Acoustics Australia

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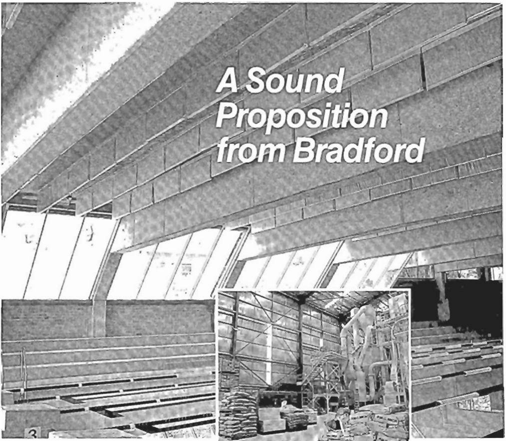

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Acoustics Australia

Vol 17 No 2 August 1989

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NEWS

NSW

March Technical Meeting

The first technical meeting of the NSW Division of the Society for 1989 was held at NAL Chatswood on Tuesday, 21 March. **Dr Harold Stanislaw,** lecturer in psychology at the University of NSW, gave a talk entitled "What Do We Hear When We Open Our Eyes?" Dr Stanislaw discussed "crossmodal" effects, in which stimulation of one sensory modality may affect perception in another sensory modality, and "attentional" effects whereby performance declines when observers attend to several sensory modalities, instead of just one. He also described an experimental method which avoids confounding these effects. An application of this method suggested that when observers process simultaneous visual and auditory stimuli, "crossmodal effects are absent, but severe attentional effects may be found". The talk was followed by a lively period of discussion and questions.

Norm Carter.

April Technical Meeting

On 20 April **Richard Heggie** from Richard Heggie Associates spoke on "Response of Structures to Vibration".

Over the past several years there has been growing awareness of the need to develop and refine criteria, standards and regulations relating to the effects of vibration on structures and their occupants. Fundamental to these objectives is the requirement to have a clear understanding of the basic mechanisms at work, particularly those associated with ground/structure interface and the dynamic response of the structures themselves.

Richard Heggie Associates was recently commissioned by Queensland University to carry out a major research study to review the current state of knowledge regarding the response of structures to vibration from blasting vibration and overpressure. In parallel with this study, the company has been conducting wide ranging investigations of the vibration effects on buildings and their occupants caused by road and rail traffic, construction equipment, pile driving, industrial machinery and other sources of vibration.

Richard Heggie described findings of some of these studies and discussed areas of further research and investigation.

WA

March Technical Meeting

The first technical meeting for 1989 was held on 6 March on "A Code of Practice for Noise Control in the Workplace". This is a document produced by the Occupational Health, Safety and Welfare Commission of WA as a practical working document for workplaces where there are noise hazards. It explains the duties of employers, employees, designers, suppliers, etc, under the new Occupational Health, Safety and Welfare Act and Regulations and gives practical strategies for complying.

The Code was presented by **Andrew Baker** and **John Macpherson** from the Noise Control Branch of the Department and generated some lively discussion.

April Technical Meeting

We were fortunate to be able to tie the April meeting in with a visit to Perth by **Klaus Hojbjerg** of the Bruel and Kjaer Acoustics Group (Denmark) during his recent Australian tour. Following his one-day seminar on "Sound Intensity, Principles and Practices" (attended by some members), Klaus stayed on to present a condensed version for the Society. A small but interested group was introduced to the B & K type 4433 Sound Intensity Analyser and its application for a range of situations.

Thanks to Klaus Hojbjerg and Les Southgate of Bruel and Kjaer for making the occasion possible.

June Technical Meeting

Stephen Samuels of the Australian Research Board spoke at a meeting on June 20 held at Technology Park, Bentley. The main topic was the prediction of noise levels adjacent to signalised intersections. This aspect of traffic noise has not been adequately addressed by standard methods such as CORTN. The talk also covered a range of activities of ARRB in road-related research.

Conference News

The Organising Committee for the 1989 AAS Conference in Perth, November 23-24, announces that **Dr Ragnar Rylander,** Professor in Environmental Hygiene at the University of Gothenburg, Sweden, has tentatively accepted an invitation to be a keynote speaker at the Conference. Dr Rylander is an authority on the effects of noise on people. His presence is expected to have a big impact on the Conference as he has a lot to offer us on the theme "Interior Noise Climates".

Further details: AAS 1989 Conference, PO Box 7055, Cloisters Square, Perth, WA 2000. Tel: (09) 426 5700.

John Macpherson.

VIC

February Technical Meeting

A symposium entitled "Traffic Noise — Whose Problem" was held by the Victoria Division at the Road Construction Authority Theatrette, Kew, on 23 February 1989. Technical papers were presented by **Stephen Samuels, Russell Matthews** and **Phil West, Chris Stapleton** and **Stuart McLachlan.** The symposium was attended by approximately 70 delegates.

April Technical Meeting

The April technical meeting was held at the Bradford Insulation fibreglass manufacturing plant at Nunawading. Fifteen members attended. The group saw, first-hand, the production of various fibreglass products from raw materials such as sand and soda ash through to the finished products. A short technical presentation on the properties of the products completed the evening.

May Technical Meeting

The May Technical meeting was held at the Royal Eye and Ear Hospital. **Dr Peter Seligman** discussed the development of the Cochlear Implant from inception in 1973 to the current day with 1,700 patients who have now received implants. The current implant gives approximately 30 per cent of recipients the ability to understand speech without the aid of lip reading, while all recipients claim some improvement in communication. This Australian development leads the world in cochlear implant technology.

Michael Snell.

Acoustics and Vibration Centre in Canberra

The **Acoustics and Vibration Centre** within the Department of Mechanical Engineering at the University College, Australian Defence Force Academy, was formally established in June 1988 by the University of New South Wales. The current Director of the Centre is Dr Joseph Lai, a Senior Lecturer in the Department of Mechanical Engineering.

The objectives of the Centre, relating to the areas of acoustics and vibration, include co-ordination and development of research and education, undertaking collaborative work with other organisations and provision of a consulting service.

The Centre has a wide range of modern acoustics and vibration instrumentation. The acoustics facilities include an instrumentation laboratory adjacent to an Anechoic Chamber which is of double shell construction to minimise extraneous noise and vibration and which satisfies International Standards for a lower cut-off frequency of 150 Hz. The vibration facilities include a laboratory for vibration measurements and analysis. State-of-the-art sound intensity measurements and modal analysis of structures can be performed with a dual channel, fast Fourier transform analyser together with a dedicated micro computer.

The Centre, via Unisearch Ltd, has undertaken a number of consulting projects. With a view to undertaking larger commercial projects, the Centre has recently formed a joint venture, called **Canberra Acoustics,** with two other acoustics and vibration consultants in the ACT region: Mark Eisner and Associates and Eric Taylor Acoustics.

As part of the Centre's continuing education programme, the Centre organised a seminar on the ACT Noise Control Ordinance on 11 May 1989 and conducted a Workshop on the Basics of Noise Control on 16-19 May 1989. The feedback from the Seminar and Workshop participants has been very positive. A short course on the Basics of Vibration Control will be conducted on

4-7 December 1989 and a seminar on Condition Monitoring is being planned for 8 December.

Further information about the Centre and its activities can be obtained from: The Director, Acoustics and Vibration Centre, Department of Mechanical Engineering, University College, Australian Defence Force Academy, Campbell, ACT 2600. Telephone (062) 68 8272 or (062) 68 8241. Fax (062) 68 8276.

8th FASE Symposium on Environmental Acoustics

The Federation of Acoustical Societies of Europe held their eighth symposium in Zaragoza, Spain, between 24-28 April 1989 on aspects of environmental acoustics. While the official symposium languages were English, French and German, a parallel but separate conference in Spanish attracted many of the 300 delegates. Multi-language translations were available of the opening and closing addresses as well as of the four invited papers, which indicate the scope of the symposium. These papers were on level limits for hearing protection, a comparison of traffic prediction models, calculation models for noise propagation outdoors and non-auditive effects of noise. Over 80 papers were presented at the main symposium in two parallel sessions, the timing of the presentation and discussion periods being controlled by pre-recorded musical signals. While this proved an effective method of finishing papers on time, the delegates had to suffer periodic bursts of extremely loud Spanish music: initially a source of amusement, ultimately of irritation. Two papers were presented by the Australian representative, **Dr C Don** of Chisholm Institute of Technology, while the only other non-European based delegate, from Japan, gave a paper on attenuation by multiple barriers. A comprehensive instrument display ran concurrent with the symposium while social activities included a concert of Spanish song and dance and a reception by the Mayor of Zaragoza.

Dr C G Don

Inter-Noise 89 and Seminar

Three hundred and five abstracts from authors in 30 countries have been accepted for presentation at INTER-NOISE 89, the 1989 International Conference on Noise Control Engineering. INTER-NOISE 89 will be held in Newport Beach, California, on 4-6 December 1989. It is the 18th in a series of international conferences on noise control engineering which began in 1972.

The theme of INTER-NOISE 89 is **Engineering for Environmental Noise Control.** Two Distinguished Lectures will be presented at INTER-NOISE 89.

Dr Leo L Beranek, one of the founders of Bolt and Newman Inc, will give the keynote lecture at the conference. His paper, "Criteria for Environmental Noise Control", will concentrate on engineering criteria for indoor and outdoor noise sources. Professor Jiri Tichy, head of the Graduate Program in Acoustics at the Pennsylvania State University, will also give a Distinguished Lecture. The title of his presentation will be "Noise Control Applications of Sound Intensity". Professor Tichy will show how advances in measurement technology allow engineers to follow the propagation of sound energy, determine the sound power radiated from large sources, measure sound transmission loss and sound absorption coefficients and, through the use of complex sound intensity, analyse the energy in sound fields.

Thirteen special technical sessions have been arranged for presentation at the conference. Among the topics to be covered in the special sessions are noise control around airports, interior and exterior aircraft noise, barriers for highway noise control, sound absorptive materials, sound intensity, and active noise control.

Prior to INTER-NOISE 89 there will be a three-day intensive seminar which will cover the latest techniques and the most recent advances in the use of computational techniques for noise control. The theme of the 1989 INCE Seminar will be **Computational Methods for Noise Control.** The increasing power of digital computers and digital instrumentation for noise measurement makes new methods for the analysis of noise problems practical. During the first two days of the Seminar, noise analysis and prediction methods will be discussed. The third day will be devoted to noise measurements.

The topics covered in the INCE Seminar have been especially selected for those individuals who wish to become knowledgeable of the principles underlying the computational algorithms used in boundary element methods, finite element methods, statistical energy analysis, signal processing and determination of sound intensity. The objectives of the Seminar are to develop an understanding of the underlying principles involved in computational algorithms and the advantages and disadvantages of alternative approaches.

The Seminar starts at 08.30 on Thursday, November 30, and concludes on the afternoon of Saturday, December 2. One-day, two-day or three-day options are available. The Seminar will be taught by Professor Robert J Bernhard of Purdue University, Professor Andrew S Seybert of the University of Kentucky, Dr Jerome Manning of Cambridge Collaborative, Inc, Professor Patricia Davies of Purdue University, and Dr David M Yeager of IBM.

Further information: Inter-Noise 89, PO Box 2469 Arlington Branch, Poughkeepsie, NY 12603, U.S.A.

People

Congratulations

The degree of Master of Arts was conferred on **Campbell Steele,** MAAS, on 4 March 1989 by Sydney University. The degree, which is in Pure Mathematics, was completed in the minimum time in spite of Campbell having a coronary by-pass operation in the middle. C M Steele & Associates is hoping for briefs with a mathematical flavour.

New Members

• 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
Ms L Hudson, Mr P Karantonis, Mr I C Ryan.

Victoria
Mr S J Jenkins.

• Graded

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

Student
Miss S Woon.

Member

New South Wales
Mr L J Elliott (New Zealand), Dr J L Goldberg, Mr N I Oprya, Mrs S G Reed, Dr S Thwaites.

Victoria
Mr G R Campbell, Mr S J Jenkins.

Engineering Award

Congratulations to **Louis Challis and Associates** for their Highly Commended Award as announced in Consulting Engineer, Vol 17, No 4, December 1988, in relation to their design work for the new Parliament House in Canberra. They developed a new and powerful analytical design procedure and applied it to a one-tenth scale model of the House of Representatives chamber. The computer-controlled analysis not only provided the objective data needed but also permitted the simulation of different sound qualities inside the finished chamber.

Utilising a miniature loudspeaker and microphone system, they recorded hi-fidelity sounds within their one-tenth scale model. The judges stated that the sound study was at the forefront of technology and it had involved advanced and yet simple computer modelling together with scale modelling of the chamber.

1989 AUSTRALIAN ACOUSTICAL SOCIETY CONFERENCE

DATE: 23 and 24 NOVEMBER, 1989

VENUE: COTTESLOE BEACH RESORT

THEME: INTERIOR NOISE CLIMATES

Adding a Computer to your Sound Level Meter

Robert Cook
Advanced Acoustical Technology Section
National Acoustic Laboratories
126 Greville Street
Chatswood N.S.W. 2067

ABSTRACT: By using a hand held computer control the operation of a Bruel and Kjaer Sound Level Meter type 2231, a remote data collection system is achieved. The computer stores the data for later printing or plotting of the results and, via its interactive program, controls the setting up of the Sound Level Meter (SLM). The computer can store and output the results of one minute logging periods taken over 48 hours of measurements in its battery backed up memory.

INTRODUCTION

The Advanced Acoustical Technology Section at NAL conducts research into noise measurement techniques and has for many years provided acoustical advice and conducted measurements on a project basis for the Department of Defence. Increasingly these measurements have concentrated on the environmental aspects of noise, particularly the annoyance caused by impulsive sounds in the residential areas surrounding firing ranges, detonation sites, etc. The determination of the community response to impulsive noise of this type includes the measurement of the peak level of the impulse. The development of this SLM/computer system was an attempt to provide a remote data logging system utilising the existing Bruel and Kjaer Type 2231 Sound Level Meters already in use in the Section.

The aim was to provide a system which:

- was not too expensive to purchase,
- was compact and battery powered,
- stored the measured values,
- provided a means to print and plot the results obtained versus time,
- was controlled by a real time clock to enable several systems to be synchronized, and
- could be operated as a stand alone system, thus permitting more data to be collected for a given number of staff and also permitting the collection of data from within the safety template areas surrounding detonations, etc.

By utilising a computer to store the data, rather than just attaching a printer to the SLM, the data is available for further processing back in the laboratory. To print out up to 48 hours of data at one minute intervals in the field also results in problems of paper storage, etc.

The computer selected was the Sharp PC 1600, which has available a printer/plotter accessory and a 2.5 inch disc drive. Figure 1 shows the SLM/computer system. Also shown is the external battery pack required to extend the battery life of the SLM and computer to 48 hours. In use, the equipment is housed in a self contained case which provides storage for the calibration equipment, microphone, tripod, windscreen etc. Figure 2 shows the computer outputting data to its printer/plotter and disc drive unit.

FEATURES OF THE BRUEL AND KJAER 2231 SOUND LEVEL METER

The 2231 SLM is a digital instrument with liquid crystal display. It is a very versatile instrument capable of performing many functions. Its operation is controlled by an application programme, loaded into its memory from an Applications Module inserted into a socket on the rear panel on the instrument. The same socket can house an Interface Module, which allows the output of data and the controlling of the SLM front panel. Several Applications Modules are now available but this description will be confined to the use of the SLM with the Integrating SLM Module Type BZ 7100. With this module installed the main features of the SLM are:

- Dynamic range 70 dB.
- Remote control and operation via the Interface Module type ZI 9100 / WH 2014 which is an interface "similar" to the RS-232-C standard.

Figure 1

The SLM/Computer System.

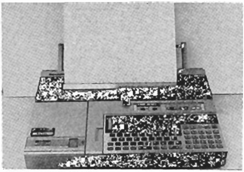

Figure 2

Computer, Printer/Plotter and Disk Drive Unit.

- Compatible with 200 V, 28 V and 0 V polarization voltage microphones.
- Simultaneous measurement of MAXP, PEAK, INST, SPL, MAXL, MINL, LEQ, SEL.
- Pre-settable measurement periods from one second to 100 hours.
- Battery life 8 hours.

FEATURES OF THE SHARP PC 1600 COMPUTER AND ACCESSORIES

The Sharp PC 1600 computer is a powerful hand held computer that runs from four 1.5 volt penlight cells. The computer may be programmed in BASIC language and comes equipped with 16k bytes of RAM as standard. Two additional RAM Modules may be installed in the expansion slots on the rear panel of the instrument. Several types of RAM Modules are available but the one used here features 32k bytes of RAM (complete with its own battery back-up), which may be configured as a RAM disc.

The main features of the PC 1600 are:

- Memory expandable to 80k bytes.
- Inbuilt real time clock
- Inbuilt RS-232-C interface as well as an optical serial interface and an eight bit analog to digital input port.
- Battery life 25 hours.
- Programmable in BASIC.
- Printing and plotting of data in four colours is possible using the CE-1600P Printer/Cassette interface.
- Storage of data and programs on 2.5 inch discs using the CE-1600F Disc Drive unit.

THE PROGRAM

The program to control the SLM and manipulate the data occupies all of the standard 16k bytes of RAM supplied with the PC 1600. One additional 32k byte Memory Module has been installed and this is configured to act as a RAM disc.

The program is split up into two sections: (1) setting up the SLM and gathering data and (2) printing, plotting and storing the data.

SETTING UP THE SLM AND GATHERING DATA

When first running the program the operator can enter the current date and time and details of the measurement title and measurement site. Once this has been completed instructions are sent to the SLM to place it in the correct output and measurement modes prior to measurements actually commencing. The operator may now enter the measurement period desired (times from one minute to 5999 minutes are permitted), and the desired starting time. All of the above information is stored in the Memory Module to accompany the data.

When the starting time for the first measurement occurs, the computer remotely starts the SLM and waits for the SLM to deliver the first data block at the end of the measurement period. The computer examines its real time clock, and, when a new minute begins, resets the SLM and a new measurement commences, thus synchronizing the start of the measurement period with the start of a minute. This means that all systems in use at that time will measure the same events. During the next measurement period the computer examines the data and if an overload is detected then it is suitably tagged for attention when finally printed or plotted. The data is then placed in memory together with the starting time of the measurement.

The measurement process continues in this way until one of the following conditions occurs; (a) the operator returns to stop the program, (b) the system fails due to a low battery condition or (c) the storage memory is full. Whichever condition occurs, the data held in the Memory Module is preserved by its own battery back-up circuitry.

Printing, plotting and storing the data.

Three separate routines allow the data to be printed, plotted or stored or retrieved from disc. Printing or plotting of a segment of the overall measurement is provided for by specifying the starting and finishing times desired.

Figure 3 shows an example of the plotted output, from 1245 to 1344 hours, derived from a measurement period commencing at 1129 and ending at 1530 hours. Figure 4 shows the printed output for this period. Levels marked "U" are underrange values from the SLM.

FURTHER DEVELOPMENT

Several modifications to the existing program could be performed which will result in improvements to the system. At present the program has been written for the Integrating SLM Applications Module BZ 7100. Unfortunately this application program cannot output data and measure simultaneously. This results in up to three seconds of measurement time being lost when transferring the data to the computer at the end of each measurement period (so far this has not been a problem). After the program was written another Applications Module (the Short Term Applications Module BZ 7106) was released which should overcome this problem and allow simultaneous measurement and data output with minimum measurement periods as short as one second.

A separate program has been written to store either Peak, L_{eq} or MAXL data from the SLM.

NAL is prepared to discuss making the software available should there be parties interested.

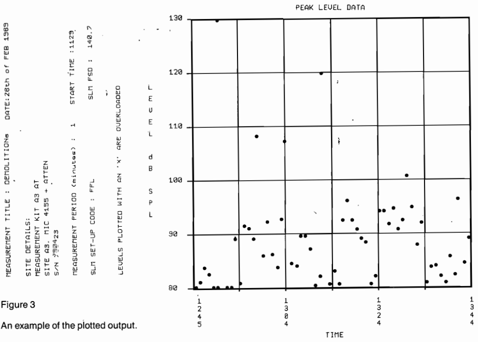

Figure 3

An example of the plotted output.

MEASUREMENT TITLE : DEMOLITIONS DATE:28th of FEB 1989

SITE DETAILS:
MEASUREMENT KIT A3 AT
SITE A3. MIC 4155 + ATTEN
S/N 790423

MEASUREMENT PERIOD (minutes) : 1 START TIME :1129

SLM SET-UP CODE : FFL SLM FSD : 140.7

PEAK LEVEL DATA
LEVELS PRINTED WITH * ARE OVERLOADED

TIME	LEVEL	TIME	LEVEL	TIME	LEVEL	TIME	LEVEL	TIME	LEVEL
1245	U___	1246	81.2	1247	83.8	1248	82.6	1249	U___
1250	U___	1251	129.8	1252	U___	1253	U___	1254	89.2
1255	80.8	1256	91.2	1257	90.8	1258	88.9	1259	108.0
1300	85.7	1301	91.9	1302	86.0	1303	83.5	1304	92.5
1305	106.7	1306	84.0	1307	83.7	1308	89.2	1309	89.1
1310	86.9	1311	U___	1312	81.7	1313	119.4	1314	U___
1315	82.6	1316	U___	1317	91.9	1318	95.6	1319	91.9
1320	90.1	1321	88.4	1322	87.6	1323	U___	1324	81.5
1325	93.5	1326	93.5	1327	91.0	1328	93.9	1329	89.9
1330	91.9	1331	99.8	1332	94.2	1333	87.1	1334	91.2
1335	U___	1336	83.1	1337	83.3	1338	81.3	1339	U___
1340	84.9	1341	81.6	1342	95.0	1343	83.5	1344	88.0

figure 4

An example of the printed output.

Power Station Noise Reduction

News Release from NAP SILENTFLO

(1) **Katherine, Northern Territory**

Katherine, located in the far north of the Northern Territory, a major tourist destination, agricultural and beef producing areas and home to the major Tindall RAAF base, is also the recipient of a state of the art natural gas-fired power station. In 1987, Solar Turbines Australia Pty Ltd won a contract to build and hand over a complete turnkey unmanned base load power station, and noise abatement was one of the critical factors identified early in the planning phase.

Realising the problem that industrial noise pollution posed for power station staff and local residents, Solar Turbines called tenders and finally selected well-known acoustic designer and manufacturer, **Nap Silentflo.** Nap's Managing Director, Mr Tim Marks, said the task was to achieve a guaranteed 85 dB(A) noise suppression at 1 metre, near field from all turbine power related equipment and NR 55 at 100 m in any direction from the station. Accordingly, the company designed, prefabricated and supplied three circular turbine exhaust silencers, turbine inlet air ductwork and silencers, and machine hall acoustic enclosures. Ventilation ductwork, fans and silencers were supplied under separate contract.

The results showed that, whilst internal noise levels rise to over 100 dB(A), measurements at 5 m from any point of the enclosure have not shown ambient noise greater than 65 dB(A).

(2) **Hazelwood, Victoria**

Hazelwood Power Station near Morwell in Victoria is a coal-fired station capable of producing up to 1600 megawatt. Built in the early sixties it is currently midway through a Plant Life Extension programme which will lengthen its useful working life by 15-20 years. In an effort to enhance the working environment for the power station's operators and maintenance crews the SEC in 1986 issued a specification to reduce the noise levels ranging up to 105 dB(A), at the fan's inlet, which is where maximum noise is generated. Each F.D. fan provides 167 m^3/s of combustion air for the pulverised coal, which is used to fire the plant's boilers.

The major requirement any tenderer had to achieve with this project was a noise level of 85 dB(A) at 1 m at maximum design rating, whilst still allowing operating and maintenance staff to have full access to fans, motor bearings, couplings and inlet vane actuators several times a day. A further requirement of the specification was that the equipment had to be able to withstand the buffeting effects of wind loading.

Nap's Chris Beale, the project engineer on the Hazelwood project says, "the noise control system has to cope with internal negative pressure generated by the F.D. fan placing severe buffeting onto the plenum structure, causing continuous stress." In essence, Nap Silentflo's approach was multi-faceted.

(1) Acoustic cladding was applied to fan case and discharge duct.
(2) Loaded vinyl cladding was attached to the 870 kw CACW electric motor driver.
(3) A plenum, consisting of Nap's demountable Sound Snap acoustic panels was designed to suppress noise comparable with that of the inlet silencer.
(4) Industrial versions of Nap's "D" series silencers were installed to each of the fan air inlets.

Strict testing by the client's engineers has proven the noise reduction required has indeed been achieved whilst access was maintained.

The Acoustic Properties of Wood in Relation to Stringed Musical Instruments *

J.I. Dunlop
School of Physics
University of New South Wales

ABSTRACT: Wood has been and remains the most favoured choice of material used to fabricate the bodies of stringed musical instruments. The mechanical properties of wood are related to its morphological structure and make it unique especially in strength-to-weight ratio and anisotropy. In most woods the acoustic velocity, a measure of its modulus, varies from 3-6 km/s along the grain to 0.8 - 1.8 km/s across the grain. The vibration damping loss in woods is due to several molecular mechanisms and depends on temperature, frequency and moisture content, the logarithmic decrement being in the region 10^{-3} — 10^{-2}. The choice of woods traditionally used in instruments shows some unique combinations of these properties — especially in the ratios of lateral to longitudinal modulus, the ratio of longitudinal velocity to density and the internal damping of the woods.

INTRODUCTION

Violin makers have always paid particular attention to their selection of wood not only as a species but also for the characteristics of a particular piece used. In Europe it has been traditional to use softwood conifers — and usually to use different woods in different parts of the instrument. In particular Norway spruce (Picea excelsa) has been favoured for top plates and Norway maple (Acer platanoides) for backs. However a wide variety of woods has been used successfully and this does not exclude Australian timbers which are unique to this part of the world. For example, there is a collection of fine violins at the Sydney Museum of Applied Science to illustrate the success of both Australian timbers and Australian violin makers.

Scientific measurement of the mechanical and acoustic properties of woods is extensive, and much of this work is documented. Properties of importance are elastic modulus (dynamic), denisty and acoustic damping and this scientific data might be utilised by the violin makers.

STRUCTURE OF WOOD

The unique mechanical properties of wood — its high strength to weight and anisotropic ratios — arise because of its morphological structure. Wood is a composite material consisting of an assembly of long thin hollow cells, the walls of which are formed of cellulose microfibrils embedding in a matrix of lignin. These cells, (tracheids), are aligned along the wood grain and cemented together by a matrix of lignin. The tracheids comprise the major component of wood and account for its high strength. There is, however, a wide range of the distribution of tracheid sizes and other morphological components, particularly in hardwoods, these variations distinguishing one species from another.

The properties of the tracheid and the embedding lignin control the resulting bulk wood properties. Lignin is an amorphous complex material of polysaccharides, phenols with a low (relatively) elastic modulus 2.6 $\pm$ .3GPa [Cousins, Armstrong and Robinson 1975] as measured by an indentation technique. Its acoustic properties have not been separately measured. The tracheid or wood cell offers a complex structure as shown in Fig.1, being composed of cellulose microfibrils embedded in a lignin matrix. The cellulose occurs as extremely thin (10^{-20} m^2 cross section) long and stiff (Young's modulus 300GPa) fibrils in a crystalline form (Cave 1968).

These fibrils and microfibrils have distinct orientation patterns in the cell wall as shown in Fig.1. The major component (80%) is the S2 layer in which the micro fibrils are aligned at a small angle to the cell orientation and

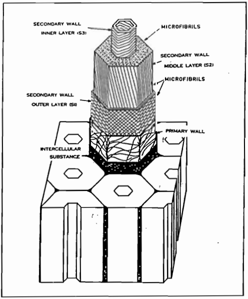

Fig.1 Simplified structure of the cell wall of a tracheid

which contributes to the high longitudinal strength of the cell. The other layers S1 and S3 play an important role in stabilising the structure against lateral deformations.

The elastic modulus of wood is therefore anisotropic, being much stronger along the grain than across it. The longitudinal modulus can be adequately accounted for in terms of the orientation of the microfibrils, which varies from species to species and also within the same tree. In Fig.2 are shown measurements relating the longtitudinal elastic modulus of a wood sample to its position in the tree relative to

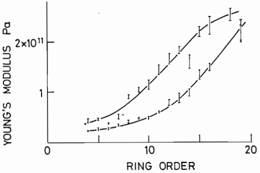

Fig.2 Relation between Young's Modulus and ring order (Cowdrey and Preston, 1966).

ring number. The higher elastic modulus values in the late growth regions (at the outside of the trunk) are due to the smaller orientation angle of the microfibrils.

The lateral modulus is much smaller due to the larger orientation angle of the S2 microfibrils and to the much greater proportion of lignin, between and within tracheids, acting in a load bearing capacity. The lateral modulus is also dependent on the orientation of the sample — whether it is radial (quarter cut) or tangential (slab cut) — it being a maximum for radial, reaching a minimum at 45° orientation (skew cut) and increasing again towards 90° (slab cut).

There is much variability in the structure of wood between species, particularly in the uniformity of tracheid sizes. This is especially so in hardwoods which exhibit a wide range of cell diameters and are further complicated by the distribution of non-structural cells responsible for tree metabolism, such as vessels, many aligned in the lateral or cross grain direction. This can therefore lead to wide variations in wood's mechanical properties.

A further important effect on the mechanical properties which must be considered is the uptake of water or moisture by wood. This can range from 0% for oven dried wood to 30% (on dry weight) before surplus water is evident. The moisture content affects the mechanical properties — wood being "stiffer" or of higher elastic modulus when dry. The moisture is capable of disrupting molecular bonds in the matrix thus reducing stiffness. It cannot enter the crystalline cellulose microfibrils.

ACOUSTIC VELOCITY

The mechanical properties of relevance to instrument making appear to be Young's modulus in the longitudinal (in grain) and in the lateral (cross grain) directions and the respective loss moduli or damping constants. Shear moduli may have some effect but this is considered to be minor. Acoustic velocity or sound speed of a medium has been widely used to characterise woods. It is related to the mechanical properties by the equation

$$C = (E/\rho)^{1/2} \quad (1)$$

where E is Young's modulus, and P is density.

A wide range of acoustic velocity values have been measured for different woods. In the longitudinal direction, i.e. along the grain, sound speed may vary from 3 to 6 km/s. Across the grain it is much lower ranging from 0.8 to 1.8 km/s. The most useful modern data is that due to Haines [1979] who made measurements on a wide range of woods of interest to luthiers. Some of his data are summarised in Table 1, from which can be noted the marked anisotrophy attributed to wood's unique morphological structure.

TABLE 1
Mechanical properties of wood (from Haines 1979)

Wood	spruces	cedar	maples	rosewood
Density(p) (kg/ms)	470	390	650	730
Acoustic velocity (km/s):				
Longitudinal C_l	5.5	4.8	4.0	4.1
Lateral C_t	1.4	1.4	1.8	1.8
Young's modulus (GPa):				
Longitudinal E_l	14.2	9.0	10.4	12.3
Lateral E_t	0.9	0.75	2.1	2.4
Log. decrement:				
Longitudinal	.023	.015	.038	.023
Lateral	.067	.038	.067	.042
Ratios:				
$E_t E_l$	.06	.08	.20	.21
C_l / ρ	11.7	12.3	6.2	5.6

ACOUSTIC DAMPING

The vibration damping properties of woods are of relevance to their use in musical instruments. This damping results in a loss of acoustic energy and hence can reduce the effectiveness of an instrument producing sounds. Damping or damping loss may be characterised by the decay time —the time required for vibrations to decay — or by the Q of the material, which may be determined from the bandwidth of a wood sample's resonance curve, the greater the Q the lower the damping. Both measures have been used in the past to specify vibration damping.

In wood there are several different mechanisms that may cause damping of acoustic vibrations. The particular mechanism involved will depend primarily on the frequency of vibration. At very high frequencies, small motions of atoms will generate heat and cause damping. At very low frequencies (e.g. creep or viscous flow) large scale motion of molecular sections have a similar effect. Each mechanism has a characteristic time constant and damping will be at maximum when the frequency of vibration matches the resonant or characteristic frequency of the particular damping mechanism the reciprocal of the decay time).

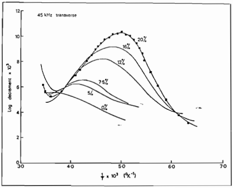

Fig.3 Damping loss versus temperature for various moisture contents (Dunlop, 1978).

Another important factor which affects damping is the temperature of the material. At low temperatures the material appears to freeze and hence the characteristic frequency of the damping mechanisms is increased. If the damping is measured at different temperatures the results shown in Fig.3 are typical. These show the damping in wood at 45 kHz as a function of temperature for various moisture contents. Similar curves at a frequency of 1 Hz have been obtained by Noack and Becker [1968].

Each damping mechanism is therefore characterised by combinations of frequency and temperature at which the damping is maximum. This phenomenon can be illustrated graphically as shown in Fig.4. On this graph two straight lines are shown determining the positions (in frequency and temperature) where the damping of two separate mechanisms are located. The higher temperature mechanism [Noack and Becker] is considered to be due to large scale motion of side chains in the lignin molecules. The lower temperature mechanism [Dunlop 1978] is due to absorbed water in the wood structure, principally the lignin.

These damping mechanisms are located in the lignin as the cellulosic microfibrils are highly crystalline, relatively impermeable to water and have extremely low damping. Thus damping measured in the longitudinal direction (along the grain) is much lower than on the lateral direction, [Dunlop 1978] — by a factor of 3 for softwoods, slightly less for hardwoods. The values of damping observed by Haines at different frequencies in the audio range are indicated in Table 1 for some woods of interest to luthiers.

The frequency range of interest to musical instruments is 100 Hz to 20000 Hz at room temperatures. This region is indicated on the graph of Fig.4. and it can be seen that it falls between the maxima of the two damping mechanisms indicated. The damping from each mechanism overlaps the region but the damping from the high temperature mechanism especially at high moisture contents probably predominates. Damping of wood instruments would be relatively greater in hot humid conditions and be more evident at low frequencies. Conversely some slight increase in high frequency damping may occur at low temperatures.

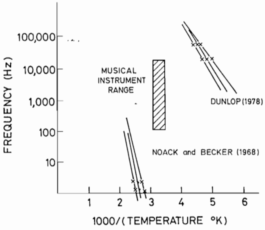

Fig.4 Temperature frequency map showing the locations of damping mechanisms. Crossed area indicates location of interest to music.

STRUCTURE OF INSTRUMENTS

The most usual structure of string instruments is a closed box with relatively short stiff sides. The top and bottom plates are excited into flexural vibrations, which are the principal source of sound. The sounds emitted by the instrument will depend on the vibration patterns excited, which in turn will be directly dependent on the properties of the wood.

The top plate with its f holes and cross bar has been traditionally designed as the principal sound source and the choice of woods used in its construction has been most restricted. Recent analyses of the top plate vibrations using finite element analysis [Schumacher 1988] have indicated that the critical properties of the wood used are Young's modulus in the longitudinal and lateral directions and the shear modulus perpendicular to the longitudinal direction. These properties of the wood determine the mode shapes possible within the dimensional constraints of the plate and hence determine the tonal character of the instrument. In the most common choice of woods the ratio of lateral to longitudinal modulus (E_l/E_l) is fairly closely maintained at 0.06 in spruce (for violins) and slightly greater at 0.08 in cedars (for guitars) usually from quarter cut section. For bottom plates, higher values (up to 0.25) have been favoured in maples and rosewoods suggesting their greater role as a structural element in the instrument. There is some uncertainty in the necessity of reproducing these ratios however, as experiments by Haines [1980] has shown that they can be substantially modified (increased) by varnish and fillers, and plywoods have been used successfully in instruments.

The damping properties of the wood will also be influential in characterising the tone of an instrument — the greater the damping the "duller" will be the sound. Plate vibration damping will depend on the damping properties of its constituents — the wood, varnish and filler. The damping properties of varnishes are usually much higher than those of woods but the exact contribution of each to instrument damping is uncertain. Traditional choice of woods by luthiers suggests that the damping characteristic of the wood is most critical, and Haines notes that the very low damping constants of guitar woods (cedar and rosewood) are necessary for "sustain" and can be troublesome in violins.

The frequencies of modes excited in instrument plates will depend on several properties of the wood — moduli, thickness and density. If traditional good instruments are to be copied there is a need to know when two pieces of wood are acoustically equivalent or matched — their elastic moduli and density may be different. As the main acoustic response of the instrument is flexural vibrations of the top plate, matching of flexural stiffness and density per unit area is important. The flexural stiffness of a plate is proportional to Eh^3, where E is Young's modulus and h is plate thickness. Thus for matching $E_0h_0^3 = E_1h_1^3$ where the subscripts 0 and 1 refer to the old and new instrument. Equal densities per unit area require that

$$\rho_0 h_0 = \rho_1 h_1$$

Combining these two equations and using equation (1) yields

$$C_0/\rho_1 = C_1/\rho_1$$

This means that if C and ρ cannot be duplicated separately the ratio of C/ρ should be the same for both species and the thickness adjusted to obtain the correct mass per unit area. This assumes that the ratio of longitudinal to transverse velocity remains the same in both species (which may not always be the case).

This characteristic of wood, the ratio of C/ρ, has been used previously to classify woods [Barducci and Pasqualini 1948] and Fig.5 shows their representation of a wide selection of timbers. In this diagram the values of the Q of each timber (inverse of damping) is shown as well as the ratio of C/ρ. From the figure it can be seen that one traditional violin wood, Norway spruce, (Picea excelsa) exhibits both a high C/ρ ratio and low damping. Norway maple (Acer platanoides) a traditional back plate wood has a much lower C/P ratio and higher damping. Also of interest on this figure is Thuja plicata (a cedar) that exhibits more pronounced features in terms of C/P ratio and damping than Norway spruce and is often used for guitars.

CONCLUSION

There is still much uncertainty in the connection between the mechanical properties of woods and their performance in stringed mucical instruments. The characteristics of good traditional instruments suggest some of the properties which appear to be critical and hence should be sought — a high C/ρ ratio in the grain direction, low damping and low E_l/E_l modulus ratio — for the top plate in particular. Thus some wood characteristics might be favoured such as wood species, with late wood growths and quarter cuts being preferred. The properties of woods found in other components of the instrument appear to be less unique in their characteristics.

There are, however, many other factors which can effect the ultimate performance of the instrument—the effects of varnishes and fillers used to finish the instrument and the variabilities inherent to hand made products. Thus it is certain that the skills and intuition of the maker will continue to play a major role in determining the quality of the finished instrument.

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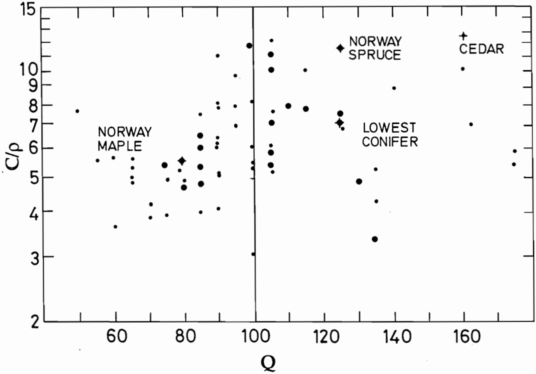

Fig.5 Parameter C/ρ versus Q (inverse of damping) for various woods (Barducci and Pasqualini, 1948).

A Violin Quality Assessment Method: Study II

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ABSTRACT: The second phase of a study for assessing violin quality is discussed. The test sounds comprised an open note and an octave scale on each string of three different violins played by the same performer. An audience of 29 listeners from the 1989 Chamber Music Summer School at Mount Buller, Victoria made assessments of Projection (Carrying Power) and Tone Quality for each of the violins played.

INTRODUCTION

A pilot study in a violin quality assessment method was reported in Acoustics Australia [1] following the administration of a violin quality rating exercise at the 1988 Riverina Summer School for Strings (Wagga, NSW). This rating exercise was performed by scoring four unseen violins, A, B, C, D for seven quality properties on a scale of +2 to −2 during cycles of playing by two violinists. It was anticipated that this rating procedure would be refined in subsequent administrations in the light of the pilot study and in response to feedback from the audiences and violinists performing the rating procedure. This paper reports on a second rating exercise at the January 1989 Chamber Music Summer School hosted by the Australian String Quartet at Mount Buller, Victoria.

METHOD

The 1989 Mt. Buller Summer School, accommodated in the comfortable Jungfrau and Benalla lodges, drew about forty participants ranging in age from 17 to senior years, dedicated amateurs and full time string students. On this occasion the participants were introduced to the rating method at the inaugural evening "Happy Hour" by rating two red wines between +2 and −2 for six qualities on a "wine rating form". After some intensive tippling by young and old, the individual ratings were totalled to give a rough measure of the group consensus on the wine qualities. Though the results were meaningless due to an apparently random spread of group opinion, indicating a lack of consensus (beyond the personal preferences recorded), familiarisation with the method in preparation for the violin rating was accomplished amidst bravado and vigorous debate.

The instructions heading the Violin Rating Forms were: "If the violin you are hearing (or playing) impresses you with any of the properties set out below, write a +1, and if the impression is strong, write a +2. If the violin strikes you as deficient in any of the properties, write a −1 or −2 according to the degree of deficiency. Write a 0 if you feel the violin is average or normal for that property. Only write next to those properties you consider meaningful. Comments are helpful."

The +2 to −2 scale is regarded as more meaningful than 1-5 or 1-10 because the participants can quantify each property within two degrees of positive or negative above or below the normal or average 0, which stands as a quality reference point. Thus terms typically used to describe sensory impressions which are usually subjective can be quantified: excellent = +2, good = +1, average = 0, poor = −1 and very poor = −2 (and more vernacular equivalent terms can be colourfully employed within the same scale).

Participants at the 1988 Wagga Summer School had found some difficulty in rating seven properties between +2 and −2 for each of the four violins, so for the 1989 Mt. Buller School the properties were reduced to five as shown in **Table 1**. However when the exercise was performed on the evening of Jan. 24, confusion about the meaning of the properties was expressed, first whether the words chosen to denote audible qualities could be regarded as +, − poles of those qualities, and second, if the properties were independent: e.g. "brightness and clarity" could well be components of "projection and carrying power". Members of the Australian String Quartet suggested a further simplification of the rating form and playing format. This discussion resulted in the "bare essentials" form shown in **Table 2** with which a second

TABLE 1
Violin Rating Form I

Property		Violin A	Violin B	Violin C	Violin D
Projection or Carrying Power					
Tone Quality	Bright or Clear (Dull or Muffled)				
	Full or Rich (Thin or Harsh)				
	Open (Closed or Boxy)				
Total					
For Players: Evenness, Ease of Response					

Comments:

TABLE 2
Violin Rating Form II ("Bare Essentials")

Property	Violin A	Violin B	Violin C	Violin D
Projection or Carrying Power				
Tone Quality				
Total				
For Players: Evenness, Ease of Response				

Comments:

exercise in rating three violins with one player was performed on Friday Jan. 27. The playing format was also simplified to an open note then an octave scale on each string of each violin, whereas on the Tuesday session two players had played a two-octave scale and an excerpt of a Bach partita on each violin.

On each occasion the audience listened to a playing cycle on all violins to familiarise with the task before recording their scores during two more playing cycles. As at the Wagga School, the audience faced away from the player(s) so they could not see the instruments which were only identified as A, B, C, D as they were played. This arrangement also reduces the level of direct sound heard by the listeners, so that the ratings depend more on indirect or reverberant sound, which is a fairer representation of a violin's overall performance.

As in the introductory wine rating exercise, the individual scores were totalled for each property, publicly, from a show of hands and recorded on an enlarged rating form displayed on a wall. This exhibited immediately some measure of the group opinion on the qualities of the three violins and in the showing of hands the level of agreement amongst the audience on the rated properties was indicated, a procedure inciting lively debate about the relative merits of the three violins.

AUDIENCE RESPONSE TO THE RATING PROCEDURE

The condensed rating form enabled all 29 listeners to complete ratings of two properties per violin within the two playing cycles (following the familiarisation cycle) of open notes and octave scales on each string of the three violins. (In the Tuesday rating, five properties for four violins had to be assessed). Most listeners thought the condensed form allowed better focus on each instrument, though elimination of subdivisions in "tone quality" increased uncertainty about the nature of that property i.e. some found resolving this important but ill-defined property into components specified its nature and assisted rating. There seems to be a trade-off between the simplicity of the rating form and the definition of the properties rated.

Several listeners entered comments in the space provided on the forms and registered impressions about the characteristics of the violins on the different strings, a common theme in discussions of violin quality. The open string and octave playing format encourages this perception. Some listeners felt a piece of music played (as in the Tuesday session) is necessary for an impression of musical quality in rating an instrument.

Naturally great interest in the relative scores of the three violins was inspired during the public summation of the ratings, and the final identification of the instruments, A, B and C stimulated comment, debate and requests to try the instruments in private to ascertain whether the audible characteristics corresponded with playing characteristics. The value of focusing attention on the tonal properties of different violins in this rating exercise was generally acknowledged.

TABLE 3
Violin Rating Results from Form II

Property	Violin A	Violin B	Violin C
Projection or Carrying Power	0.32, 0.77 (0.38, 0.77)	1.07, 0.81 (1.23, 0.73)	0.92, 0.94 (1.23, 0.60)
Tone Quality	0.03, 0.98 (0.15, 0.80)	1.00, 1.11 (1.30, 1.03)	1.14, 0.72 (1.46, 0.66)
Total	0.35, 0.88 (0.53, 0.79)	2.07, 0.96 (2.53, 0.88)	2.06, 0.83 (2.69, 0.63)

Violin A: "poor" violin, mid nineteenth century Mittenwald.
Violin B: new violin, made in Australia, 1988, to pattern Guarneri del Gesu, 1733.
Violin C: "good" violin, J.B. Guadagnini, 1751.

DISCUSSION

Table 3 shows average ratings on the +2 to −2 scale and the standard deviations derived from the 29 "bare essentials" rating forms completed on Friday 27 Jan. Results from the Tuesday 24 Jan. rating are not shown due to the confusion expressed by the audience about the meaning of the properties and their opposites. In brackets are shown the average ratings and standard deviations for 13 violinists in the audience of 29 musicians.

While the standard deviations (s.d.'s) were with one exception less than 1, the unit of the rating scale, indicating an acceptable consensus of audience opinion on the properties of the violins, the average s.d.'s in the totals were about the same as those derived from the 1988 Wagga rating exercise. Hence no improvement in consensus was achieved by familiarising the Mt. Buller audience with the rating method and by condensing the rating form to allow better focus on the fewer properties to be rated. This is disappointing, but perhaps not unexpected after the debate about the subjective meaning of the properties being rated, the appropriate playing format and the listening conditions. Given that the individuals in the audience are assigning a measure of quality to an enormously complex auditory signal from a variety of backgrounds and musical experiences, the possibility that we may never achieve greater consensus (evident in smaller s.d.'s) than reported in these studies must be considered. This would imply that the variation of opinion on violin tone measured in these string-playing audiences is a fair indication of the range of taste in the musical community at this time and place in history.

Nevertheless there are some trends in the s.d.'s which are worth noting. While it was found in the Wagga study that the lowest s.d. in scores occurred with the highest ratings, in this study, the violin C rated highest by the 13 violinists had the lowest s.d.'s. but the next highest rated violin B (in fact statistically equivalent to the highest rated) had the largest s.d.'s. We cannot attach high significance to the results from such a low sample under (13), except to observe that both violinists and total audience varied much more in their opinions of violin B's quality than they did for violin C. Comments on the rating forms referred to B's "full", "rich", "mellow" and "open" lower range sound while C was considered "balanced" and "even". Further discussion with participants suggested it is harder to interpret a strong impression in the lower strings than a "balanced" one, and this may account for the different consensus of opinion on two violins of overall equal quality rating.

The three violins used in this rating were chosen after criticism from the Tuesday rating that the four violins presented on that occasion were all good instruments and difficult to distinguish. Hence for the Friday rating I selected a demonstrably "good" violin, a demonstrably "poor" violin (in the opinion of its owner) and an untried new violin. The "good" violin was a prime example of the work of Johannes Baptista Guadagnini (1711-1786) who, with Carlo Bergonzi, is regarded as the principal heir to the standards and traditions bequeathed by Stradivari. This instrument of 1751 was acquired in 1952 from connoisseur and dealer Emile Francais by teacher and benefactor Richard Goldner (who initiated Musica Viva in Australia) and subsequently donated to a promising soloist. It is now held in trust for assignment to leading Australian musicians, currently William Hennessey, leader of the Australian String Quartet, who made it available for this exercise.

The "poor" violin was a mid nineteenth century Mittenwald instrument, nicely crafted in attractive tonewoods with high belly and back arching. Its evident mediocrity (as rated) may be due to its state of adjustment rather than its acoustic design, although highly arched violins are rarely favoured for modern playing styles. The new violin was made in Australia in 1988 to a pattern of Guarneri del Gesu, 1733.

A critic of this method for assigning a measure of quality to a violin from audience ratings might raise objections citing the complexity of the tone production, transmission, reverberation, reception and assessment processes upon which a quality judgement depends. The variable effects of the player(s) on the different instruments, the type of exercises and examples played, the state of adjustment of the instruments, etc. may also be debated. It is pertinent to reply that all these objections apply to every other situation in which violins are judged in subjective terms and where non-musical factors bear heavily on the qualities assigned. This method removes two of the strongest non-musical factors from the assessment process: the age of the violin and its maker and the expressed opinion of the most experienced or assertive musician involved. In this case all the violins were strung with Pirastro Eudoxa, the same notes were played by the same violinist with the same bow in a reasonably reverberant room. In the Wagga exercise and the first Mt. Buller exercise two violinists played and differences in qualities due to differences in styles were noted. One violinist argued that the differences due to playing styles were greater than the differences between violins, but most listeners were satisfied that the audible qualities of the violins played emerged through the playing styles.

The result that a raw (little-played) modern violin was rated essentially equal to an Old Italian Master Instrument is surprising to string players subject to the premise that old pedigree instruments are unsurpassed in projection and tone quality. In fact objective comparisons of old and new professionally crafted instruments conducted since the 1930's [e.g. 2, 3, 4] demonstrates the inability of connoisseurs and audiences to distinguish between old and new instruments. Playing tests are harder to devise since players receive many non-musical cues from the instruments they hold, even blindfolded. The evenness and ease of response of a superior instrument inspires security and confidence in the player, and is regarded as the ultimate test of an instrument's quality even when listeners cannot distinguish differences. Old violins are held to excel in ease of response, and apocryphal accounts of the majestic powers they release in players adorn the pages of violin journals, such accounts being now de rigeur for journalistic respectability. Hearts duly inflamed to gain admittance to the league of the Old Italian Sound, string musicians are driven to financial haemorrhage to meet the prices commanded by the assumed musical masterpieces, thereby feeding the cycle of supply and demand for rare violins. Within this established scenario the committed musicians cannot afford to even contemplate the equivalence of old and new violins and so objective comparisons are not approved or recognised. One of the unfortunate consequences is that musicians pay excessive prices for even mediocre old instruments and do not consider seeking superior new ones. Fortunately several leading virtuosos perform and record routinely on new instruments at no disadvantage to quality of sound.

CONCLUSION

We have reported here on a second Violin Quality Rating Exercise following a foregoing (1988) pilot study of the rating procedure. Redesign of the rating form and administration format in an attempt to improve audience consensus on the rated qualities will continue, even though no consensus improvement in the rating was achieved in this second study.

ACKNOWLEDGEMENTS

I am sincerely grateful to Jim Vizard for inviting me to contribute to the 1989 Mt. Buller Summer School and for fostering this assessment exercise amongst the participants. Eleanor Lea and Tamsin Bailley conscientiously played all violins as fairly as possible for the ratings.

This is another study in a program of music acoustic research funded by the Australian Research Council.

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(Received 17 May 1989)

ACTIVE NOISE CONTROL INSIDE AIRCRAFT

An active noise control system is being developed by the university of Adelaide's Department of Mechanical Engineering to reduce noise inside aircraft.

The project is particularly aimed at light aircraft and small aircraft and is backed by a substantial government and private fund grants.

Just one year old, the project got off the ground with the initial injection of a $182,500 grant from the Sir Ross and Sir Keith Smith Fund. This grant was the first to be made by the Fund since it's establishment in1986.

The Fund was set up in memory of South Australia's pioneer aviators through the advancement of the science of aeronautics in South Australia Lady Smith, Sir Keith Smith's widow, bequeathed her entire estate for this purpose.

This grant was followed by another of $60,000 through a university Research Grant and a Department of State Development and Technology Grant of $10,000.

Noise in an aircraft is an occupational hazard for pilots of small aircraft and also affects passenger comfort. Most pilots have ear damage after a few years flying.

The six academic staff members working on this project are making good progress. The project is expected to reduce noise levels by half to threequarters.

NASA is also working on a similar system in the United States, which can be adapted to larger aircraft.

One of the research team, Dr. Colin Hansen, said the group was constantly in touch with NASA and was working in close co-operation with them.

"It's a situation where we are both funded by our own countries and are working together to achieve the same end."

An effective noise control system is the active suppression of unwanted noise by the introduction of appropriately phased noise from one or more secondary sound sources.

"Noise energy cannot be cancelled on a global basis, although local areas of cancellation are possible. All the experiments we have conducted so far have involved manual control, using frequency to find out whether a secondary noise source should absorb some of the noise or change what the primary noise source radiated due to that secondary sound", he said.

"Construction of an automatic control system will adjust the vibration actuator outputs to minimize interior noise at a number of locations and will adapt itself to changing aircraft operating conditions.

"The key to noise control is to minimise the primary noise getting past the secondary source.

"While noise energy cannot be cancelled out, as some theories in the past have suggested, it can be absorbed or changed by using a secondary noise source.

Dr. Hansen also said there are two schools of thought on noise control. "The first says a lot of speakers should be used inside the aircraft, to achieve noise reduction at various, localised locations throughout the aircraft.

"Although speakers can control the noise coming into the aircraft, the problem is that the speakers don't minimise the total amount of noise energy coming in - they only achieve local areas of reduced noise.

"The second school of thought says stop the noise coming in to start with. To do this the fuselage design must be changed to reflect the noise from the propellers, rather than transmit it into the aircraft.

"Vibration creates the aircraft noise, so vibration actuators have to be positioned on the fuselage.

"That is a complicated exercise because it depends on the size and areas which vibrate as to where the actuators must be placed," said Dr. Hansen.

It is the second school of thought which the research team supports. Funding for the project runs out at the end of this year and the research team is not committed to having something operational by then, but it must show that such a system can work in a complicated cylinder similar to an aircraft fuselage.

It is thought that at the end of the year the Adelaide research team will have developed a technique for specific application to small aircraft with the eventual goal of producing the hardware which can be retrofitted to existing light aircraft.

The project has great scope because the techniques developed will also be applicable to the control of noise inside motor vehicles and ships, externally radiated noise from ships, noise from rotating machinery, engine exhausts, electrical transformers and timber milling and metal cutting saws.

"I guess the end result would be that aircraft manufacturers would incorporate this system in new aircraft designs," said Dr. Hansen.

(From Laboratory News, July 1989)

REPORT

ACT Noise Control Ordinance Seminar

Joseph Lai

Department of Mechanical Engineering
Australian Defence Force Academy
Campbell, ACT 2600

A seminar on the ACT noise control ordinance was organised by the Acoustics and Vibration Centre at the Australian Defence Force Academy and was held in the afternoon on 11 May 1989. The aim of this half-day seminar was to provide a forum to discuss the ACT Noise Control Ordinance which was introduced in November 1988 with the intention to review the provisions after 12 months of its operation. Speakers were invited from various sectors, including the Environment Protection Section of the ACT Adminstration, Comcare and Acoustics consultants. The seminar was attended by about 40 people from academic institutions, government and industry sector, and various clubs and unions.

The seminar was held in two sessions. The first session dealt with the Ordinance itself while the second session took the form of a panel discussion and examined the various aspects of the Ordinance. In the first session, a background to the introduction of the Ordinance was outlined by **Hugh Crawely,** Manager, Environment Protection Section, ACT Administration. The drafting of the Ordinance started in mid-1983 and was based on established noise control measures adopted in all other States, and the recommendations by the National Medical and Health Research Council and Australian Standards. A brief introduction to some of the terms used in the Ordinance such as sound pressure level, A-weighting function and daily noise dose was given by **Joseph Lai** from the Acoustics & Vibration Centre. **George Knight,** from the Environment Protection Section of the ACT, then gave a summary of the Ordinance, emphasising that the purpose of the Ordinance is to promote co-operation for a better acoustic environment rather than to prosecute offenders. The Ordinance covers most noise generating sources except motor vehicles, animals, trains and aircraft. The Ordinance provides for protection against excessive noise in the environment by defining the criterion for excessive noise, by limiting the hours for operation of certain items such as lawn mowers and by prohibiting the sale of articles exceeding the prescribed levels or of unlabelled articles. The Ordinance also provides for hearing conservation in the workplace by requiring noise reduction when a noise exposure exceeds a daily noise dose of 0.33. Between November 1988 and March 1989 there were 1,189 complaints received compared with about 220 per year prior to the introduction of the Ordinance. The major sources of complaints have been related to noise from air conditioners and swimming pool pumps. So far only six noise direction notices have been issued, and they have been complied with.

In the second session there were four speakers who each expressed their view on a particular aspect of the Ordinance. **Marion Burgess** from the Acoustics & Vibration Centre pointed out two disadvantages of using measured background level for the definition of excessive noise, namely, the increase in background noise levels with time due to an increase in activities and the difficulty in obtaining accurate representative background noise levels under certain circumstances. **Greg Ash** from Comcare examined the Ordinance from the point of view of hearing conservation in the workplace and predicted that if the daily noise dose limit of 0.33 specified in the Ordinance is adhered to, then the compensation payout for hearing impairment will be greatly reduced. **Mark Eisner,** a private acoustical consultant, representing himself and **Eric Taylor** (also a private acoustical consultant), discussed the role of an acoustical consultant dealing with noise problems and commended the introduction of the Ordinance in the ACT. The legal aspects of the Ordinance were discussed by **Di Dibley,** a lawyer. She considered the quantification of excessive noise as the greatest attribute of the Ordinance. However, in its present form, the Ordinance does not provide relief for noises most commonly encountered in residential areas, such as animals' noise, traffic noise, etc. Furthermore, the Ordinance contains provision for exemption and the terms used such as "reasonable excuse" or "reasonable grounds" are not specific. What constitutes a "reasonable excuse" is unclear and has to be clarified by test cases.

Each of the presentations had allowed for a short question time but the general discussion was held following the last talk. A wide range of issues were raised, ranging from control of animal noise, traffic noise, skateboard ramp noise to hearing conservation in the workplace, clubs, concerts and at school socials. Concern was expressed about low frequency noise, such as that generated by music bands and the need to take into account the tonal components in the specification of excessive noise. Suggestions were made to improve the definition of excessive noise, such as using octave band specifications, defining excessive noise according to the noise source, etc. It was pointed out that this could be implemented in the Noise Control Manual to be prepared for use with the Ordinance. It was also suggested that instead of using the measured background noise as the basis for quantifying excessive noise, acceptable sound levels could be specified for areas through a zoning system as adopted by some other States. It was felt that traffic noise should be brought under the control of the Ordinance and that consideration should be given to the operating hours of garbage collection. An interesting question was posed as to the obligation of parents and the school authority to hearing conservation of teenage children attending rock concerts or school socials as apparently they are not protected under the Ordinance in such situations.

On the whole, the general feeling at the seminar was that the Ordinance is a step in the right direction and even in its current form it has alleviated some noise problems experienced by people in the ACT.

Modal Analysis: Four New Application Notes

Bruel & Kjaer has released four short application notes concerned with modal analysis.

The first of these, *Mobility Measurements*, provides a short, practical introduction to the field, with an overview of the applications.

An Introduction to Modal Testing outlines the theory of modal testing and illustrates the ease with which a Bruel & Kjaer modal analysis system can be applied to real-life problems.

How to determine the modal parameters of simple structures illustrates how modal frequencies, damping and mode shapes can be found from basic measurements by using only a Type 2032 Dual-channel Signal Analyser or a Type 2034.

The fourth application note, *Four-channel Modal Testing*, explains how a simple modification within the Type 2032 or the Type 2034 permits simultaneous measurements of the force input and the vibration response of a structure in three directions. This modification saves time and brings about greater accuracy.

REPORT

Activities in Department of Mechanical Engineering

David Bies

Department of Mechanical Engineering
University of Adelaide

Our book, Engineering Noise Control: Theory and Practice, D A Bies and C H Hansen, Unwin Hyman, UK, became available in January of this year in Australia. It represents a development effort of about eight years with some very concentrated work in the last two.

Colin Hansen and I have also collaborated in the preparation of three papers. Two on the relationship between noise induced hearing loss and noise exposure have been submitted to JASA and are under review. In these papers we show that noise induced hearing loss scales on the integral of pressure (not pressure squared) with time and we show how to add the effects of noise induced loss and presbycusis. To make our case we have used data provided by ISO draft standard 1999 and annexes. We have shown that earlier work of Burns and Robinson and Glorig also supports our conclusion. As we are attacking ideas which have become deeply entrenched over a period of 37 years we expect objections and thus we have carefully prepared our case in expectation of a fight!

The third collaborative paper by Colin and me is concerned with attenuation of sound propagating in straight lined ducts with mean flow of uniform but arbitrary cross section and bulk reacting anisotropic linings covered by a limp membrane. Locally reactive and isotropic bulk reacting linings are included as limiting cases. A considerable effort has gone into appropriate programming as one of the two equations resulting from the analysis is transcendental. However, we are now readily able to generate useful design curves in terms of convenient dimensionless variables. This paper will be submitted to JSV. It is also the subject of a poster paper for the ASA May '89 meeting in Syracuse, NY. I will attend the latter meeting and present the paper.

Colin Hansen has taken up the pursuit of active noise control. He and his very capable PhD student **Scott Snyder** have written several fundamental papers on the subject. Other papers on the same subject have been written by Pan Jie, C H Hansen and D A Bies. Besides conference proceedings they will appear in JSV and JASA.

Graham Furnell, an applied mathematics student jointly supervised by Dr Peter Gill of Applied Maths and me, has recently submitted a PhD thesis on the general subject of sound propagation in ducts of arbitrary curvature and cross section. He and I have co-authored two papers on his subject describing new procedures which will appear in JSV. This work represents an important advance on the subject with very wide application.

Pan's thesis on room acoustics shows that in general Morse's assumption of locally reactive walls can only be justified (considered true) when the acoustic field is diffuse. When the field is not diffuse then in general modal coupling between the acoustic field and the walls of any enclosure will determine the acoustic field transient response (reverberation time) and Morse's assumption is then useless. While these facts have been recognised with respect to sound field response in vehicles of various kinds no one appears to have previously made the extension to the important cases of architectural acoustics. One paper has previously been published by Pan Jie and D A Bies and four more are presently under review for publication in JASA. This work has important implications.

Dr Pan has addressed an issue in his thesis raised by Morse himself in his fundamental 1939 paper, "The original analysis of the room acoustics problem", which seems to have been totally ignored and never questioned in the intervening fifty years of research and publication on the subject with one exception. Evidence of modal coupling in our reverberation room is described in a Master's thesis by Tom Munro, one of my former students, but we didn't publish anything.

☆ ☆ ☆

Australian Noise Abatement Policies —Some findings on their effectiveness

Marion Burgess

Postscript to Article in

Acoustics Australia

Vol 17, No 1 (1989) p 15

Since the preparation of the diagrams in Appendix A, the involvement of the Commonwealth environmental agency (currently called the Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT)) with the noise related committees of the AEC and ATAC has changed. Following a review of the best allocation of the limited staff resources within DASETT the department has decided that it must substantially reduce its involvement in the environmental noise area in order to meet other priorities. Accordingly DASETT will no longer provide the secretariat for the Environmental Noise Control Committee (ENCC) or for the Advisory Committee on Vehicle Emissions and Noise (ACVEN).

The role of the secretariat for these committees includes assistance for the Chairman, preparation of the documents for the meetings and ensuring that actions are taken on decisions agreed to at the meetings. The secretary from the Commonwealth agency has provided continuity for the committees and has been able to play a key role in assisting consultation and co-ordination between the relevant bodies on environmental noise matters.

At this stage no decision has been made on the manner in which the secretariat services will be provided for ENCC and ACVEN in the future.

BOOK REVIEWS

MACHINERY NOISE AND DIAGNOSTICS

Richard Lyon

Butterworths, 1987, ISBN 0-409-90101-6, Australian Distributor: Butterworths Pty Ltd, PO Box 345, North Ryde, NSW 2113, Hard Cover, Price A$89.

Machinery Noise and Diagnostics is a most welcome addition to the library of books on noise and vibration. It is essentially aimed at postgraduate students and at practising engineers and technologists concerned with the design of machines having less noise and vibration and at those concerned with utilising diagnostic systems for monitoring the operations of individual machines or complete processes. The book is well written and well presented and it is derived from lecture courses given by the author to postgraduate students and practising engineers over the past few years. Also, all the practical examples discussed in the book are derived from the authors own consulting experiences.

The main strength of the book is its original and unique approach to noise and vibration control. Emphasis is placed on designing out machinery noise and vibration where possible, rather than implementing 'band aid' solutions. The diagnostic potential of noise and vibration signals is also clearly illustrated with the aid of various basic and advanced signal analysis techniques and with the emphasis being continually placed on signal energy levels and signal phase. The book contains eight chapters and some useful appendices.

Chapter 1 introduces the reader to machinery noise and diagnostics. Relationships between noise and diagnostics are identified, goals of noise reduction compared to those of diagnostics are reviewed, general features of noise reduction programmes are outlined together with cost assessments, and diagnostic procedures are introduced. The chapter also emphasises noise reduction by design and approaches to diagnostic system design. The chapter is a clear statement of the theme of the book and the reader is put in the correct frame of mind. The author's original and unique approach to machinery noise and vibration is very evident from a reading of this introductory chapter.

Chapter 2 is a fairly basic chapter on sources of vibration in machinery noise. The author includes reciprocating imbalance, impact, electrical-mechanical analogies, piston slap, crank slider vibration, displacement sources in gears and cams, fluctuating magnetic forces, diesel engine combustion pressure, and turbulent flow. The various vibration sources are concisely discussed and the reader needs to refer elsewhere if specific details are required. The author provides a short but useful list of relevant books, journals and magazines in the bibliography.

Chapter 3 is a fundamental chapter about structural response to excitation. The concepts of wave motions in structures, power flow, wavenumbers, modal densities and reciprocity are introduced. Specific examples pertaining to force transmission in machine structures, structural response to imbalance, modal response of finite structures and isolator performance on flexible structures are presented. The material contained in this chapter forms the basis for the important (but often neglected) topic of structure borne sound. The reader is also referred to other specialised texts on this subject in the bibliography.

Chapter 4 is on vibration transmission in machine structures. The concepts of statistical energy analysis (the subject of a previous and a forthcoming book by the author) are reviewed here. The concept of using statistical energy analysis for organising vibration data is discussed. This is a useful tool for consultants when attempting to identify vibration sources.

Chapter 5 is a general chapter on sound radiated by machines. The topics of radiation ratios, reciprocity, bending waves, reverberant sound power, radiation above and below critical frequencies etc. are discussed here, together with numerical methods of sound radiation. The topics covered in this chapter whilst not unique to this book are presented in the authors own style and relate to various sections in other parts of the book.

Chapters 6, 7, and 8 are to a large extent the core of this book. Advanced readers could bypass chapters 2-5 and delve straight into these chapters which deal with advanced machinery noise diagnostic topics. Much of the work presented here relates to the authors own research and consulting experiences.

Chapter 6 is about diagnostics using signal energy. High frequency resonance techniques for bearing diagnostics are discussed together with power cepstrum, transfer function and inverse filters. Examples relating to a horizontal centrifuge, valve seat impact, and valve resonance are discussed in some detail.

Chapter 7 is about diagnostics using signal phase — i.e., the phase characteristics of structural transfer functions. The procedure of waveform recovery is discussed in some detail with specific reference being made to cylinder pressure. The chapter includes discussions on the poles and zeros of transfer functions, phase variability, and non-minimum phase systems. The chapter is unique as far as noise and vibration diagnostics goes, and in essence it is about recovering the temporal waveform of a source of vibration and other aspects of diagnostics using the phase of a signal. Whilst emphasis is placed on cylinder pressure recovery, enongh specific information about the procedure is provided for the reader to consider using it for other applications — procedures for the construction of inverse filters based on measured data are also provided in the appendices.

Chapter 8 delves into some of the more advanced diagnostic topics including waveform recovery for sources that operate simultaneously, diagnotic system design and application, and system identification using orthonormal functions. Chapters 6 and 7 need to be read prior to attempting chapter 8.

The appendiecs contain some useful topics including Fourier Series, Fourier Transforms, Frequency Analysis, Z-Transforms, Inverse Z-Transforms, Discrete Fourier Transforms, Hilbert Transforms, Cepstra, criteria for machinery noise and vibration, and, as already mentioned, procedures for the construction of inverse filters based on measured data.

In summary, Machinery Noise and Diagnostics is a book that all noise and vibration researchers, postgraduate students and consulting engineers should have on their bookshelves. Although the specific practical examples in the book are limited to the author's own experiences, the fundamental principles, analysis techniques and procedures described are intentionally presented in a very general format so as to be applicable to most engineering noise and vibration problems. Techniques such as reciprocity, statistical energy analysis, mechanical mobility techniques, diagnostics using signal energy and signal phase, and waveform recovery diagnostic techniques are useful and relatively new concepts in noise and vibration. The book is unique and comes strongly recommended.

Michael Norton.

* * *

INTER-NOISE 87 PROCEEDINGS

Acoustical Society of China, PO Box 2712, Beijing, Peoples Republic of China. 2 Volumes, 1,692 pp. Price: $US80 (includes postage).

These proceedings contain the pre-prints of 412 papers which were presented at INTER-NOISE 87, the 16th International Conference on Noise Control Engineering, and organised by the Acoustical Society of China and the Institute of Acoustics, Academia Sinica. The theme of the Conference was "Noise Control in Industry" and the distribution of the papers in the various categories was: General 1 per cent, Physical Phenomena 4 per cent, Vibration 7 per cent, Immission: Effects of Noise 17 per cent, Immission: Physical Aspects 12 per cent, Requirements 4 per cent, Emission: Noise Sources 17 per cent, Noise Control Elements 12 per cent and Analysis 26 per cent.

In the opening address, Fritz Ingerslev outlined the background to Inter-Noise and the relationships between the institutes and organisations for acoustics, eg, ICA, INCE, ICBEN, IEC Technical Committes, etc. The first plenary lecture was given by J E Ffowcs Williams from the University of Cambridge on "Active Control of Unsteady Flow". The second by R H Lyon from the Massachusetts Institute of Technology on "Conflict Resolution-nology on "Conflict Resolution — Noise Reduction Style". The third was given by D Y Maa from Academia Sinica, Beijing, on "General Laws and Reduction of Aerodynamic Noise".

These papers are then followed by the contributed papers which are included within each of the categories listed above. Each paper is only four pages long so only gives the main essential concepts. The value of proceedings of this nature is that there is enough data for the reader to assess if the information is of sufficient interest to warrant following up with personal communications. The breadth of topics covered by the papers also gives guidance to the current areas of research throughout the world. Inter-Noise has the reputation of encouraging papers dealing more with applications than with theoretical considerations and these proceedings would seem to justify this reputation. This practical approach is emphasised by the theme of the conference.

The proceedings would be of interest to anyone at all involved in noise control in industrial situations. They would be a valuable addition to any library and, at a cost of less than 5c (US) per page, represent excellent value.

Marion Burgess

* * *

TRANSPORTATION NOISE REFERENCE BOOK

P. Nelson (Editor)

Butterworths, London, 1987, pp500, ISBN 0-408-01446-6. Australian Distributor: Butterworths Pty Ltd, 271-273 Lane Cove Road, North Ryde, NSW 2113. Price A$220.

This book, exclusively on road, rail and air transport noise, contains 24 chapters written by 27 authors from six different countries. A recipe for disaster? Not so. The breadth of material covered, the depth of specialist knowledge contained in the individual contributions and the impressively strong editorial control has produced a thoroughly readable, and long overdue comprehensive source book on the generation, assessment and control of transportation noise.

Sections on each of the three transport modes are structured in the same way. They begin with the sources of vehicle noise and possible engineering emission controls; then on to factors which influence levels during vehicle operation and propogation to the receiver. Prediction models and mitigation strategies and wider issues associated with noise from each transportation system follow. Chapters are also devoted to vibration from each of road and rail transport. Most chapters approach a state-of-the-art review.

Two-thirds of the 24 chapters are specific to a transport mode. The remaining chapters provide a basic, but totally adequate, introduction to transportation noise measurement scales and ratings; a synthesis of findings on community response to transportation noise; and specific reviews of evidence of the effects of transportation noise on health and sleep. An overview is also provided of different methodologies for the environmental evaluation of transport plans and there are brief chapters on the evaluation of noise and economic instruments for transport noise abatement. The list of references and further readings at the end of each chapter increase the utility of the text as a source book.

What sets this book apart from other acoustic texts is its unashamed focus on transportation. Apart from *Transport and Environment* by Hothersall and Salter and *Road Traffic Noise* by Alexandre et al, neither of which have been particularly successful, workers in the field have had to rely on general texts on the effects or control of environmental noise, on relatively small transport related sections in the standard noise control handbooks, and on keeping track of where definitive material on a particular transport topic had appeared in the technical journals. Much important transport noise information, particularly with respect to aircraft noise, has also been relatively inaccessible in government or industry reports. *Transportation Noise Reference Book* is a timely solution to this omission from the book shelf for what is, after all, the most widespread pollution problem in urban areas of the developed world.

The text is comprehensively illustrated with figures many of which appear to have been redrawn to standardise the format across the different chapters. Effective editorial control is also evidenced by minimal overlap in the material of different authors, quite extensive cross referencing between chapters where this was appropriate, and an insistence on at least a common vocabulary and symbols for the multitude of noise scales. The latter was no mean achievement and broke down only a few times.

I was somewhat disappointed that chapters on noise from marine craft were not included in the text, particularly as hovercraft, hydrofoils and recreational craft are frequently found in operation near to residential areas. Noise from "new" urban transport modes such as monorail vehicles also did not find a place.

It is a book which no-one with an interest in transportation noise or transportation management should be without — though your bank manager might not agree. At least make sure your library orders a copy!

Lex Brown.

NEW PRODUCTS

Cirrus

Acoustic Editor

ACOUSTIC EDITOR is a new acoustical processing programme for IBM compatible computers. Data is taken from a Sound Level or Data logging L_{eq} meter such as the CRL 2.36 and stored as a series of data elements on the computer's disk ACOUSTIC EDITOR will allow the data to be examined in many ways and plotted out in many different forms. The calculations in ACOUSTIC EDITOR are of sufficient accuracy to meet the requirements of the Laboratory grade of the International Standard IEC 651 and CEI 804 type 0.

ACOUSTIC EDITOR can plot the variation of Sound Level against time as all the parameters such as dynamic span, time, resolution, etc. can be varied. The plot can be of any length from 1 second up to several years with a resolution from 5 mSec up to about 24 hours. The dynamic range is from —10 dB right up to 190 dB, the limit being set by the Sound Level Meter to acquire the data. If a Cirrus CRL 2.36 data logging unit is used for acquisition, the measuring span is from about 20 to 140 dB.

ACOUSTIC EDITOR offers a data filing system with clearly defined parameters to ensure not only compatibility with existing programmes but also with correct data handling. While ACOUSTIC EDITOR was designed to operate with Cirrus Research meters, special programmes are available to interface almost any currently available professional Sound Level Meter using a Cirrus interface card, allowing your existing meter to be used. While ACOUSTIC EDITOR or one of the dedicated Cirrus programmes can give almost any acoustic index you may require, it is possible to export data from ACOUSTIC EDITOR files to standard database or spreadsheet programmes such as Lotus 123, Symphony or Smart. This allows the calculations to be put into a standard report as part of the text without having to retype the data.

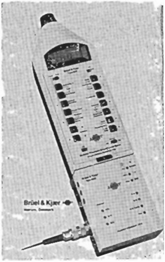
Further information: M. B. & K. J. Davidson Pty Ltd, 17 Roberna Street, Moorabbin, Vic, 3189.

Bruel & Kjaer

Human-vibration Unit and Module

Human-vibration Unit Type 2522 and Human-vibration Module BZ7105, just released by Bruel & Kjaer, combine with Modular Precision Sound Level Meter Type 2231 to form a dedicated and portable human-vibration analysis set which can measure simultaneously in up to three channels. It is ideally suited for the monitoring of human-vibration for the assessment of health risk such as Raynaud's phenomenon (vibration-induced white finger).

A digital data store allows storage of measurement data in up to 99 records, either automatically at user-defined intervals, or manually. Data can be simultaneously recorded on a level recorder or stored in the data store for subsequent hard-copy results in one in five formats. There is an easy-to-use facility for the recall of stored data to the display.



Human-vibration Unit Type 2522 with Modular Precision Sound Lever Meter Type 2231.

Sine/Noise Generator

The new high-performance Sine/Noise Generator Type 1054 offers signal purity and accuracy over a 0,01 Hz to 2,54 MHz frequency range with a frequency resolution of 10 mHz. For single, repetitive or continuous sweeps, the sweep rate is adjustable from 0,001 Hz/s to 2,54 MHz/s for linear sweeps, or 0,001 μdec/s to 4,000 dec/s for logarithmic sweeps.

Output levels from 1 mV to 5V are selectable with better than —60 dB harmonic distortion. The Generator has an amplitude linearity of $\pm$0,1 dB in the 20 Hz to 20 kHz range. A built-in compressor provides 118 dB of "live" amplitude regulation, which is continuously displayed on the Generator's front panel.

For frequently repeated tests, the Generator stores nine complete sets of control panel settings internally for instant recall. The Type 1054 also stores a 1024-point amplitude-weighting to equalise non-ideal sound and vibration test-source responses. Complex amplitude weightings are quickly entered either manually by means of the Generator's automatic interpolation feature or "learned" in connection with the built-in compressor.

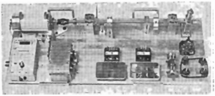
Additional features of the Type 1054 include outputs providing narrow-band, white and pink noise. The Generator also provides a 5 MHz crystal clock which can be used as a test system master-clock or synchronised with an external clock. All the front panel functions are easily programmed by using simple software instructions via the Generator's powerful IEEE interface. On the front panel the user can continuously monitor up to four control functions by means of the forty-character line display.

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

Vipac

Vibration Fault Determination Rig

Introducing a superb new vibration simulation system from VIPAC for training staff and students in vibration monitoring and fault diagnosis. The Vibration Fault Determination Rig (VFDR) allows a trainee to see, feel and learn the characteristics of a wide range of machine vibration problems in a short period of time. This simulation system gives the trainee rapid feedback and self assessment, and a "safe" environment where mistakes can be made without fear of damage.



The trainee can be exposed to real faults that may not be seen in one plant for months or even years, yet when they are he will be expected to recognise them and recommend remedial action.

Some of the faults that can be simulated by the rig include: imbalance, misalignment, gear, belt, electromechanical and journal bearing faults; as well as: bearing stiffness, resonance and torsional faults.

The system has been specifically designed for industry and educational situations where a "hands on" understanding of machine vibration is considered vital.

NEW PUBLICATIONS

Noise & Vibration Control

L Beranek

A revised edition of the now-classical 1971 text edited by L Beranek, "Noise and Vibration Control", has been published by the Institute of Noise Control Engineering. "Noise and Vibration Control" is of great value to design and safety engineers, consultants, scientists, architects, government researchers, public officials and others concerned with the control of noise emitted by machinery and with control of environmental noise in buildings, in the workplace, near airports and highways, and in the community. This revised edition has been updated to include modern methods for the determination of machinery noise emission, and the chapter on noise criteria has been completely revised to reflect criteria for control of building air system noise and criteria for control of noise around highways and around airports.

"Noise and Vibration Control" is available from the Institute of Noise Control Engineering, PO Box 3206 Arlington Branch, Poughkeepsie, NY 12603, USA. The post paid price is $38 per copy. Overseas orders for books to be shipped by air mail should add $22 per copy to cover the costs of air mail packing and postage.

* * *

Structural Testing — A Two-part Primer

What is a mobility measurement? A mobility matrix? Quadrature picking? Mode shape? What is an operational deflection shape? A modal model? Curve-fitting? What are pole location and residue? Where is the modal-space? Why make a modal analysis? The answers to these and many other questions are all given in "Structural Testing", the latest — two-part — primer from Bruel & Kjaer.

Part One, Mechanical Mobility Measurements, charts the reasons for making a structural analysis, surveys the techniques used for measuring both the excitation and response signals, and examines the application of dual-channel FFT analysers.

Part Two, Modal Analysis and Simulation, takes the reader into the world of modal testing, with its specialised techniques and computer software. A step-by-step example of a modal test charts the production of a dynamic modal model and its subsequent application for response and modification simulations.

Throughout both parts of "Structural Testing", intuitive introductions are given to the theory so that definitions are not buried in mathematical formulae. The two parts together form a comprehensive introduction to modal analysis and structural dynamics. Many realistic examples and explanatory illustrations help the reader to attain a basic understanding of these often apparently complex subjects.

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

* * *

Noise-Con 88 Proceedings

Noise Control Design: Methods and Practice was the theme of Noise-Con 88, the 1988 National Conference on Noise Control Engineering. Noise-Con 88 was sponsored by the Institute of Noise Control Engineering and Purdue University. The meeting was held on the Purdue Campus on 20-22 June 1988. The Proceedings of Noise-Con 88 are now available. One hundred papers on a wide variety of topics on noise control engineering appear in the Proceedings. Topics include fan noise control, interior noise reduction in aircraft, absorption of sound in the atmosphere, active noise control, the acoustics of open plan offices, sound power determination, acoustic holography and sound intensity.

The Proceedings will be of interest to engineers concerned with noise control technology, educators, acoustical consultants, government researchers and regulators, noise control officials, and others concerned with the technology of noise control.

Copies of the Noise-Con 88 Proceedings are available for $US60 each from Noise Control Foundation, PO Box 2469, Arlington Branch, Poughkeepsie, NY 12603, USA. If shipment overseas by air is desired, the extra charges are $19 per book. The book contains 656 printed pages.

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No 53 (March 1989).
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Vol 8, No 1 (March 1989).
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J Catgut Acoustical Society
Vol 1, No 3 (Series II), May 1989.

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Vol 21, Nos 1, 2, 3, 4, 5 (1989).

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University of Southampton.

No 163, Sept 1988, **D W Robinson,** The assessment of noise containing tonal components, 46 pp.

No 164, Aug 1988, **H G Lee,** Comparison between predicted and measured rotational frequency response functions, 30 pp.

No 165, Sept 1988, **S J Elliott** and **P A Nelson,** Multiple point least squares equalisation in a room, 22 pp.

No 167, July 1988, **C Y Chen** and **D Anderton,** Experimental determination of ground absorption in the measurement of vehicle noise, 14 pp.

No 168, **O J Wilson,** Recent developments in frequency specific threshold estimation in pre-school children, 90 pp.

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Report 122: **J Macrae,** Deterioration of hearing associated with hearing aid use, Australian Government Publishing Service, Canberra (1989).

NEW PRODUCTS . . .

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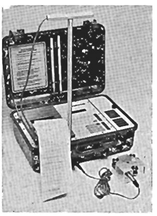

Noise versus View

One of the environmental aspects considered prior to the staging of the 1987 Birmingham Super Prix was that of noise for the residents near the streets to be used.

The circuit is approximately 2½ miles long and includes part of two main arterial roads, both of which have high rise dwellings along one side and part of the inner city ring road which passes through areas of both high and low rise housing. Many of the dwellings in the vicinity of the circuit are exposed daily to high levels of traffic noise and, indeed, many have been provided with noise insulating double glazing under the provisions of the Noise Insulation Regulations 1975. Nevertheless, it was clear from previous assessments made in 1984, when motor racing trials were held to judge the suitability of the circuit, that noise would be a significant factor. Many of the vehicles, particularly those taking part in the Formula 3000 event, have high performance engines and no silencing.

Based upon measurements and calculation, the houses around the circuit were placed into three categories,. as follows:—

(i) Significantly Affected
Where speech interference level would exceed 49 dB, ie, where it would be very difficult or impossible to follow a radio or TV commentary, even with the sound turned up loud, with racing in progress.

(ii) Moderate Intrusion
A speech interference level between 43 dB and 49 dB, ie, where it would be difficult to follow the radio or TV set to normal listening.

(iii) Properties where the effect of the race would not intrude into normal activities
ie, where speech interference levels in this region would be below 43 dB with racing in progress.

A map was drawn indicating the degree of intrusion. It was evident that almost all of those likely to experience the greatest level of noise had a first class view of the racing and were at the centre of what many considered to be the most spectacular spectator sporting event Birmingham had to offer. Experience showed that many chose to watch the racing rather than stay indoors.

It is worthy of note with peak sound levels recorded between 119 dB (A) and 125 dB (A) at various points around the the circuit, the only complaint received by the Environmental Services Department related to early morning repairs to the safety barriers occasioned by overnight vandalism.

(Extracted from London Environmental Bulletin, 4 (4), 1988)

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Publications by Australians

We are grateful to Dr Richard Rosenberger, University of NSW, for this updating of publications by Australian authors. Within each year the listing is alphabetical by first author.

1987

On the Insertion Losses Produced by Plane Acoustic Lagging Structures
A C K AU, K P BYRNE
School of Mechanical and Industrial Engineering, The University of New South Wales, PO Box 1, Kensington, NSW 2033.
J Acoust Soc AM **82 (4)**, 1325-1333 (1987).

Theory of Twin-Core Optical Fibre Frequency Shifter
P L CHU, A W SNYER
School of El Eng & Computer Sciences, The University of New South Wales, PO Box 1, Kensington, NSW 2033.
Electronics Letters **23 (21)**, 1101-1102 (1987).

Phase Spectral Evidence for Vortex Structures in Turbulent Mixing
M R DAVIS
Dept of Civil and Mechanical Eng, University of Tasmania, Hobart, Tas 7001.
J Sound Vib **116 (2)**, 303-321 (1987).

A Coincidence Damper for Reducing Pipe Wall Vibrations in Piping Systems with Disturbed Internal Turbulent Flow
I. M. HOWARD, M. P. NORTON, B. J. STONE
Dept. of Mechanical Eng., University of Western Australia, Nedlands, W.A. 6009
J. Sound Vib. **113 (2)**, 377-393 (1987).

Community Response to Noise: A Review of Factors Influencing the Relationship between Noise Exposure and Reaction
R F S JOB
Dept of Psychology, University of Sydney, NSW 2006.
J Acoust Soc Am **83 (4)**, 1325-1333 (1987).

The Effects of a Face Interview Versus a Group Administered Questionnaire in Determining Reaction to Noise in the Workplace
(1) R. F. S. JOB
(2) R. B. BULLEN
(1) Dept. of Psychology, Sydney University, N.S.W. 2006
J. Sound Vib. **116 (1)**, 161-168 (1987).

Acoustic Scattering from an Arbitrarily Rough Surface
B J KACHOYAN, C MACASKILL
Dept of Appl Mathematics, University of Sydney, NSW 2006.
J Acoust Soc Am **82 (5)**, 1720-1726 (1987).

Fun with Missing Fundamentals
T. M. KALOTAS, A. R. LEE
Dept. of Physics, La Trobe University, Bundoora, VIC. 3083
Am. J. Physics **55 (2)**, 184 (1987).

A Comparison of Modal Density Measurement Techniques
P R KESWICK, M P NORTON
Dept of Mech Eng, University of Western Australia, Nedlands, WA 6009.
Appl Ac **20 (2)**, 137-153 (1987).

Non-Linear Mode Coupling in Symmetrically Kinked Bars
K A LEGGE, N H FLETCHER
Dept of Physics, University of New England, Armidale, NSW 2351.
J Sound Vib **118 (1)**, 23-24 (1987).

Generalisation of the Method for the Estimation of the Frequencies of Tones in Noise from the Phases of Discrete Fourier Transforms
D. R. A. McMAHON, R. F. BARRETT
Weapons Systems Res. Laboratory, Defence Science and Technology Organisation, Defence Res. Centre, Salisbury, G.P.O. Box 215, Adelaide, S.A. 5001
Signal Processing **12 (4), 371-383** (1987).

Young's Modulus and Shear Modulus of a Composite Shaft from Resonance Measurements
A. SPENCER
Research Establishment, AAEC, Lucas Heights, Private Mail Bag, Sutherland, N.S.W., 2232
Composites Science Technology **28 (3)**, 173-191 (1987).

Modelling of Structure-Born Noise in Vehicles with Four-Cylinder Motors
J K VETHACAN, L A WOOD
Dept of Civil and Aeronautical Eng, RMIT, GPO Box 2476V, Melbourne, Vic 3001.
Int J of Vehicle Design **8 (4/5/6)**, 439-454 (1987).

1988

The Properties of Wood and Musical Instruments ....
K BAMBER
JAAMIM **7**, 3, No 33 (Dec 88).

Kosters Prism Time-Integrating Acousto-Optic Correlator
M S BROWN
Defence Science and Technology Organisation, Dept of Defence, Adelaide, SA 5001.
J Physics E: Scientific Instr **21 (5)**, 192-194 (1988).

Why are Old Violins Superior?
G CALDERSMITH
20 Dryandra Street, O'Connor 2601.
JAAMIM **7**, 22, No 1 (Mar 88).

The Variance of Decay Rates at Low Frequencies
J L DAVY
CSIRO Divn Bldg Constrn & Eng, Highett 3190.
Appl Ac **23 (1)**, 63 (1988).

The Effect of Moving Microphones and Rotating Diffusers on the Variance of Decay Rate
J L DAVY, I P DUNN
Div of Building Research, CSIRO, PO Box 56, Highett, Vic 3190.
Appl Ac **24 (1)**, 1-14 (1988).

Acoustic Properties of Timber
J I DUNLOP
School of Physics, Univ NSW, Kensington 2033.
JAAMIM **7**, 11, No 3 (Dec 88).

Obliquely Truncated Simple Horns: Idealized Models for Vertebrate Pinnae
(1) N H FLETCHER
(2) S THWAITES
(1) Inst of Physical Sc, CSIRO, Limestone Avenue, Canberra, ACT 2602.
Acustica **65 (4)**, 194-204 (1988).

Dispersion of Waves in Piano Strings
M PDLESAK, A R LEE
Physics Dept, La Trobe University, Bundoora, Vic 3083.
J Acoust Soc Am **83 (1)**, 305-317 (1988).

Can Sound Quality be Measured?
H F POLLARD
School of Physics, Univ NSW, Kensington 2033.
JAAMIM **7**, 8, No 2 (Oct 88).

On Estimating the Instantaneous Frequency of a Gaussian Random Signal by Use of the Wigner-Ville Distribution
L B WHITE, B BOAHASH
Dept. of Electrical Eng, CRISSP, University of Queensland, Brisbane, Qld 4067.
IEEEA Trans on Ac, Speech and Signal Processing **36 (3)**, 417-420 (1988).

ADVERTISER INDEX

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

FUTURE EVENTS —

● Indicates an Australian Conference

1989

August 6-10, PRAGUE
XX 1st CONGRESS OF INTERNATIONAL ASSOCIATION OF LOGOPEDICS AND PHONIATRICS
Details: IALP 1989, c/- Czechoslovak Medical Society, J E Purkyne, Mrs Ludmila Fortova, Vitezneho unora 31, CS-120 26 Prague 2.

● August 8-10, SYDNEY
COMPUTING SYSTEMS AND INFORMATION TECHNOLOGY 1989
Details: Conference Manager, Institution of Engineers, 11 National Circuit, Barton, ACT 2600.

August 16-18, SINGAPORE
INTERNATIONAL CONFERENCE NOISE & VIBRATION 89
Details: The Secretariat, International Conference Noise & Vibration 89, c/- School of Mechanical & Production Engineering, Nanyang Technological Institute, Nanyang Ave., Singapore 2263.

August 19-22, MITTENWALD
INTERNATIONAL SYMPOSIUM ON MUSICAL ACOUSTICS
Details: Sekretariat des ISMA 1989, c/- Muller-BBM, Robert-Koch-Str 11, 8033 Planegg, W. Germany.

August 24-31, BELGRADE
13th ICA
SYMPOSIA

September 1-3, ZAGREB
Electroacoustics

September 4-6, DUBROVNIK
Sea Acoustics

Details: 13 ICA Secretariat, Sava Centre, 11070 Belgrade, Yugoslavia.

September 5-7, OXFORD
5th INTERNATIONAL MEETING ON LOW FREQUENCY NOISE AND VIBRATION
Details: Multi-Science Publishing Co Ltd, 107 High Street, Brentwood, Essex CM14 4RX, UK.

September 26-28, PARIS
EUROSPEECH 89
Details: D. Bovis, ESCA Secretary, EEC-DG XIII/ESPRIT, 25 Rue Archimede, Brussels, Belgium.

October 3-6, HIGH TATRA
28th CONFERENCE ON PHYSIOLOGICAL ACOUSTICS, ACOUSTICS OF SPEECH AND MUSIC
Details: House of Technology, Eng L Goralikova, Skultetyhd ul, 832 27 Bratislava, Czechoslovakia.

October 4-6, MONTREAL
IEEE/UFFCS
Ultrasonics Symposium.
Details: Allied-Signal Inc., Atten.: H. van de Vaart, PO Box 10221R, Morristown, NJ 07960, USA.

October 16-18, SICILY
INTERNATIONAL CONFERENCE ON MONITORING, SURVEILLANCE AND PREDICTIVE MAINTENANCE OF PLANTS AND STRUCTURE
Details: Italian Society for Nondestructive Testing, via Arnaldo Foresti No. 5, 25126 Brescia, Italy.

October 17-19, KYOTO
INTERNATIONAL CONFERENCE ON MUSIC, PERCEPTION AND COGNITION
Details: ICMPC Secretariat, Dept Music, Kyoto City University of Arts, Kutsukake, Ohe, Nishikyo-ku, Kyoto, 610-11 Japan.

October 18-19, BARCELONA
II WORLD CONGRESS OF CHRONICAL RONCOPATHY
"Snore and OSAS Syndrome."
Details: Prof. E. Perello, Facultat de Medicina, Universitat Autonoma de Barcelona, Passeig de la Vall D'Hebron, S/N 08035 Barcelona, Spain.

November 14-16, ADELAIDE
● AUSTRALIAN INSTRUMENTATION AND MEASUREMENT CONFERENCE
Details: The Conference Manager, AIM 89, The Institution of Engineers, Australia, 11 National Circuit, Barton, ACT 2600.

November 15-17, BILBAO
INTERNATIONAL SESSIONS ON THE SINGING VOICE
Details: PO Box 1346, 48080 Bilbao, Spain.

November 23-24, PERTH
● 1989 AAS CONFERENCE
Interior Noise Climates.
Details: C. Paige, C/- BHP Engineering, 221 St. Georges Terrace, Perth 6001 Australia.

November 26-29, CANBERRA
● 1989 ERGONOMICS SOCIETY OF AUSTRALIA CONFERENCE
Ergonomics, Technology & Productivity
Details: Beth Steward, ACTS, Suite 2, BMI Building, City Walk, Canberra, ACT, 2601.

Nov 27-Dec 1, ST LOUIS
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

December 4-6, NEWPORT BEACH
INTER-NOISE 89
ENGINEERING FOR ENVIRONMENTAL NOISE CONTROL
Details: Inter-noise 89, PO Box 2469, Arlington Branch, Poughkeepsie, NY 12603, USA.

December 10-15, SAN FRANCISCO
INTERNATIONAL SYMPOSIUM ON NUMERICAL METHODS IN ACOUSTIC RADIATION
Details: Prof R J Bernhard, Ray W Herrick Labs, School of Mech Eng, Purdue University, West Lafayette, IN 47907.

December 11-12, RIO DE JANEIRO
3rd INTERNATIONAL SEMINAR ON NOISE CONTROL.
Details: Organising Committee, Laboratorio de Acustica e Vibracoes, Pem-Coppe/UFRJ, C.P. 68503, 21.945, Rio de Janeiro, Brazil.

1990

February 13-15, LEIPZIG
4th CONFERENCE ON HYDRO- AND GEOACOUSTICS
Details: Dr Wendt, Wilhelm-Pieck-Universitat Rostock, Sektion Technische Elektroink, Albert Einstein Strasse 2, Rostock, GDR-2500.

April 17-20, VIENNA
DAGA 90
Details: DAGA.

May 21-25, PENNSYLVANIA
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

June 6-8, BRIGHTON (UK)
16th CONGRESS OF A ICB
The Future for Noise Control — towards an interdisciplinary approach.
Details: Dr. iur. Willy Aecherli, Rechtsanwalt Hirschenplatz 7, CH-6004, Luzern, Switzerland.

August 1-6, GOTHENBURG
INTERNOISE 90
Details: Swedish Road and Traffic Research Institute, S-581 01 Linkoeping, Sweden.

August 8-10, GOTHENBURG
INTERNATIONAL TIRE/ROAD NOISE CONFERENCE.
Details: Intern. Tire/Road Noise Conference, C/- Sandberg, Swedish Road and Traffic Research Institute, S-581 01 Linkoeping, Sweden.

● September 18-20, MELBOURNE
VIBRATION & NOISE CONFERENCE
Details: L Koss, Dept Mech Eng, Monash University, Clayton, Melbourne, Vic, 3168.

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.

1991

● November, BRISBANE
WESTERN PACIFIC REGIONAL ACOUSTICS CONFERENCE IV
Details: Unisearch Ltd, PO Box 1, Kensington, NSW 2033.

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