, and speech perception. A final chapter discusses some practical applications of auditory theory, including, interestingly, a section on psychoacoustics and the choice of home Hi-Fi equipment.

I found this book very readable and informative, and, for its size, remarkably comprehensive and not lacking in essential detail. Its structure of chapters and their sub-section organises the subject matter very understandably. Discussion of theory is always balanced and related cogently to experimental results, and, where experiments are described, and this is often, the coverage seems to be no more and no less than is required to cover the point. The later chapters on object perception and speech perception, with their emphasis on the use of alternative cues and integration of information from other sources than hearing, relate the earlier chapters on the basic processes in the ear to behaviour in a very interesting way.

Criticism of such a good book is probably churlish, and no doubt everyone would like some topic or other to be given more space. I could not help noticing that asymptotic TTS was missing from the discussion. The concept of a TTS critical band was not noted; nor was the relation of the spectrum of impulsive noises to their potential for causing hearing loss. Also the reference to damage risk and amplified music failed to note that the apparently high prevalence of hearing loss in industry is not matched by findings of widespread hearing loss due to loud music. The current position on this issue was worth at least a paragraph. However, I can recommend this as a very compact and useful book.

Norm Carter

Norm Carter is the Head of the "Human Effect" research group at the National Acoustic Laboratories. His work has included many studies of the effects on humans of various types of noise including environmental, work-related and recreational noises. He is currently the Chairman of the NSW Division of the AAS.

New Publications

Applied Acoustics
Vol. 28, No. 4, 1989
Vol. 29, No. 1, 1990

Archives of Acoustics
Vol. 14, Nos. 1 & 2, 1989

Canadian Acoustics
Vol. 18, Nos. 1 & 2, 1990

Chinese Journal of Acoustics
Vol. 8, No. 4, 1989
Vol. 9, No. 1, 1990

CSIRO Industrial Research News
No. 197, Dec. 1989
Nos. 198, 199, Feb. & Apr. 1990

Seminar

Hearing Loss in the Workplace 10 May 1990

A half day seminar on "Hearing Loss in the Workplace" was held at the Australian Defence Force Academy (ADFA) on Thursday 10 May 1990. This seminar was organised by the Acoustics and Vibration Centre at ADFA, with the support of the ACT Division of the Safety Institute of Australia. The aim of the Seminar was to provide a forum for discussion of the various issues relevant to Hearing Loss in the Workplace.

There were fifty participants, including those involved with the presentations. The seminar was opened by **Chris Vevers**, the Registrar of Occupational Health and Safety in the ACT. He provided an overview of the recently introduced Occupational Health and Safety Legislation in the ACT.

For the first session on "Noise and Hearing Loss", **Marion Burgess**, from the Acoustics and Vibration Centre, was the Chairman. An introduction to noise Measurement and Control was provided by **Joseph Lai**, from the Centre. Joseph supplemented his talk with demonstrations of various sound levels. **Greg Ash**, currently working for Comcare in the ACT, outlined the Effects of Hearing Loss. This included temporary and permanent loss and individual variability. Legislation for Hearing Conservation was discussed by **Stephen Weeden** from the Standards Branch of the National Occupational Health and Safety Commission. He reported on the Draft National Standard and Code of Practice issued in 1989 which are currently going through the review process following the receipt of public comments. This first session was completed with a spirited presentation by **Gerry Holmes** from the Trade Union Training Authority on the Legal Approach to Remedies and Prevention.

Following afternoon tea, **Alan Pomeroy** from the Safety Institute was the Chairman for session two on "Noise in the Workplace". The View of Employers was presented by **Dorothy Swanson** from the Confederation of ACT Industry. She stressed that not all employers are unconcerned about the working conditions for their staff and many have themselves been employees. **Charles McDonald** from the Trades and Union Council of the ACT followed with the View from the Employees. He emphasised the importance of the awareness of noise in the work environment. The formal presentations completed with **Peter Skeen**, General Manager of Operations at Comcare, who presented the View of an Insurer. He explained the objectives of Comcare and the interactive rehabilitation system which has been established.

Marion Burgess

NEW PRODUCTS

PETERS
Auditory Trainer

The Alfred Peters AP102 is one of a comprehensive range of specialist audiometric and acoustic products for teaching and diagnosis of the deaf. The AP102 Auditory Trainer conforms with electrical safety specification BS5724 Part 1 (IEC601-1), and it is primarily intended for use in Partial Hearing Units of Schools and Clinics, yet sufficiently economical, versatile and straightforward for use in the home.

Children from the age of 5 years who have a hearing problem with a consequential, or associated speech impediment, will benefit greatly from the use of the Peters AP102 in the hands of an experienced peripatetic teacher of the deaf. The auditory trainer enables the pupil to hear the teacher's voice at a comfortably amplified level and also hear their own voice in their effort to reproduce the teacher's words. The output level to each ear has separate adjustment in 5dB increments to allow for optimum acoustic matching to actual hearing loss, even where the ears have different losses. With a maximum output of 135dB SPL and bass/treble cut function to improve discrimination, the AP102 Speech Trainer is ideal even for those children with a severe hearing loss. Overall microphone gain is provided and the control is used in conjunction with the built in panel meter.

Further information: MB & KJ Davidson, 17 Roberna St, Moorabbin, Vic. 3189. Tel: (03) 555 7277.

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VIPAC
Intrinsically Safe SLM

Larson Davis Laboratories is pleased to announce the release of their Intrinsically Safe Sound Level Meters/Dosimeters. Both the 700 & 710M Models are now available with Instrinsically Safe Certification for Australian Standard AS2380.7-1987. This allows their use in hazardous areas e.g. mines, petrochemical plants and combustible dust areas etc. All are easy to use and with built-in memory and RS232 interface, allows downloading to a PC or directly to a printer.

Further information: Vipac Engineers & Scientists, 275 Normanby Rd, Port Melbourne, Vic. 3207. Tel: (03) 647 9700.

BRUEL & KJAER
New Pistonphone

Pistonphone Type 4228 is a small, battery-operated, high-precision sound source. Each Pistonphone is individually calibrated and comes complete with adaptors, allowing use with 1″, 1/2″, 1/4″ and 1/8″ microphones. It operates at 250 Hz and 124 dB.

Type 4228 provides quick and accurate calibration of sound measuring equipment including sound level meters. With the included barometer, it satisifies IEC 942 (1988) Class 1. With an external barometer, it is capable of meeting Class 0 of IEC 942 (1988). It also complies with ANSI S1.40-1984. It can be used in the field across a wide range of temperature, humidity and pressure conditions while still maintaining high accuracy. The Pistonphone is extremely useful for supplying a standard sound pressure level.

The piston arrangement, based on an original Bruel & Kjaer design, consists of two pistons mounted on opposite sides of a cam disc. The rotation of the cam disc forces the pistons to move, in phase, in and out of the coupler cavity. The design reduces cam disc eccentricity and harmonic distortion, and ensures maximum level stability. With only one control switch, the Pistonphone is very simple to operate. It can be held in one hand in any position, while the free hand adjusts the sensitivity of the sound measuring equipment until a reading corresponding to the sound pressure level produced is obtained.

Sound Level Meter and Module

Bruel & Kjaer's Modular Precision Sound Level Meter Type 2231 is now even more versatile, with new features and an addition to its large family of Application Modules — the Integrating SLM Module BZ 7110. The 2231 now has improved data-storage and interfacing capabilities, making communication with other RS 232 C-compatible equipment (for example, a printer or computer) quicker and more comprehensive. With the BZ 7110 module loaded, the 2231 is a complete integrating sound level meter for general sound measurements.

The improved 2231 has a 64 kbyte RAM for storing application programs, measurement records and set-ups. With the BZ 7110, this means up to 99 measurement records can be stored. Measurement set-ups can be stored, ready for recall whenever required. The real-time clock marks measurement records with the date and time of measurement — a useful feature when storing data for future review. A special program in the 2231 gives access to its functions and entire memory from RS 232 C-interfaced computers, via the Interface Module ZI 9101. This allows data to be written to, and read out from, the 2231. When using the Graphics Printer Type 2318, print-outs of measurement records can be obtained in 6 languages.

With the BZ 7110 module, data can be stored manually, by external control, or automatically. The module features a differential-display facility: the bar indication in the 2231's display shows the instantaneous SPL as a centre value, with subsequent values being shown relative to this. This is particularly useful for analyzing variations in machine noise. Seven printer formats are available, and a user-definable format for transferring data to a computer. The module also includes a dedicated communication program for easy remote control of the module's functions.

High Frequency Module

With High-frequency Module ZT 0318, the analysis range of Real-time Frequency Analyzers Types 2123 and 2133 is increased by up to a factor of eight. Thus, you can now obtain a broader range of measurements in areas such as Underwater Acoustics, and the analysis of transient signals and fast analysis of stationary signals (in Quality Control, for example).

With one HF module installed inside your analyzer, single-channel spectra can be measured in real time at higher frequencies. For 1/3-octave band analysis, the maximum centre frequency is now 80 kHz, and 63 kHz for 1/1-octave band analysis — excellent for the Underwater Acoustics. Larger frequency ranges are also available for 1/12 octaves (up to 21.8 kHz for both single channel and dual channel) and for 1/24 octaves (up to 11.1 kHz, single channel) — excellent, this time, in Quality Control. With Type 2133, two modules similarly extend the real-time frequency range of dual-channel measurements. The high-frequency digital filters of the ZT 0318 are in accordance with ANSI S1.11 — 1986, IEC 225-1966 and DIN 45652.

Automatic Machine Monitoring System

The Automatic Machine-monitoring System is intended for permanent installation in the production plant, to keep a continuous watch on vital rotating-machinery and to provide the earliest possible warning of faults. The system fully automates the process of data collection and fault detection — picking up the widest range of faults at a very early stage, long before they become critical, and without the fear of false alarms.

Accelerometers are permanently attached to the monitored machines, and hard-wired via sturdy cables to the following control-room analysis equipment: a PC running Application Software Type 7616/BZ 7027; a Vibration Analyzer Type 2515; and a Printer. Vibration measurement and analysis are automatically controlled by the PC and Vibration Analyzer. During the automatic measurement cycle, frequency spectra are recorded at each measurement point and compared with reference data. Increases in vibration anywhere across the frequency range will be detected, and an appropriate warning automatically given.

Spectrum-comparison monitoring ensures that faults are detected at a very early stage in their development. The Bruel & Kjaer specialised Constant Percentage Bandwidth (CPB) frequency spectrum, also ensures that the widest possible range of faults can be detected. Further, by compensating for the speed of the machine and operating parameters such as load, temperature and pressure, the spectrum comparison can be adapted to remove the danger of false alarms and thus ensure reliable trouble-free monitoring.

Application Note

A new Application Note from Bruel & Kjaer BO 0326 examines the signal source requirements for dynamic testing of A/D Converters. *Dynamic Testing of A/D Converters — Signal Source Requirements* discusses the importance of using a precise signal source in the test system. It demonstrates that only a signal generator which synchronizes the measuring system can provide the accuracy and stability required. The Bruel & Kjaer Type 1051 Sine Generator is one of the few instruments on the market which can meet these requirements.

In recent years dynamic testing of ADCs has increasingly replaced traditional static test methods. This is only natural, as, in the real world, ADCs function in a dynamic environment. In other words, they are subjected to "live" signals of varying amplitude and frequency. However, dynamic testing makes additional demands on the signal source, demands which traditional RC-based oscillators cannot meet. This Note discusses these signal source requirements and suggests an effective solution to the problem.

Further information: Bruel & Kjaer, 24 Tepko Road, Terrey Hills, NSW 2084. Tel: (02) 450 2066.

Australian Metrosonics

db-3100 Metrologger

- Extremely Compact — Fits into a pocket
- Simple Three Button Operation
- Very Flexible — Performs as a:
  - Universal Noise Dosimeter
  - Time History Profiling Dosimeter
  - Integrating/Averaging Sound Level Meter
  - True Peak Sound Level Meter
- Generates Fully Formatted Reports and Graphs

The db-3100 is a revolutionary new multi-purpose noise dosimeter and sound analyzer which satisfies industrial hygiene, safety and community needs. This exceptional instrument functions simultaneously as a universal noise dosimeter, integrating/averaging and true peak sound level meter, and time history monitor.

A special three button design makes the db-3100 easier to operate than any other monitor of its type, on the market today. By simply pressing one or two buttons, you can turn the logger on and off, start and/or stop logging, output data to a printer or computer, calibrate, view statistics, and more. Also, the db-3100's rugged, lightweight and pocket sized design, provides ultimate convenience and go anywhere use. It even has a detachable microphone.

Selectable exchange rate, criterion levels and cutoffs allow the db-3100 to monitor in accordance with all noise exposure criteria currently in use, including OSHA, DOD and ISO. Another valuable feature is the ability to break up a test period into a series of equal-duration intervals and produce a time history profile. In different locations, the db-3100 can automatically time each measurement, separate the data and identify each location.

For permanent hard-copy documentation, fully formatted reports may be generated at any time on an RS-232 serial printer. Also, since the db-3100 is IBM PC compatible, data may be transferred to a computer for further analysis and storage.

Further information:
Australian Metrosonics Pty Ltd, 37 Benwerrin Drive, Burwood East, Vic 3151. Tel. (03) 803 5744.

ETMC

Transient Recorder

ETMC Technologies have introduced the Rene Maurer portable transient recorder, ADAM, with a sampling rate of up to 20 MHz and resolution to 12 bits and with applications in many physical/-mechanical tests and experiments.

Up to 12 channels, each with 64 K samples memory can be functioned, with ADC and preamplifiers to users requirements. This provides for tailor made instruments for any application or set of applications. The main features are dual time base, sophisticated, fine stepped trigger settings, with pos/neg delays, channel staggering and 100 mV to 100 V input ranges with ±100% offset.

It has resident firmware for post record processing and is available all in a handy portable box including video display. A field type data storage/analysis unit EVA is also available for storage of recorded data and extensive post processing using the software package MEDUSA III or FADAM.

Further information:
ETMC Technologies Pty Ltd, 6 Pound Rd, Hornsby 2077. Tel. (02) 477 1764.

Ultrasonics Institute

The Ultrasonics Institute has been transfered from the Federal Department of Community Services and Health to CSIRO's **Division of Radiophysics**. It is now known as the Ultrasonics and Medical Technology Group (UMTG) and it forms part of the Division's Signal and Image Technology Program. The transfer gives a boost to CSIRO's work in medical instrumentation, the Institute having played a leading role in Australia in the development of ultrasound for medical diagnosis. The move should lead to substantial spinoffs to industry. In its new research context, the Group is concentrating on developing improved ultrasound techniques, instrumentation and applications in medicine, as well as extending medical ultrasonics methods to related areas such as veterinary science, animal production, and industrial measurement and control.

IRN, CSIRO — Oct 1989

ADVERTISER INDEX

Readers are asked to mention this publication when replying to advertisements.

FUTURE EVENTS

● Indicates an Australian Conference

1990

August 13-15, GOTHENBURG

INTERNOISE 90

Dept Applied Ac, Chalmers University Technology, S-412 96 Goteborg, Sweden.

● August 26-31, DARWIN

15TH ARRB CONFERENCE

Roads in a Transport Environment.
Details: ARRB, P.O. Box 156, Nunawading, Vic. 3131

August 27-29, SENIS

3RD INTERNATIONAL CONFERENCE ON INTENSITY

Structural Intensity and Vibrational Energy Flow.
Details: CETIM, BP 67, SNLIS, FRANCE 60 304.

August 27-31, AUSTIN

12TH INTERNATIONAL SYMPOSIUM ON NON LINEAR ACOUSTICS

Details: Dr M. Hamilton, Dept Mech Eng, Univ. Texas, Austin U.S.A. 78712-1063.

September 11-13, LONDON

MEETING ON OPTICAL, ELECTRICAL AND ACOUSTIC PROPERTIES

Details: Plastics & Rubber Institute, 11 Hobart Pl., London SW1, UK.

September 11-14, MARSEILLE

9TH MEETING ON ACOUSTICS PROPAGATION

Details: Laboratorie de Mecanique & Acoustique, 31 Chemin Joseph Aiguier, Marseille Cedex 09, France, 13402.

● September 18-20, MELBOURNE

VIBRATION & NOISE CONFERENCE

Details: L Koss, Dept Mech Eng, Monash University, Clayton, Melbourne, Vic. 3168.

October 2-5, HIGH TATRA

ROOM, BUILDING & URBAN ACOUSTICS

Details: House of Technology, Ing L Goralikova, Skultetyho UR.1, 832 27 Bratslava, Czechoslovakia.

October 9-11, LONDON

QUIET REVOLUTIONS

International Conference on Power Train and Vehicle Noise Refinement.

Details: Conference Dept C420, Institution Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW1H 9JJ.

October 14-18, TENERIFE

20TH INTERNATIONAL CONGRESS ON AUDIOLOGY

Details: Dr J Barajas, Perez de Rozas 8, Santa Cruz de Tenerife, Canary Islands, Spain.

October 15-17, AUSTIN

NOISE-CON 90

Reducing the Annoyance of Noise

Details: Noise-Con 90, Cont. Eng. Studies, College of Engineering, Cockrell Hall 10.324, University of Texas, Austin, Texas, U.S.A. 78712.

● October 15-19, MELBOURNE

METROPOLIS '90

Details: Secretariat, 545 Royal Parade, Parkville, Vic. 3052.

October 22-25, SENDAI

10TH INTERNATIONAL ACOUSTIC EMISSION SYMPOSIUM

Details: Prof. Niitsuna, Engineering, To hoku University, Aramaki aza Aoba, Sendai 980, Japan.

October 29-31, KUMAMOTO

INTERNATIONAL JOINT MEETING

Workshops on Acoustic Emission in Civil Engineering and Acoustic Emission and Rock Fracture Mechanics.

Details: Dr Ohtsu, Dept Civil & Env. Engineering, Kumamoto University, Kurokami 2-39-3, Kumamoto 860, Japan.

November 18-22, KOBE

1990 INTERNATIONAL CONFERENCE ON SPOKEN LANGUAGE PROCESSING

The first international conference on spoken language processing by both humans and machines.

Details: Secretariat, ISCLP-90, c/- Simul International Inc. Kowa Building No 9, 1-8-10 Akasaka, Minato-ku, Toyko 107, Japan.

November 26-30, SAN DIEGO

MEETING OF ACOUSTICAL SOCIETY OF AMERICA

Details: Fredrick Fisher, Marine Physical Lab, P-001, Scripps Institute Oceanography, Univ. California, San Diego, La Jolla, CA 92093-0701, USA.

November 26-30, HIGH TATRAS

NOISE & VIBRATION CONTROL IN INDUSTRY

Details: Dom Techniky CSVIS, Nadja Bajova, Cesta Miery4, CS-011 32, ZILNA, Czechoslavakia.

December 5-7, HONULULU

ULTRASONICS SYMPOSIUM

Details: R.S. Kagiwada, Mail Station R6/1563, One Space Park, Redondo Beach, CA 90278, USA.

December 12-14, DELHI

INTERNATIONAL CONGRESS ON ULTRASONICS

Details: Dr. Ashok Kumar, Ultrasonics, National Physical Laboratory, New Delhi, India, 110012.

1991

April 28-May 3, BALTIMORE

MEETING OF ACOUSTICAL SOCIETY OF AMERICA

Details: Acoustical Society of America, 500 Sunnyside Blvd, Woodbury, NY 11797, USA.

May 5-9, BALTIMORE

MEETING OF ACOUSTICAL SOCIETY OF AMERICA

Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

July 1-4, LE TOUQUET

ULTRASONICS INTERNATIONAL 91

Details: Conference Organiser, Ultrasonics International 91, Butterworth Scientific Ltd., P.O. Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH, U.K.

July 15-19, SOUTHAMPTON

4TH CONFERENCE ON RECENT ADVANCES IN STRUCTURAL DYNAMICS

Details: ISVR Conference Secretary, ISVR, Southampton, S09 5NH, UK.

August 19-24, AIX-EN-PROVENCE

12TH INTERNATIONAL CONFERENCE OF PHONETIC SCIENCES

Details: Secretariat, Universite de Provence, 29 Avenue, Robert Schuman 13621, Aix-en-Provence Cedex 1, France.

November 4-8, HOUSTON

MEETING OF ACOUSTICAL SOCIETY OF AMERICA

Details: Robert Finch, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

● November 26-28, BRISBANE

WESTERN PACIFIC REGIONAL ACOUSTICS CONFERENCE IV

Details: Unisearch Ltd, PO Box 1, Kensington, NSW 2033.

● December 2-4, SYDNEY

INTER-NOISE 91

Details: Unisearch Ltd, PO Box 1, Kensington, NSW 2033.

1992

May 11-15, SALT LAKE CITY

MEETING OF ACOUSTICAL SOCIETY OF AMERICA

Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, USA.