Acoustics Australia

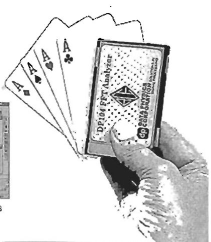
HISTORICAL ISSUE

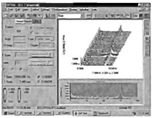
- *The Society*
- *The Journal*
- *Architecture*
- *Music*
- *Noise*
- *Ultrasound*
- *Hearing*
- *Other Fields*

Australian Acoustical Society **Vol. 28 No. 3 December 2000**

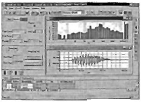
FOR YOUR DIARY,

SEMINAR 2001.

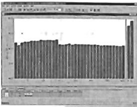




Real Time Waterfall



Live Time Domain Displays

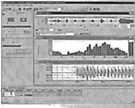


Waveform Signal Generator

Data Physics & Agilent Technologies Australia in conjunction with Kingdom Pty Ltd will provide Seminar 2001 a series of seminars showing Agilent Technologies range of VXI Signal Processing Digitisers and Data Acquisition modules together with Data Physics':

SignalCalc 620 VXI Dynamic Signal Analyser software
- 4 to an unlimited number of input channels with Bandwidth of 0 to 76 kHz.

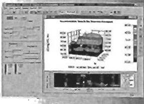
SignalCalc ACE PCMCIA Dynamic Signal Analyser System.
- 2 Input and 2 Output channels and a dynamic range >100dB.



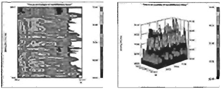
Simultaneous Record & Playback

The seminars will be held at venues to be advised in:
Sydney on Tuesday **March 20, 2001**
Melbourne on Thursday **March 22, 2001**
Adelaide on Tuesday **March 27, 2001** and
Auckland on Friday **March 30, 2001.**

Dr Sri Welaratna, President and CEO of Data Physics Corpn will lead the seminars presenting an insight into the rapidly developing science of Signal Processing around the world and together with Agilent Technologies VXI, will demonstrate many of the application available in SignalCalc software and instruments and AT hardware, including **Real Time Full and 1/3 Octave, Throughput to Disk and Replay Analysis.**



Histogram



Transient Signal Analysis

and much more...

For more information on Data Physics or Agilent Technologies products and to register for Seminar 2001 please ring :

(TM) **KINGDOM PTY LT**
Phone: 02 9975 327

AA 12/00

Acoustics Australia

Acoustics Australia General Business
(subscriptions, extra copies, back issues, advertising, etc.)
Mrs Leigh Wallbank
P O Box 579
CRONULLA NSW 2230
Tel (02) 9528 4362
Fax (02) 9523 9637
wallbank@zipworld.com.au

Acoustics Australia All Editorial Matters
(articles, reports, news, book reviews, new products, etc)
The Editor, Acoustics Australia
Acoustics & Vibration Unit
Australian Defence Force Academy
CANBERRA ACT 2600
Tel (02) 6268 8241
Fax (02) 6268 8276
email: acoust-aust@adfa.edu.au
http://www.users.bigpond.com/Acoustics

Australian Acoustical Society Enquiries see page 128

Acoustics Australia is published by the Australian Acoustical Society
(A.B.N. 28 000 712 658)

Printed by
Cronulla Printing Co Pty Ltd,
16 Cronulla Plaza,
CRONULLA 2230
Tel (02) 9523 5954,
Fax (02) 9523 9637
email:print@cronullaprint.com.au
ISSN 0814-6039

Vol 28 No 3 December 2000

CONTENTS

AUSTRALIAN ACOUSTICAL SOCIETY - SUSTAINING MEMBERS

ACOUSTIC RESEARCH LABORATORIES
LEVEL 7 BUILDING 2
423 PENNANT HILLS ROAD
PENNANT HILLS 2120

ACRAN
P O BOX 34
RICHLANDS 4077

ADAMSSON ENGINEERING PTY LTD
P O BOX 1294
OSBORNE PARK 6916

ARMSTRONG WORLD INDUSTRIES
P O BOX 109
MORDIALLOC 3195

ASSOCIATION OF AUSTRALIAN ACOUSTICAL CONSULTANTS
96 PETRIE TERRACE
BRISBANE 4000

BARCLAY ENGINEERING
31 FELSPAR STREET
WELSHPOOL 6106

BORAL PLASTERBOARD
676 LORIMER STREET
PORT MELBOURNE 3207

BRUEL & KJAER AUSTRALIA PTY LTD
24 TEPKO ROAD
TERREY HILLS 2084

CHADWICK TECHNOLOGY
9 COOK STREET
FORESTVILLE 2087

CSR BRADFORD INSULATION
55 STENNETT ROAD
INGLEBURN 2565

ENCO NOISE CONTROL PTY LTD
50 RIVERSIDE ROAD
CHIPPING NORTON 2170

G P EMBELTON & CO PTY LTD
P O BOX 207
COBURG 3058

INC CORPORATION PTY LTD
22 CLEELAND ROAD
OAKLEIGH SOUTH 3167

KELL & RIGBY
8 DUNLOP STREET
STRATHFIELD 2136

NAL CONSULTING
126 GREVILLE STREET
CHATSWOOD 2067

NOISE CONTROL AUSTRALIA PTY LTD
70 TENNYSON ROAD
MORTLAKE 2137

NSW ENVIRONMENT PROTECTION AUTHORITY
P O BOX A290
SYDNEY SOUTH 1232

NUTEK AUSTRALIA
UNIT 3, 10 SALISBURY ROAD
CASTLE HILL 2154

PEACE ENGINEERING PTY LTD
P O BOX 4160
MILPERRA 1891

PYROTEK SOUNDGUARD
149 MAGOWAR ROAD
GIRRAWEEN 2145

SOUND CONTROL PTY LTD
61 LINKS AVENUE NTH
EAGLE FARM 4009

VIPAC ENGINEERS AND SCIENTISTS LTD
279 NORMANBY ROAD
PORT MELBOURNE 3207

WARSASH SCIENTIFIC PTY LTD
UNIT 7, 1-9 MARIAN STREET
REDFERN 2016

WORKCOVER ACOUSTICS
919 LONDONDERRY ROAD
LONDONDERRY 2753

Editorial

It is appropriate, in this millennium year (whether you believe this should be 2000 or 2001!) to look back at the history of acoustics in Australia and gain some feeling for what we have achieved. Some of these achievements are physical monuments—great and successful concert halls and theatres, musical instruments, or electronic devices. Some are much less concrete but equally important contributions to the quality of life through noise regulations and the careful design of factories, roads and airports. Looking back, I feel sure we can take pride in what has been achieved, though remaining thoroughly aware of what still remains to be done.

Putting together this survey has been the work of many people, whose names appear on the articles, and I would like to thank them all. The Editors are acutely aware, however, that the field has not been covered thoroughly. There is, for instance, no history of the National Acoustic Laboratories or of the Ultrasonics Institute, though there are articles on the CALAID produced by NAL and on some of the achievements of the Ultrasonics Institute in medical imaging. There is also nothing on loudspeakers or microphones, or about atmospheric and underwater sonar systems, or about active noise suppression, or about standards and calibration, despite the fact that Australia has made significant contributions to all these areas. Even Australia's great achievements in cochlear implants receive no coverage. Limitations of time and space are largely responsible, and we might point out in mitigation that some of these topics have been covered, though perhaps not from a historical perspective, in recent issues of our journal. To aid the interested reader, the final short paper in this issue gives references to sources for some of this additional information. (The footnote on each paper indicating that this is an "Unrefereed Historical Issue", incidentally, is to preserve the status of our journal in the eyes of those collecting university publication statistics!)

The point of history is that we should be aware of our past and should use that knowledge to better plan our future. Looking ahead, it seems clear that both the needs and the opportunities in acoustics will continue to expand in the future, and we should go forth to meet them with confidence.

From the viewpoint of this journal, we too have plans for changes for the new millennium, one of which is announced in this issue and will be instituted in the first issue for the year 2001. This is a new section in the journal with the title Acoustics Forum which aims to give an opportunity for the exchange of views about current issues and achievements in acoustics without the length restrictions of a Letter to the Editor or the formal review requirements of an article. We hope that consultants and other professionals in the field will welcome this innovation and will send us their contributions regularly.

From the President

In personal and corporate life there are many unanticipated events and crises experienced which at the least upset our equilibrium and change our plans, or sadly may close the chapter of our life and the lives of our family and friends.

Your President experienced a plan change immediately before the Council Meetings in Perth when Rosemary, my wife faced emergency surgery instead of attending the Perth Conference as my accompanying person. Our Vice-president Charles Don kindly took over at very short notice and chaired both Council Meetings and Annual General Meeting. I take this opportunity to thank Charles for your concern and assistance during this period.

We were saddened to learn of the passing of Graeme Yates our immediate Past President, when full recovery from his illness had been expected. On behalf of the Society I express to Graeme's wife Marilyn and daughters Jennifer, Elisabeth, Katherine and Carolyn our deepest sympathy. Graeme has been an untiring member of the Society since its inception in Western Australia, and the details of his professional life in acoustics and his involvement in the AAS are presented in detail in this issue of Acoustics Australia.

It was also distressing to learn of the motor vehicle accident which claimed the life of Mark Eisner and seriously injured his wife Judith. Mark has been a long time Member of the AAS and devoted over three decades of his life to professional acoustics. Again on behalf of the Society, I express to Judith and family our deepest sympathy. Mark's work in acoustics is also detailed more fully in this issue of AA.

Meanwhile the Council of the AAS has focussed on a range of important issues to the Society at the recent Council meetings in Perth. There was ongoing discussion on Accreditation. A working committee has been established to look at this issue.

Council expressed appreciation for the work that our General Secretary, David Watkins has done over the past several years... well beyond his call of duty. Consideration was given to ways of easing his work load Maintenance of our web-site was one area identified. Terry McMinn (WA Division) is to carry out this role. It is probable that our Directory of Members will be produced on the web - available to members in 2001. There are still some issues including security and the benefits to Sustaining Members which need to be investigated.

In respect to the Registrar's role, Council expressed deep appreciation for the work that Ray Piesse has done over many years in this position and I express likewise my appreciation for Ray's long service as Registrar, his work for the Society extending back to its foundation including his role as President of AAS.

The Registrar's position will now take on a pro-active role in membership application processing and procedure. Gillian Adams (Qld Division) has offered to carry out this new role.

The AAS now has a new Treasurer, Ken Mikl (NSW Division). I express on behalf of the Society our thanks to Les Huson for his work in that position over the past several years.

The awarding of the President's Prize was highlighted in Perth. The recipients of the prize this year were Colin Kestell, Colin Hansen and Ben Cazzolato for a paper entitled 'Virtual Sensors in Active Noise Control'. Divisions are reminded that the President's Prize can only be awarded to a Member/s of the Society

And so another year has passed. For some members the start of a new millennium, and others the final year of the past millennium. Whatever your position on the matter the year has now past with all its unexpectancies - positive or negative and we are faced with a new and hopefully a better year in 2001. I thank all Councillors, Division Committee members and all others who have assisted the Society in any way this past year. It is appreciated. And may I wish all members a very successful and enjoyable year to come.

Geoff Barnes

HISTORY OF THE AUSTRALIAN ACOUSTICAL SOCIETY

The history of acoustics in Australia is intimately linked with the development of the Australian Acoustical Society. Because of our diverse heritage of States and the long distances involved, this development was rather fragmentary, and moves towards forming a National society took place concurrently in several places. The present collection of articles pieces together that development from the viewpoint of people involved in each of the States where there are now Divisions of the AAS.

BEGINNINGS IN NEW SOUTH WALES

Howard Pollard
6 Wren Place, Cronulla, NSW 2230

When a group of enthusiasts get together and decide to form a society, little thought is given to the possibility that years later someone might like to know how everything started. Systematic records of initial meetings or lists of those present are often difficult to find. Some time in the future there will be a feverish search for minutes of meetings or old records to supplement the hazy memories of surviving foundation members. The rare exception is when some diligent soul is found to have kept a folder containing copies of all relevant papers.

The Australian Acoustical Society had almost simultaneous beginnings in New South Wales and Victoria. In Sydney during the 1960s, acoustical activities were starting to expand with a number of consultants becoming active, courses starting at the University of NSW and the numerous activities and research programs at the National Acoustics Laboratory having a significant impact. Apart from a basic need for all concerned to communicate, there were increasing numbers of court actions that required expert technical evidence. The need for an acoustical society was starting to become urgent.

Much of the credit for initiating some concerted action must go to Peter Knowland who, during early 1964, made a systematic series of telephone calls to all potentially interested parties, seeking their support for the formation of a society. At the time, Peter was employed as an acoustical consultant in the engineering firm of Norman and Addicoat in North Sydney. In due course a formal meeting was called on 5 August 1964 at the offices of Norman and Addicoat with Peter Knowland as chairman. Following is a list of those who attended, which includes Vivian Taylor who had offices in both Sydney and Melbourne and who intimated that similar discussions were also taking place in Victoria: Benson, J Ernie; Clarke, J H; Eisler, G L; Elliot, H B; Harris, Robert W; Knowland, Peter; McCrae, N J; Mehaffey, Warwick; Murphy, R G; Parts, A A; Pollard, Howard F; Rose, J A; Taylor, H Vivian; Thorne, Ross; Weston, E T; Weston, H R. A second meeting was held on 23 September 1964 at which the original 16 persons attended together with Bookland, W; Caddy, R S; Flockhart, A P; Irvine, J A; Kaldor, A F; and Lawrence, Anita.

At these meetings lengthy discussions took place concerning the aims of an acoustical society, whether the membership should be graded, and the type of activities to be organised. In her recent article [1], Anita Lawrence comments: "A committee was elected to consider the formation of an Australia-wide group, to prepare a draft constitution including conditions of membership, to suggest activities and consider the organisation of a symposium, and to call another general meeting in a few months time. The four committee members were Peter Knowland (Chairman), John Irvine (Secretary), Warwick Mehaffey and Anita Lawrence."

"Much work then ensued and the NSW and Victorian committees battled with drafting an acceptable constitution, one of the most difficult areas was deciding on the requirements for admission to the various proposed grades of membership. As there were few, if any, people with direct academic qualifications in 'acoustics', it was difficult to define who should be eligible for the professional grade of 'Member'. Eligibility for admission was considered to be someone eligible for membership of a profession recognised as a professional by the Commonwealth Public Service. At that time there were a number of well-respected acousticians without academic qualifications, so a 'grandfather' clause was included to allow those who had been working at a professional level in acoustics for a number of years to also be admitted to corporate membership."

From the start it was recognised that some form of publication was needed to keep the membership informed of acoustical activities and to provide an outlet for published articles on current acoustical work. The NSW Division started publishing a newsletter initially edited by Ted Weston, Peter Knowland and John Irvine. This newsletter eventually grew into the Bulletin of the Australian Acoustical Society following incorporation of the society in 1971.

The process leading up to incorporation was subject to lengthy delays since the NSW Government was taking a long time to amend the necessary legislation. Jack Rose chaired the group responsible for all the prior discussions and negotiations. Incorporation of the Australian Acoustical Society (in NSW) was finally achieved on 1 April 1971. The first meeting of the Council of the AAS was held on 18 April

1971 with Jack Rose in the chair and five councillors each from NSW and Victoria. Councillors present were Ron Barden, Jim Bryant, Gerald Riley, Vivian Taylor and Graeme Harding from Victoria; Louis Challis, Peter Knowland, John Irvine, Jack Rose and Anita Lawrence from NSW. The first office bearers for the new Federal society were Vivian Taylor, President; Peter Knowland, Vice-President; Jim Bryant, General Secretary and John Irvine, Treasurer.

Early public meetings of the NSW Division included a Symposium on Auditoria Acoustics in June 1967; an International Acoustics Symposium together with an Annual Conference in 1968; and a conference on "Noise Legislation and Regulation" in 1972.

At the AGM of the NSW Division in June 1971, Jack Rose proposed that the Australian Acoustical Society apply to hold an International Acoustics Congress in Australia. After a long process of planning and lobbying, the Australian society was awarded the 1980 Congress to be held in Sydney. With Jack Rose as Chairman of the Organising Committee, a very successful Congress was held at the University of New South Wales.

REFERENCES

1. Lawrence, Anita, "Australian Acoustical Society—From the Beginning to the End of the 20th Century", *Proc AAS Conference—Acoustics Today*, Melbourne, 1999, 15–18.

BEGINNINGS IN VICTORIA

C. Louis Fouvy
241 Cotham Rd, Kew, Vic. 3101

Following the founding of the Acoustical Society of America (ASA) in 1929, and the subsequent periodical issue of its prestigious *Journal of the Acoustical Society of America* (JASA), it was inevitable that in due time a group of Australians working in the various fields of acoustics should found such a society in Australia. Before such founding, numerous Australian acousticians were either members of the ASA or regular subscribers to JASA. Some were contributors to the JASA as well as other overseas journals such as *Acustica* and the *Journal of Sound and Vibration.* H. Vivian Taylor, a pioneer Australian acoustician, had been an ASA member since 1931. The very existence of the ASA and similar professional organisations elsewhere, and of a sizeable group of Australian acoustics professionals pointed to the need for such an organisation in Australia. The more senior amongst us probably well remember the times before the ASA.

The Australian Acoustical Society (AAS) had its beginnings in 1964, almost simultaneously in New South Wales and Victoria. The following account has been put together from numerous items of information gathered from AAS Conference-99 papers and personal communications from Anita Lawrence [1] and Gerald Riley [2], from Graeme Harding who provided copies of the Notice for the meeting to be held on 23 September 1964 with its appended undated circular letter from the inaugural NSW early September meeting [3], an extract from the 22 September 1964 CSIRO DBR reply [4], the Notice for the inaugural Victorian meeting to be held in Melbourne at RMIT on 16 November 1964 [5], the minutes of this inaugural 16 November 1964 Victorian general meeting [6], and Notice for the second Victorian general meeting arranged for 26 March [7].

Anita Lawrence's paper [1] reports that the first NSW meeting was held in Sydney on 5 August 1964 in Peter Knowland's offices (at Norman & Addicoat). This was in fact an exploratory meeting (similar to that held in Melbourne on 9 October 1964) at which 16 people were present. The original document from this meeting (held by Peter Knowland), and a copy (held by Ray Piesse), gives the signatures of those who attended, and includes Vivian Taylor as the one Victorian present.

The inaugural NSW meeting was held about a month later, in early September, and was attended by the earlier 16 together with a further 6. Its outcomes were published in an undated Circular Letter recording these 22 names (with two obvious mis-spellings) [3], which refers to the meeting held "early this month" and, with the Notice of Meeting for the next to be held on 23 September 1964, was sent to, and invited comments from, not only those present at that inaugural meeting but also other acousticians who it was considered would be interested in becoming members of an Australian acoustical society. The first 16 of these 22 names appear in exactly the same order as those listed as present at the 5 August 1964 exploratory meeting.

The Notice for the 23 September 1964 ("next") meeting accompanying the undated circular letter [3] quite clearly shows that the first NSW meeting was the early September, not the August meeting, because the Agenda refer, inter alia, to confirmation of the *Minutes of First Meeting*. At the time of writing, several NSW Division historians have been in process of putting together a more detailed account of these early NSW meetings.

That a copy of this NSW undated circular letter was sent to several Victorian acousticians, apart from Vivian Taylor who had attended the first NSW meeting, is shown in that a reply dated 22 September 1964 sent to the NSW group [4] was "a joint reply on behalf of the interested persons at (CSIRO) Division of Building Research (DBR, Highett), namely Bill Davern, Paul Dubout, Werner Lippert, Roy Muncey and Arthur Nickson".

Gerald Riley's paper [2] further reports that he, having been approached by Arthur Nickson, and Ken Connor (RMIT Physics Dept), met them at CSIRO DBR, Highett on 9 October 1964. Having discussed the NSW undated circular letter [3], they "agreed that in view of the extremely successful *Symposium on Noise* held at Monash University the previous August (ie, 1964), there could well be a sufficient number of interested people in Victoria", and convened a meeting to be held at RMIT on 16 November 1964. The resulting Notice of Meeting [5], authorised by Ken Connor, announced that "an Australian Acoustical Society is in process of formation by a provisional organising committee" and that the group who had held some preliminary meetings had "asked Mr H Vivian Taylor to convene a meeting of interested persons from Victoria and Southern States to consider whether it will be desirable to establish a Victorian chapter or Southern division". Lower tear-off portions of the Notice asked those who had received it to return it, and indicate their interest in this proposal, and whether or not they would be present on 16 November 1964. Altogether, around 150 notices were sent to various persons and organisations.

The Minutes of this inaugural meeting held in Melbourne on 16 November 1964 [6] reported, inter alia, that of the 44 who had indicated they would attend this meeting only four (their names were not recorded) did not actually do so. A further 24 had indicated that although they could not attend this meeting, they wished to be kept informed on progress. These names are appended. An outcome of this meeting was that it was agreed that a "steering committee be appointed to investigate the membership potential for an acoustical society in Victoria, and to arrange a pilot program of activities of general interest to potential members of the proposed Australian Acoustical Society". The following committee, given power to co-opt other members, and directed to maintain contact with the Sydney group, was nominated and appointed: Prof Ron Barden (convener), H Vivian Taylor, Gerald Riley, Ken Connor, Paul Dubout, Ron Carr and John Heine. The second general meeting was held on 26 March 1965 [7].

The reference documents discussed here do not tell all. It would be interesting to know, for example, who at the inaugural NSW meeting had arranged that a copy of that meeting's outcomes be sent to the CSIRO DBR acoustics group, to whom was it sent, and who had replied on behalf of the group. And Anita Lawrence's comment in her Conference-99 paper [1] that Vivian Taylor had, at that inaugural NSW meeting, "explained that the formation of an Australia-wide acoustical organisation was currently under discussion in Victoria" does not tell us who were party to these discussions. After 36 years, it is now no longer easy to find answers to these questions. While, for example, it is probable in view of other recorded events and personal comments that Arthur Nickson was the 1964 contact at the CSIRO DBR, Highett, Vic, we can only surmise that before the inaugural NSW meeting Vivian Taylor might have discussed forming an acoustical society with acousticians such as Ron Carr or Arthur Nickson.

Of continuing interest to all AAS members are the views about the Society's aims, functions and membership expressed at those meetings in 1964 at the time the formation of an acoustical society was being contemplated.

The statement of outcomes in the undated NSW circular letter [3] asked for comments on the *Aims* of an Australasian acoustical society, on its *Organisation* at both federal and state levels, and on *Membership* requirements and professional standing. In addition, those at this NSW meeting "expressed the view that an acoustical society should be authoritative, should disseminate information, and act as a clearing house for local and international acoustical news. To fulfil these purposes, State meetings would be organised on a regular basis, with possibly annual Federal conferences. It will probably be desirable to form working groups to deal with the various topics such as noise, architectural acoustics, electro-acoustics, standards in acoustics, psycho-acoustics, musical acoustics, phonetics, etc. People in other States may wish to form similar groups to assist in the development of an acoustical society on an Australasian basis. However, it may be more expedient if the preliminary work is done by one group, to avoid duplication, and the NSW group would be willing to undertake this work." [3]

The CSIRO DBR group reply [4] showed that they

1. Favoured the formation of an acoustical society on a national or Australasian basis, and would seek to become members,
2. Accepted the NSW group's offer to develop a suitable organisation, with State branch committees eventually assuming appropriate local functions,
3. Asked whether the NSW provisional organising committee members were widely enough known to inspire confidence in potential members throughout Australasia,
4. Agreed with the general proposals outlined, but didn't wish to then comment further on *Aims* or *Organisational details,* and
5. Recommended that membership levels provide not only for corporate and sustaining members as in the Acoustical Society of America, but also for bona fide undergraduate students at reduced membership fees ("to foster and encourage pursuit of the acoustics specialties of science and technology..." [4]), and that entrance qualifications to these levels not be limited to academic qualification, but allow also for those with established professional standing in acoustics (Anita Lawrence's *grandfather clause* [1]).

While the inaugural Victorian meeting of 16 November 1964 discussed these matters of aims, organisation, membership, etc, it made no additional minuted decision on them. Instead, it accepted the following statement for transmission to the NSW group. "This meeting wishes to express its appreciation of the work done by the Sydney group. In support of this a pilot committee has been set up in Victoria to promote activity with the aim of working towards a common constitution providing for a Federal Council." [5]

At this early stage in the formation of the AAS, two important matters can be seen to have been left open for future decision: the Society's geographical scope (whether *Australian* or *Australasian*) and its overall organisation (whether *National* or *Federal*). As it currently stands 36 years after its NSW and Victorian inaugural meetings, the AAS is an Australia-wide society, though there is no reason why at some future time it could not widen its scope to become Australasian; and its constitution shows it to be organised on a *national* (not federal) basis, with the ultimate authority and responsibility vested in its Council, which consists of representatives of its five subordinate state Divisions.

The AAS thus began life in 1964 with NSW and Victorian Divisions. Those of us who attended the Victoria Division's very successful 6 to 8 March 1971 Noise Zoning Conference at Warburton will remember being told that the Society's incorporation was then imminent. After six years of NSW(Victorian co-operative preparation of its Constitution, the Society was established as an Incorporated Australian Society (incorporated in NSW) on 1 April 1971 [1]. That the process of incorporation took as long as it did occurred because it was done, as Jack Rose recently told me, against a background of the NSW company incorporation legislation being re-appraised, re-drafted and revised.

In 1971 the Society's National Council of ten representatives comprised five from NSW and five from Victoria (including Tasmania) [1]. With the subsequent incorporation within the AAS of the Western Australia, South Australia and Queensland Divisions on 1 April 1972 [8], 1 March 1976 [9] and 23/24 November 1985 [10] respectively, the 10-member Council now has two representatives from each state Division. Some account of the activities of the Society and its members has been told in its *Bulletins* (1973-1984) and *Acoustics Australia* (from 1985), and in its generally-annual Conference Proceedings. However, much yet remains to be told, a task on which some of the Society's historians are currently engaged.

ACKNOWLEDGMENT

In addition to those already acknowledged above and in the references, my thanks go to Peter Knowland, Ray Piesse, Howard Pollard, Jack Rose and Ross Thorne of NSW, and Bill Davern, Paul Dubout and Roy Muncey of Victoria for interesting personal communications and help in providing information for this article. I, however, must be held responsible for the accuracy of its statements.

REFERENCES

1. Lawrence, A. "Australian Acoustical Society: From the beginning, to the end of the 20th century" *Proc. 1999 AAS Conf. "Acoustics Today"*, pp. 15–18.
2. Riley, G.A.B. "A forerunner of Australian acoustics" *Proc. 1999 AAS Conf., "Acoustics Today"*, pp. 9–14.
3. NSW Acoustical Society *Notice for the 23 September 1964 ('next') meeting* and undated *Circular Letter*.
4. CSIRO DBR Acoustics Group *Extract from reply of 22 September 1964 to NSW circular letter*.
5. Victorian Acoustical Society *Notice of Meeting* for inaugural 16 November 1964 Melbourne meeting.
6. Victorian Acoustical Society *Minutes of Victorian Inaugural Meeting* held on 16 November 1964.
7. Victorian Acoustical Society *Notice of Meeting* for 26 March 1965 Melbourne meeting.
8. "AAS Activities—Western Australia Division" *AAS Bulletin*, **1**(1), 6 (1972).
9. "News & Notes—South Australia Division formed" *AAS Bulletin*, **4**(1), 6 (1976).
10. "Australian News—Queensland: Formation of Division" *Acoustics Australia*, **13**(3), 83 (1985).

APPENDIX

Present at the 16 November 1964 Victoria meeting in Melbourne (an unnamed four were not present): Barden, Prof R G, Blackwell, M B, Burton, F R, Carr, R J, Clifton, S J, Clutterbuck, A C, Connor, A K, Curtis, R A C, Davern, W A, de Steiger, P J, Devereux, J, Drury, G S, Dubout, P, Elworthy, C G, Gilbert, W N, Gimesy, O A T, Graham, J C, Gunson, S, Harding, G E, Heine, J F, Hodder, I R, Jefferies, M A, Kassimates, E, Knox, G W, Martin, L, Martin, V R, McLeod, R W, Molnar, J, Murphy, P A, Nicholls, R G, Nickson, A F B, Peresjolkow, V, Richardson, S A, Riley, G A B, Robson, B C, Rosauer, T, Stevenson, Dr D C, Stinson, B W, Sundercombe, J C R, Taylor, H V, Thompson, J K, Watson, J H, Watson, K M, Wilkinson, R C.

Not present at the 16 November 1964 meeting in Melbourne, but who asked to be kept informed of progress: Coffee, C L, Cook, K R, Fisher, S A, Fouvy, C L, Freeman, B C, Griffiths, W B, Hughes, R R, Johnson, A C J, King, R B, Lalor, A P, Lippert, Dr W K R, Marshal, J H, Martin, W R B, Muncey, R W, Nelson, J A, Pavia, R E, Pryce, M, Ridyard, J, Sharpe, A, Simpson, R McC, Syvertsen, R C, Tarrant, M R, Warner, J M E, Webb, N L C.

QUEENSLAND

R.J. Hooker
53 Marshall Lane, Kenmore, Qld 4069

The Queensland Division is the youngest of the five AAS. Divisions, but activity in acoustics pre-dates the formal establishment of the Division by at least 25 years. An early, perhaps the first, major study was in the late 1950s, a PhD project in the Department of Mining and Metallurgical Engineering at the University of Queensland. The topic was "The production, character and abatement of noise in pneumatic percussive rock drills" and the (successful) student was J.L.Beiers. He used a Scott sound level meter with half-octave filter. It was probably the first sound level meter in the state although one consulting engineering group had a meter at that time. Apart from a field calibrator, neither meter is recorded as ever visiting a calibration service.

In 1963 the Department of Mechanical Engineering at the University of Queensland bought a B&K 2203 for a study of passenger car tyre noise and for general and teaching use. Although further meters were bought, the original remained in use until, as one staff member observed to students, the meter was older than they were. Later, while still in regular use, it was older than some staff members. It is still serviceable although rarely used. One might note that the first large digital computer in Queensland was installed in 1962.

In the 1960s community noise problems arose with bowling alleys, river barges, supermarket refrigeration plant, squash courts, hotels and motor sports. A first educational activity of any size was a Symposium on Noise Control, conducted in1967 under the auspices of The Institution of Engineers, Australia.

The following decade became an active period. Some consulting work developed, the State Government formed a Noise Control Committee and passed the Noise Abatement Act, and added the words "and Noise Control" to the Division of Air Pollution. The University of Queensland ran two projects related to mining, one on large mining machines and another on the percussive rock drill. The (then) Queensland Institute of Technology conducted several extension courses on noise primarily for public health inspectors. The first glimmerings of an AAS Division can possibly be discerned, described on one occasion as "shadowy wisps of conversation over many years". In response to a now lost enquiry, NSW Division, which then included Queensland, suggested that there were not enough members in Queensland to form a division. A division committee has ten members. The membership in Queensland at the time totalled 11, of whom 7 lived in Brisbane. Even from that 11, only 10 names are recorded.

The shadowy wisps gradually gained substance, as those engaging in the conversations talked themselves into doing something. A "Meeting of Interested Persons" was held on 18 July 1984. Attendance was 39, with 25 apologies. Out of the woodwork! A group of three (Noela Eddington, Warren Renew, Robert Hooker) prepared a submission to AAS Council, Perth, 1984, to which Council gave in-principle approval and recommended formation of a Steering Committee to pursue formation of a division. Basically, the Steering Committee operated as a Division would , including facing a difficulty over registration of the name of the Society in Queensland, and a proposal was prepared.

The Queensland Division was formally established by resolution of Council at Leura on 24 November 1985. The foundation committee comprised: A.L. Brown, A.R. Brown, N.J. Eddington, R.J. Hooker (Chair), F. Kamst, W.C. Middleton, W.D. Renew , R.H. Rumble, W. Tonnison and R.C. Windebank. Typical technical and social meetings have continued since that time.

The first major event was the Community Noise Conference, Toowoomba, 1986, sponsored jointly by the Society and the State Government Division of Air Pollution and Noise Control. This was followed in 1991 by the combined AAS Annual Conference and WESTPRAC-4, again with joint sponsorship with the Department of Environment and Heritage. The Society 1996 Annual Conference was held in Brisbane.

The active acoustics scene in Queensland has seen Division membership grow to around 50 in the year 2000.

WESTERN AUSTRALIA

J.D. Macpherson

20 Megalong St, Nedlands, WA 6009

Ah, the rugged independence of the West… ever heard of ASWA? Tibor Vass, founding member of ASWA, writes of its formation:

"It was in 1969 when a group of people sat down in a cafe at the University House bar at UWA to discuss our interest in acoustics and how we could be involved actively in that field. We could see two options available to us here in the West:

1. We could join as individual members of the NSW or Victorian Divisions of the then already existing Australian Acoustical Society, and give up any hope of WA contributing actively in the running of AAS (this happened in SA and eventually in Queensland); or
2. We could form our independent Society here in WA, by creating the Acoustical Society of WA (ASWA).

We decided on the second option and called an inaugural meeting of people interested in acoustics in the following year, on 7 May 1970. Twenty people attended the meeting, and at the end of the meeting, Dr Brian Johnstone was elected as Chairman, Dr Harold Marshall as Vice-Chairman and Tibor Vass as Secretary-Treasurer. A subcommittee set out to write the Constitution and set in motion an application for the incorporation of ASWA.

We achieved these in a few months and by 23 February 1971 we had an independent, Incorporated Acoustical Society of WA."

The new Society got into stride quickly. On 11 September 1970, an afternoon symposium was held at UWA on the theme of "Noise control in the community and its cost". Topics addressed by the speakers included: the effect of noise on the body, the extent of hearing conservation problems, the cost of noise control measures, and the sociological aspects of aircraft noise. Registration cost was $1.00.

By November 1970, there were 16 Members and one Affiliate. Annual fees were $10.00 for a Member and $5.00 for an Affiliate.

Tibor Vass continues: "Soon after this, alarm bells were ringing in Sydney. It was discreetly suggested that, instead of creating two Acoustical Societies in Australia, we should amalgamate and apply to be part of the AAS, and if we did so, we would be recognised as the WA Division of the AAS. In due course we applied and on 31 March 1972, we officially became the WA Division of the Australian Acoustical Society. This was announced in Vol. 1 No. 1 of the newly-launched Bulletin of the AAS."

Membership of the Division has steadily increased over the years, to about 40–45 members during the 1990's. The membership has retained the diversity of acoustic interests apparent amongst the founding members, and has avoided the temptation to become a "learned" society. The Technical Meetings have been varied, of a high standard and well attended. Thanks to some enterprising work on sponsorship for the AAS National Conferences held in Perth in 1984, 1990 and 1995, the Divisional finances have remained in good shape.

In recent years, the WA Division has branched out with the introduction of its own newsletter, "Acoustic Feedback", containing local acoustics news and articles of interest. An annual day-long WA Division Conference was held in 1998 and 1999, as a forum for members to present current work.

What is apparent from a perusal of the Division history is the enormous contribution made by the AAS members to the development of acoustic practice in WA, whether in development of legislation, provision of consultancy and contracting services, or in academia.

SOUTH AUSTRALIA

Colin Hansen* and Bob Boyce**
***33 Parsons Street, Marion, SA 5043**
****7 Hank Street, Lockleys, SA 5032**

The SA Division of the AAS owes its beginning to the enthusiastic initiative and leadership of the late R. Bruce King (a local acoustical consultant), and the enthusiastic support of Garry Stafford (a Scientific Officer with the State government) and Don Woolford (an engineer with the ABC). On Thursday, April 24, 1975, these three enthusiastic individuals met and plotted the formation of the SA Division. They arranged to send circulars to all relevant people on their mailing lists advising them of a preliminary public meeting on Thursday, June 12, 1975 at the ABC studios in Collinswood to discuss the formation of the SA Division. They agreed that Garry Stafford would invite Ray Piesse, Director of the National Acoustic Laboratoriess to address the meeting. There are no records confirming that this meeting actually occurred.

However, a public meeting to discuss the formation of a SA Division was held on August 4, 1975. Jack Rose addressed the meeting and informed those present of the history and purpose of the AAS, which was formed in 1964. Approximately 70 people attended this meeting and there were about 20 apologies. This may be compared to recent times where our Annual General Meeting has attracted between 15 and 20 people. It was noted at the first meeting that all membership fees, except those from Sustaining Members would be made available to the local Divisions. Apparently a questionnaire had been sent out to relevant individuals At the end of the meeting, the proposal that a Division of the Australian Acoustical Society be formed in SA was passed unanimously.

At the time of the first public meeting to discuss the SA Division formation, there were already 7 members of the AAS residing in South Australia. These were Messrs Kendrick, King, Luxton, Pryce, Reilly, Swanson and Williamson.

The first ad hoc committee meeting was held in the Offices of Bruce King on September 8, 1975. At this meeting 20 new applications for membership of the AAS were ratified. The formation of the SA Division was approved by Council on 29 February, 1976 and became effective on the March 1, 1976. At this time there were 23 members.

The inaugural meeting of the SA Division of the AAS was chaired by Bob Boyce and was held in the ABC studios at Collinswood. The AAS President, Dr Carolyn Mather, and the General Secretary, Bill Davern attended. The first office bearers were elected and they were Chair, Bruce King, Vice Chair, Bob Boyce, Secretary, Don Woolford and Treasurer/Registrar, Ken Martin. Ken Martin held this position for more than 20 years. At the end of the meeting, the Adelaide String Quartet gave an outstanding performance of works by Mozart, Webern and Schubert.

The SA Division of the AAS has never looked back. We have 4 or 5 technical meetings each year (preceded by an informal dinner each time) and always a Christmas Dinner where members can get to know one another in a more relaxed setting. The SA Division has hosted the AAS Annual Conference on three occasions and also organised the 5th International Congress on Sound and Vibration in Adelaide in 1997. In 1999 and 2000, the Division has also organised short courses for industry, councils and the community on noise control and environmental noise. As of November 2000, the SA Division of the AAS had 46 members.

HISTORY OF THE JOURNAL OF THE AUSTRALIAN ACOUSTICAL SOCIETY

Howard Pollard* and Marion Burgess**
***6 Wren Place, Cronulla, NSW 2230**
****School of Aerospace and Mechanical Engineering, University College, UNSW**
Australian Defence Force Academy, Canberra 2600

The *Bulletin of the Australian Acoustical Society* was established in 1972 as the regular journal of the Society, and in 1985 its title was changed to *Acoustics Australia*. Its aim has always been two-fold: to serve as a medium for the communication of Society activities to members, and to promote the development of acoustics in Australia by publishing peer-reviewed articles of relevance to the Australian situation.

Soon after the formation of the Society in 1964, it was felt that there should be some form of regular publication to reflect activities, bring acoustical news to the members and act as a vehicle for publishing articles on Australian acoustical work. Early on, Peter Knowland and John Irvine started editing a newsletter for the NSW Division. In November 1971, the Council approved the establishment of the *Bulletin of the Australian Acoustical Society* as a replacement of the NSW newsletter, the production to alternate between the NSW and Victoria Divisions. So, in 1972, the *Bulletin of the Australian Acoustical Society* was born, the New South Wales Division agreeing to organise its initial production. Over the next few years, members of the Editorial Committee included Peter Knowland, John Irvine, Ted Weston, Ferge Fricke, Richard Heggie and Marion Burgess. In 1979, the Victoria Division took over responsibility for the production: Robin Alfredson was appointed as the Chief Editor followed by Rob Law in 1980 and Don Gibson in 1981.

The *Bulletin* was successful in fulfilling its aims of publishing interesting articles based on acoustical work in Australia, news concerning the activities of branches and members, as well as maintaining good advertiser support. The editorial committee in Victoria performed a sterling self-publication effort and in particular ensured a regular schedule of three issues per year, which was all important for continued advertising revenue. The voluntary time and work applied to this task enabled the *Bulletin* to be produced with a profit margin. There was a growing feeling, however, that there was a need for changes in presentation and production to reflect the growing national and international scope of the Society. In 1982, the production moved back to New South Wales with Howard Pollard as Chief Editor and Marion Burgess as Associate Editor. The new editorial team was given the authority and additional finance by the Council to carry out this process.

For the first issue of Volume 10 in April 1982, Artsett Services were commissioned to redesign and layout a new-look *Bulletin*. In addition to the two editors, a number of Consulting Editors were appointed, one for each major branch of acoustics, whose tasks included acting as referees and coordinators of contributions for special issues on their particular topics. To assist in the collection of news items, a liaison officer was appointed in each member state. We even had a volunteer cartoonist, Doug Cato, from RANRL, and a columnist, Graeme Harding, for a new 'People' page.

In a statement of policy in the first editorial, the editor stated: "Following the lead of previous editorial committees, it is our intention to convert the *Bulletin* into a standard technical journal. The *Bulletin* has a dual role to play. Firstly, it provides an outlet for information relating to local activities and members' peregrinations (contrary to rumour, 'Gossip' has not been pensioned off but will be included under the new heading 'People'). Secondly, the *Bulletin* is available for publishing both short and long technical articles. While original papers will be most welcome, there is room for informative review papers (especially in areas of interest in Australia), discussion and tutorial papers and short papers giving preliminary reports of investigation or research. With the active cooperation of those who feel the urge to write (or can be persuaded to do so) we hope to continue the process of producing an interesting and informative journal that will be primarily directed towards Australian acousticians and those with a general interest in acoustics, but hopefully will also present an active image to our many international subscribers."

Mainly due to one-off expenses associated with the re-design, the cost of producing Volume 10 No.1 was considerably more than had been estimated. After exploring a number of alternative printing procedures, a change was made to the Cronulla Printing Co, a family business with a reputation for quality printing and modest costs. Right from the start there was debate over our decision to use glossy cover and paper, which many members associated with expensive business publications. Advertisers were happy as they were able to plan for improved presentations. As it transpired, because the paper was bought in bulk lots, the 'expensive' glossy paper worked out cheaper than ordinary bond paper.

Doug Cato's witty cartoons were generally applauded but the editors' attempt to enliven the reports section with occasional satirical notes received the thumbs down. It appeared that there was a limited scope for humour in acoustics. Other journals have found the same reaction, scientists and engineers in general like to keep a straight face, except for one or two English journals where satire still survives.

In August 1984 (Vol 12 No.2) the first special issue appeared on the topic of Underwater Acoustics, assembled by one of our consulting editors (Marshall Hall). While there was never a problem in persuading members to write an article, it was interesting to note the greater enthusiasm generated by a request to contribute to a special issue. On a number of occasions the ready response resulted in one or two articles having to be left over for the next regular issue. Special issues continue to the present and it has been gratifying to receive a number of overseas articles for these issues.

During 1984, the question of a name change was debated. The original name was causing uncertainty with many potential advertisers who perceived it to be a 'house journal' rather than a technical publication. The contributors, advertisers and some subscribers thought that the old name did not adequately describe the contents or style. In April 1985 the Council agreed to change the name of the journal to *Acoustics Australia*. The brief to the editors was to continue producing a quality technical journal that served both as a reflection of acoustical activities in Australia and as a medium for news and product information of interest to members. To celebrate the change, Leeway Graphics were commissioned to produce a new masthead and cover design. The general style has remained the same to the present with only relatively small changes to this design.

During 1987 financial problems became dominant especially after the dramatic stock market crash that led to a decline in advertising. There was not a lot of room for economies as customary printing procedures were very labour intensive. At this time, the final version of most editorial material was typed by a secretarial agency, followed by typesetting done on a special machine, after which printing plates were prepared. At each stage it was necessary to carry out proof reading. Improvements in the printing process were introduced from time to time but the big economy came with the introduction of computers to eliminate the traditional typesetting stage. Manuscripts submitted by an author on a disk did not require any retyping, although the printer needed to add formatting to the journal style. Further improvements in technology has led to the electronic transmission of the files which saves more time and costs.

In December 1989, Mrs Leigh Wallbank was appointed as Business Manager and immediately made an impact on the efficiency of producing the journal. She also introduced a more systematic approach to advertising and gradually expanded the number and range of our advertisers. The continuity provided by Leigh and her dedication to the various task of the business management have been greatly appreciated by the editors.

In April 1993, Howard Pollard retired as Chief Editor and production of *Acoustics Australia* was handed over to the present team in Canberra comprising Neville Fletcher, Marion Burgess and Joseph Lai with assistance for some time from Leigh Kenna. This team has continued to improve upon the standards set by the previous editors while keeping the costs to a level acceptable to Council.

A journal such as *Acoustics Australia* could not survive without the voluntary support of many from within and outside the Society. The responsibilities and time commitments of the editors are quite significant. To date the journal has been produced without any payments to the production editors, consulting editors, authors or the referees. With the increasing pressures from so many directions this may have to change in the future as people find it more difficult to find the time for yet another activity in their busy schedule. It is sincerely hoped that such a change will not occur for some years and that those in the profession of acoustics will appreciate the benefits of the journal and provide support as necessary.

ARCHITECTURAL ACOUSTICS IN AUSTRALIA

A few of the buildings of acoustical significance in Australia are briefly reviewed together with some of the people involved in architectural acoustics in the 20th century, their work, and the organisations and institutions for which they worked.

A NSW PERSPECTIVE

Fergus Fricke

Department of Architectural & Design Science

University of Sydney, NSW 2006

INTRODUCTION

Most historical works covering the history of acoustics start with Pythagoras although music and musical instruments were in existence long before 600BC. There is anecdotal evidence that the study of sound in relation to buildings began before then (the Tower of Babel and the Walls of Jericho being two Biblical examples and the Greek amphitheatres another). Although these examples are not Australian and most can be assigned to the categories of myth, legend and prehistory, it is difficult to define what history is, what has had an effect on architectural acoustics in Australia and even what defines something as Australian. Hence this paper is a "partial" history in more ways than one.

The history of acoustics in Australia probably began about 60,000 years ago. This work has survived in Koori music, language and culture. That there was an interest in sound by the original inhabitants is indicated in one local language where the word for a peaceful quiet place is "anembo".

As far as most architects are concerned the history of architectural acoustics started, (and for many ended!) with Vitruvius Pollio, the Roman architect and engineer who wrote his "Ten Books of Architecture" 2000 years ago. For most of those practising architectural acoustics in Australia (and there are surprisingly few architects amongst them) or elsewhere, the subject began 100 years ago with the work of Wallace Sabine, at Harvard University, on the relationship between the decay rate of sound in a room and the volume of and absorption in the room.

Although there are some notable 19th century examples of surviving built works, such as the Great Hall at Sydney University, there is little dating from the first half of that century. Ross Thorne, an architectural historian who worked with Vivian Taylor nearly 50 years ago, has however documented the history of theatres in Australia [1]. But as there are very sketchy records of the development of theories, ideas and practice in the 19th century the history of architectural acoustics will be mainly taken as that of the 20th century. Even this presents considerable problems because a list of the titles of publications on the subject is large, the importance of the papers difficult to assess and anyway architectural acoustics is more than academic works. In fact the history has very little to do with written work and, where it does have, the written work is more often a standard or code than a research paper.

WHAT IS ARCHITECTURAL ACOUSTICS?

The field is fairly generally considered to cover room acoustics, perception of sound in rooms, speech intelligibility, the design of rooms for speech and music, the attenuation of sound by the building envelope and the interior partitions in a building, structure-borne noise and building services noise control. It obviously overlaps with such fields as noise control, vibration and impact, acoustic measurement and analysis, psychoacoustics and environmental acoustics, to name a few. As always there is considerable overlap of designated areas of acoustics, e.g. where does environmental acoustics end and architectural acoustics begin? Is sound propagation in air conditioning ducts architectural or duct acoustics and is the perception of speech in real rooms the prerogative those studying sound perception?

Architectural acoustics is commonly considered to be an art as well as a science but this comment largely applies to the "room acoustics" part of architectural acoustics. The reason for the "art", black magic etc is that there are so many criteria and variables to consider that it becomes possible to treat only parts of the subject in a scientific way. To some extent this accounts for the interest in the subject but, despite the best efforts of many workers, room acoustics remains shrouded in mystery.

SCOPE OF THE REVIEW

There are many ways of reviewing the significant work which has been done in architectural and building acoustics in Australia. One possibility is to list the papers that have been written on the subject but just this would take the whole of one issue of Acoustics Australia and even listing the papers of just one author on the subject would take more than the word limit for this paper. What to do? One could be selective and write about the papers that have had the greatest impact by giving the numbers of citations but this is a boring academic exercise of little use to anyone except bureaucrats pushing their political masters' barrows.

Architectural acoustics is, like most subjects, evolutionary rather than revolutionary. It is the practitioners who develop the subject as much or more than those who publish papers in learned journals. The development of building techniques and forms is greatly influenced by designs and ideas developed in other countries. How do we say what is "Australian" and what isn't? If it is built here is it Australian even though the building was designed elsewhere? If the building is built somewhere else but the architect or acoustical consultant is an Australian, is the building part of Australian architectural acoustics?

Architectural acoustics is also about teaching and learned society activities and standards and codes and consulting.

So this is the scope of the paper, like that of many histories, is subjectively defined. A work such as this must inevitably miss some important names and activities. What has been attempted is to give a brief overview and go into enough detail in a few cases to show that there is meat on the bones. What I have not done is to try to cover all aspects of the subject and so instrumentation, design methods, building products and materials and their suppliers have not been covered and nor have matters such as patents. Also, only the briefest of mentions is made of consultancies and software.

In case it may appear that there is a Sydney bias in the paper I would point out that there seems to be more interest in architectural acoustics in Sydney than in Melbourne or elsewhere in Australia. Most acoustical consultants are in Sydney for instance. It almost seems as though the amount of interest in acoustics is proportional to the acoustical problems encountered!

IN THE BEGINNING THERE WAS VIVIAN TAYLOR

Vivian Taylor (1894 to 1981) is the father of architectural acoustics in Australia. He was trained as an architect, started practising in Victoria in 1923 and at about the same time became interested in acoustics. He started working professionally in acoustics in 1928 on churches and public halls. His work on cinemas at the introduction of the "talkies" into Australia in 1929 is legendary [2,3]. From 1930 until 1941 his office acted as a consultant for at least 434 theatres and public halls.

In 1931 Vivian Taylor set up a reverberation chamber in Melbourne for the measurement of absorption coefficients of materials. Later he acted as a consultant on many prestige buildings such as the Houses of Parliament in South Australia and constructions such as the Circular Quay railway in Sydney. The ABC relied on him for acoustical advice from 1940 to 1956.

The following is a very brief mention of names of people involved in architectural acoustics in Australia. A few are covered in a little more detail elsewhere in this paper. (It is fully realised that there are many others who deserve mention and those mentioned deserve far more detail than there is space in this short paper.) Arthur Nickson, Roy Muncey, Werner Lippert, Bill Davern, Paul Dubout, Ian Dunn and John Davy have been at the forefront of architectural acoustics research at CSIRO in Melbourne from the late 1940s. Acoustical consulting and standards and Acoustical Society activities in architectural acoustics have been led by Vivian Taylor, Gerald Riley, Ken Cook, Anita Lawrence, Peter Knowland, and Graeme Harding. Other consultants who have made important contributions in architectural acoustics are Robert Fitzell (for projects such as Star City Casino and Fox Studios), Louis Challis (in particular for Parliament House, Canberra), Renzo Tonin, Peter Griffiths and many others. Ted Weston, at EBS, made an outstanding contribution to documenting the airborne transmission of sound through walls and developed a system for measuring the impact transmission properties of walls. Marion Burgess made important contributions at EBS, at UNSW and at ADFA. John Irvine was responsible for some of the early work on light-weight partitions in the CSR Acoustics Laboratory at Concord. Ernest Benson and Neville Thiele earned international reputations for their contributions to sound reinforcing systems.

SOME BUILDINGS OF NOTE

There is no such thing as "perfect acoustics" even though guides for tours of the Sydney Opera House frequently use the term and give anecdotal evidence about hearing pins drop on stage to prove it. What is more apt to describe the acoustics of some venues is a phrase Sir Thomas Beecham used to describe Dame Nellie Melba, "uninterestingly perfect and perfectly uninteresting". We strive for perfection and when we approach it, it disappears. "Schadenfreude" is a term that can be applied to our feelings about buildings as well as the misfortunes of people!

GREAT HALL, UNIVERSITY OF SYDNEY

The University of Sydney was the first university in Australia and the first building to be built, in the 1850s, included the Great Hall. The hall seats about 500 people and was an amazing inclusion given that the university started with about 20 students. The Great Hall was designed by Edmund Blackett but the basis for the acoustic design, if any, is unknown (a sobering fact for acoustical consultants!). One of the great claims to fame of the Great Hall is that Eugene Goosens, the conductor of the Sydney Symphony Orchestra in the middle of the 20th century, insisted on using the Great Hall for all the recordings he made with the orchestra. Dr Ernest Benson is also famous for the PA system installed in the hall which made speech intelligible for those over forty (and for many under forty). He was also the designer of a sound system for the Sydney Town Hall in the late 50s and the original electroacoustic system in the Sydney Opera House and St Andrews Cathedral and was a consultant for the loudspeaker design in the new Parliament House in Canberra.

CARCOAR COURT HOUSE

Carcoar is a small town in Western NSW between Bathurst and Cowra. It is a town that has been largely preserved as it was in its heyday in the late 19th century. Not only has the courthouse survived, but the acoustic treatment has survived as well. The treatment used is one that was used in the Royal Albert Hall in London in the early 1900s and subsequently removed. The acoustic treatment is miles of fine wire stretched under the ceiling of the court!

SIDNEY MYER MUSIC BOWL

The Sidney Meyer Music Bowl in Melbourne was the first large permanent outdoor concert venue in Australia. It broke new ground mainly because of the size of the venue and because it needed a sound system to enable the audience on the lawns behind the fixed seating to hear performances. Much of the work to achieve realistic sound was undertaken at CSIRO. Physical modelling techniques for design purposes were developed and research undertaken into the precedençe effect, column loudspeakers and signal delays in order to ensure the success of the venue.

SYDNEY OPERA HOUSE

Despite the lack of Australian content and a not altogether resounding success as a concert hall and opera hall there is one building which most practitioners mention as of prime importance in Australian architectural acoustics history and that is of course the Sydney Opera House. It is sometimes mentioned as the eighth wonder of the world and must be one of the few (if not the only) building to have an opera written about it. This is not just because it is the best known building in Australia and is despite the concert hall being severely bass deficient and having other problems and the opera hall orchestra pit having had more consultants with less resulting improvement than even Philharmonic Hall in New York. The solution in the case of the Philharmonic Hall (gut it and start again) cannot however be contemplated at the Opera House.

Besides being notable as a sculptural masterpiece the Opera House is also important because of the way the acoustics were "designed". One-tenth scale physical models were constructed on which V.G. Jordan undertook evaluations of several designs [4]. There were also Australians working on many aspects of the building. Peter Knowland was one of those and obviously learned much from the experience of working with two acousticians of world renown: Cremer and Jordan. It was a time of flowering for Australian architectural acoustics.

NATIONAL ACOUSTIC LABORATORIES

The Taj Mahal of Australian acoustics is the "sound shell" and the facilities in it at the National Acoustic Laboratories building in Chatswood, NSW. It is an extraordinary piece of architectural acoustics the like of which will probably never be seen again. The facility is a series of shells within a shell, built in an area of low background noise and ground vibration.

ANGEL PLACE RECITAL HALL

Sydney has long lacked a good recital hall. Other venues have been used with little enthusiasm either because of unsatisfactory acoustics, limited seating, or unsatisfactory backstage or front of house facilities. Peter Griffiths and Arup Acoustics have done a fine job on the acoustics and produced a hall that will be a benchmark for future halls in Australia in the 21st century.

RESIDENTIAL BUILDINGS

There are some residential buildings in Australia that are perhaps notorious rather than notable as far as architectural acoustics is concerned. Unfortunately, the libel laws are such that we dare not mention them and their well-known architects. (There is the famous case of a building in Canberra which was described as "leaking like a sieve". The newspaper and the writer of the article were successfully sued because it was shown that the building in question had only 127 holes in the roof whereas an average sieve had many more. There are several other notable examples including one where a cartoonist was involved.) It is these "failures" which are probably more important than the "successes" in progressing architectural acoustics but as mention of them has been driven underground mistakes continue to be made. Unfortunately there appear to be no houses in Australia of the notoriety of Frank Lloyd Wright's "Falling Water", which reputedly had the occupants continually wetting their beds, and the lesson seems to have been well learned (or else there is a lack of waterfalls to build houses over).

SANIP

What will be the biggest and most expensive architectural acoustics undertaking (and probably more expensive than all the acoustics projects ever carried out put together) in Australia is the Sydney Aircraft Noise Insulation Program (SANIP). Hundreds of houses and public buildings have been treated. This is an ongoing attempt at compensating residents under flight paths for the noise to which they are subjected. It was started after the introduction of the Third Runway at Sydney Airport, which was designed to not have a significant impact on the environment. The cost of the insulation program has been immense, even though the program has not been completed and it is only houses in the ANEF 30 plus areas (not ANEF 20 as suggested under AS 2021) that are being treated.

Overall the program appears to have been valuable but the attempt to reduce the wool stockpile by using it for ceiling insulation was a failure when the wool had to be removed after it became infested with beetles. Also, ventilation of many of the insulated buildings is unsatisfactory. The second biggest architectural acoustics project in Australia will be the evaluation of the SANIP. There has been no suggestion that this will be done but it must be undertaken if lessons are to be learned and money well spent in future.

OTHER BUILDINGS

Many of the cinemas, both new and old, are worthy of mention but a reference to another of Ross Thorne's books [5] will have to suffice. Theatres such as the Capitol Theatre in the Haymarket, the old Elizabethan Theatre in Newtown and town halls such as the Adelaide and Melbourne Town Halls and the Queensland Performing Arts Centre are also worthy of note. The Eugene Goosens Hall in the ABC building in Ultimo, Sydney, deserves a mention, as it was designed as a rehearsal space for the Sydney Symphony Orchestra with an acoustic similar to that of the concert hall in the Sydney Opera House.

Some restaurant guides in Australia now rate restaurants for their acoustics. This is a significant advance and hopefully will lead to a change from the hard reflective surfaces now in fashion. On the other hand publicans and restauranteurs know well that the noisier a venue is the more people eat and drink.

STANDARDS

Standards and codes have probably helped, hindered and distorted architectural acoustics in Australia more than any other factor. In the early days the standards committee on architectural acoustics was an important forum for discussions about the standards needed and served to transfer information on the theory and practice of many subjects, as there was a wide range of backgrounds among the committee members. There were too the seemingly endless (and sometimes pointless) arguments over matters such as the relative merits of dB(A) as opposed to NR.

That there was a need for standards (and for professionals to use them) was obvious from stories such as that of an architect who had conducted his own acoustic isolation test when residents complained that they could hear the "creaking bedsprings" in adjoining bedrooms of a block of units. The test consisted of the architect lying on the bed in one unit listening for the sound of his assistant "bouncing" on the bed in an adjacent unit. This method had the potential for being the basis for a very popular standard, though it would have required two people in the "source" room and the standardisation of the bed activity would have presented problems especially where multiple measurements were required. The AK/4 (AV/4) committee chose to write a standard based on a pink noise source rather than red-blooded passion!

The instigator of standards in acoustics in Australia and the first chairman of the AK/4 committee on Architectural Acoustics was Vivian Taylor. He was followed by Carolyn Mather, Fergus Fricke and the present chairman, Norbert Gabriels. On the committee there were consultants such as Peter Knowland, Gerald Riley and Graeme Harding. There were also representatives of building materials suppliers such as John Irvine and Arne Parts. The government labs were represented by the likes of Paul Dubout, Ted Weston and Prem Narang, while public authorities, the Australian Acoustical Society and universities were represented by Anita Lawrence, Marion Burgess and Ken Cook.

The AK/4 committee produced many important measurement standards but it will probably be best known for AS 2107 on recommended noise levels and reverberation times in buildings [6] and AS 2021 on the siting and construction of buildings around airports [7] which had its genesis in Carolyn Mather's PhD dissertation [8]

THE BUILDING CODE OF AUSTRALIA

The late Ted Weston is credited with the introduction of the acoustic provisions of the Building Code of Australia and its forerunner, Ordinance 70. Ted's attitude was that it was better to get some acoustic provisions into the building code than have none at all. At the time their introduction was being considered, he felt that if the proposed acoustic regulations were too stringent then nothing on acoustics would be included in the building code. He felt that once acoustic provisions were included they could be upgraded later.

Deregulation/private certification, urban consolidation, rapacious developers and inadequate acoustical requirements in the building code requirements have given architects, builders, developers and acousticians a bad name in many parts of Sydney. The situation is compounded by the problem of doing anything retrospectively to reduce the sound transmission between units or changing the BCA.

UNIVERSITIES

In NSW the best known universities for architectural and building acoustics are the University of New South Wales and the University of Sydney. Both of the NSW universities acted on the post-war recommendations of the Royal Institute of British Architects: that there was a need for more science and technology in architectural education. Jack Cowan was appointed as Professor of Architectural Science at the University of Sydney in 1954 and initially concentrated on structural aspects of buildings, but soon introduced environmental issues. At UNSW Ralph Phillips, Anita Lawrence and others were concerned with the environmental issues of lighting and acoustics, and Anita was responsible for the introduction of the MSc(Acoustics) degree. Early PhDs in architectural acoustics were awarded, at the University of Sydney in 1971 to Carolyn Mather for her work on the siting and constructing of buildings affected by aircraft noise (before that she did a Master's dissertation on noise in office buildings [9]), and to Laurie Hegvold, at the University of NSW, on the acoustic modelling of audiences.

In Melbourne, RMIT with Ken Cook and Elizabeth Lindqvist has also had an important influence on architectural acoustics. The work done on the sound transmission of roofs by Ken Cook has been of great value and there has been a long history of undertaking consulting and testing for industry. Mechanical Engineering Department at Monash University started out with a superbly equipped acoustics laboratory and the attention of Ron Barden and Cliff Stevenson. Len Koss, Robin Alfredson and others have since undertaken work of importance to architectural acoustics on impacts and the vibration of structures, barriers and enclosures.

Adelaide University has a proud history of acoustics research. While most of this work would not be classified as architectural acoustics some of the work that Dave Bies and Colin Hansen have done on subjects such as attenuation of sound in ducts and the coupling of structures to the acoustical field in a room are relevant.

For a while the universities in WA developed expertise in architectural acoustics with Harold Marshall and his co-workers, George Dodd and Michael Barron, and later when Harold Marshall moved to the University of Auckland, Tibor Vass and Derek Curruthers.

RESEARCH INSTITUTIONS

Undoubtedly the CSIRO Division of Building, Construction and Engineering (and its forerunner, the Division of Building Research) was the pre-eminent research institution in architectural acoustics. The work of Nickson, Muncey, Davern and Dubout on absorption of air and materials, acoustical modelling, speech intelligibility, the acceptability of late reflections in speech and music, room acoustics, sound reinforcement etc date back to the late 1940s. The results of their work have been published in nearly 150 CSIRO reports and papers in journals such as *Acustica* and *Journal of Sound and Vibration*, and in conference proceedings. John Davy, the current leader of the CSIRO group, has arguably done more to put architectural acoustics on a sound theoretical base than anyone else in Australia.

The National Acoustic Laboratories has not traditionally been involved in architectural acoustics but in recent years has made a significant contribution to measuring the sound transmission of walls and other building acoustics measurements.

The Experimental Building Station that later became the National Building Technology Centre and then, still later, part of the CSIRO Division of Building, Construction and Engineering, produced the authoritative work on sound transmission [10]. More recently, Prem Narang has been involved in the study of rain noise on roofs and the insulation of buildings against aircraft noise.

SEMINAL WRITTEN WORKS

Anita Lawrence's books, *Acoustics in Buildings*, published in 1962 [11] and her later works, *Architectural Acoustics* [12] and *Environmental Acoustics* [13] are the most important Australian architectural acoustics monographs, while the EBS Report 48 on the transmission loss of walls by Ted Weston et al. [10] was for many years the definitive work on wall performance. In terms of scientific papers the jury is probably still out and probably won't ever come back in or give a definitive decision. It has already been mentioned that papers by Muncey, Nickson, Dubout, Davern, Dunn and Davy have been published in the most prestigious acoustics journals. Fricke and his post-graduate students, eg Wu, Nannariello, Haan, Field and Mohajeri, have also published internationally in widely diverse areas of architectural acoustics but their work on assessing concert hall acoustics, the application of neural network analysis to acoustic problems and noise reduction through ventilation openings will probably be seen as their most important work. For anyone wishing to study architectural acoustics the lecture notes and demonstrations prepared by Densil Cabrera for the Masters program in engineering at the University of NSW are highly recommended.

OTHER WORK

There are some other developments that are worth mentioning. Amongst the most important are several pieces of software such as ENM and dBRay developed by Renzo Tonin and AutoSEA developed by Paul Bremner.

LOOKING TO THE FUTURE

Architectural acoustics is dying academically for a number of reasons, the two most important ones being that it gives little or no commercial advantage and has no strategic value. Part of the reason for the lack of interest from the building industry is that the provisions of the Building Code of Australia are so easy to comply with. Until the BCA is changed there will be little need for architectural acoustics research in an era of research driven by commercial necessity. Even if that changes, the research will be more than likely undertaken by acoustical consultants, as the time-scales that universities work to with PhD students are too long for most commercial interests.

Briefly, the future for architectural acoustics is mixed. There is a crying need for better sound isolation in many aspects of buildings and better predictions of subjective reactions to the acoustics of spaces. But unless the acoustics researchers can come up with ways of building better walls, floors, rooms etc there is little point in having architectural acoustics academics. Sadly there are no strategic reasons for putting money into architectural acoustics and there are few commercial ones for the reason indicated above and also because few developers or building materials suppliers see that they will get a commercial advantage from any research in Australia. In fact new acoustical products are often discouraged because, as one developer explained, "they draw attention to noise problems".

Architects seem to feel that acoustics has little or no place in a School of Architecture and, perhaps because of "Architecture" in the title, few other university departments seem to consider it as important. It is therefore left to the odd institution to carry the architectural acoustics torch. One such institution is the Acoustics Research Centre at Auckland University, but even that august institution is at risk from the economic rationalism broom that is cleaning out universities. There appears to be a reduction in the number of people working in architectural acoustics research and education and an increasing number working as consultants in Australia. Unless architectural acoustics continues to develop it will not survive. The future of architectural acoustics is not bleak, but it can hardly be said to be bright as the past.

REFERENCES

1. R. Thorne, *Theatre buildings in Australia to 1905: from the time of first settlement to the arrival of cinema*, Architectural Research Foundation, University of Sydney (1971).
2. Hugh Vivian Taylor Obituary, *Bulletin of the Australian Acoustical Society*, **9**, 2 (1981).
3. G. Riley, "A forerunner of Australian acoustics," Paper delivered at the Australian Acoustical Society Annual Conference, *Acoustics Today*, Melbourne (1999).
4. V.L. Jordan, "Acoustical design considerations of the Sydney Opera House," *Journal and Proceedings, Royal Society of New South Wales*, **106**, 33–53 (1973).
5. R. Thorne, L. Tod, and K. Cork, *Cultural Heritage of Movie Theatres in NSW 1896–1996*, Department of Architecture, University of Sydney (1997).
6. AS 2107-1987, *Acoustics—Recommended design sound levels and reverberation times for building interiors*, Standards Australia (1987).
7. AS 2021-1994, *Acoustics—Aircraft noise intrusion: Building siting and construction*, Standards Australia (1994).
8. C.E. Mather, *Some aspects of the aircraft noise problem in the vicinity of Sydney (Kingsford-Smith) Airport*, PhD Dissertation, University of Sydney (1971).
9. C.E. Mather, *The acoustical environment of four modern office buildings*, MBldgSc Dissertation, University of Sydney (1968).
10. E.T.Weston, M.A. Burgess and J.A.Whitlock, *Airborne sound transmission through elements of buildings*, Technical Study No. 48, Department of Housing and Construction, Experimental Building Station (1973).
11. A. Lawrence, *Acoustics in Buildings*, Hodder and Stoughton, Melbourne (1962).
12. A. Lawrence, *Architectural Acoustics*, Elsevier, Amsterdam (1970).
13. A. Lawrence, *Acoustics and the Built Environment*, Elsevier Applied Science, London (1989).

A VICTORIAN PERSPECTIVE

C. Louis Fouvy
241 Cotham Road, Kew, Vic 3101

In Victoria, also, there has been much activity in the field of architectural acoustics since the early 1920s. In this brief article, the emphasis will be on the activities of earlier workers, particularly those of H. Vivian Taylor, MBE, LFRAIA, FAAS (1894–1981), architect-acoustician, and of the CSIRO Division of Building Research, Highett, Vic and its team of acoustics researchers. While these, and more recent activities, are to be described in greater detail in a forthcoming account of acoustical work in Victoria, an outline will be given here.

H Vivian Taylor was one of the 20th century's early acousticians in Victoria. By 1923, when his interest in acoustics began, he had been admitted as an Associate to the Royal Victorian Institute of Architects and was registered and practising as an architect in Victoria, a practice subsequently extended to New South Wales. In 1931 he became a member of the Acoustical Society of America (founded in 1929), and was a foundation member of the Victorian Acoustical Society (1964), and first president of the AAS at its incorporation in 1971.

As architect and acoustician his earlier projects included some 55 churches, public halls, and industrial buildings. With the arrival of sound films ('talkies'), his projects after 1927 included at least 400 cinemas (many Hoyts), some as existing auditoriums whose acoustics he greatly improved, and some new, such as the Regal, Hartwell, and the 'new' Rivoli, Camberwell Junction, opened on 11 October 1940 and regarded in its day as a most modern cinema, complete with Crying Room for separating parents with young children from the rest of the audience [1]. He also designed public buildings throughout Australia, the SA Parliament House, ABC broadcasting studios in all states (including the original studios at William and Lonsdale Sts corner, Melbourne), and, during World War II, the Pagewood, NSW film studios, and, for the Australian Dept of Aircraft Production and the US Air Force, the silencing of the aero engine test cells for the SW Pacific area.

When Vivian Taylor began his acoustical work, Wallace Clement Sabine's (1868-1919) comprehensive *Collected Papers on Acoustics* [2] were amongst the few then available texts on architectural acoustics; the *Journal of the Acoustical Society of America* became available after 1929, with F R Watson's "Reverberation equation" [3], Vern O Knudsen's "Hearing of speech in auditoriums" [4], Walter A MacNair's "Optimum reverberation time for auditoriums" [5] and similar articles being published soon afterwards.

From these he learned not only of the influence of the reverberation time of a room or auditorium on the clarity and intelligibility of speech or music performed in them, and of ways of modifying this time to obtain its optimum for speech or music by introducing sound absorbent material to reduce excessive reverberation, but also of using appropriate materials for studios' and music rooms' walls, ceilings and floors as acoustic barriers to minimize the entry of unwanted sound from adjacent areas. A further development in obtaining optimum reverberation times arose from taking account of the average octave frequency spectra of speech and music sources, and, from these, developing a reverberation time vs frequency band characteristic such that, with corresponding acoustic absorption, all frequency components of the sound source would die away to inaudibility at the same moment.

In applying this experience he was able to design the interiors of cinemas, broadcasting studios, and auditoriums for speech and music to obtain good acoustics, through having shorter reverberation times (around 0.5 to 1.0s depending on room volume) for intelligible speech in cinemas and studios, and longer times up to 2.0s in studios and auditoriums for music. Because a single microphone is analogous to monaural listening, he found it important for broadcasting studios and other rooms to use lower reverberation times than for binaural listening conditions, and to eliminate all extraneous noise. These design procedures are described in detail in his 1938 Convention paper on "A new approach to architectural acoustic design" [6].

Because, in the late 1920s there was little information available about the acoustic properties of materials, he obtained the use of an office suite in 1931 for use as a reverberation room for assessing the properties of the acoustics materials then available [7].

As an acoustical consultant, Vivian Taylor also worked on community and other noise problems, with then current noise sources as varied as entertainment, industrial undertakings, mechanical plant, office machines, traffic and transportation. Where noise cannot be further reduced at its source, he argued that some form of noise zoning is necessary to preserve the acoustic amenity of an area or neighborhood. When the possibility of noise nuisance is taken account of and included at the design and construction stages of a project or piece of equipment, the resulting cost is considerably less than the "staggering cost" of subsequent remedial work. Noise zoning within a multi-dwelling or multi-use building is a matter of intelligent and proper planning and design; noise zoning within a multi-land use neighborhood needs an effective land use zoning ordinance. The 1957 Chicago Zoning Ordinance he considered to be "realistic, satisfactory and capable of enforcement" because it delineated and classified residential, business, commercial and industrial districts, and stipulated the permitted maximum octave band noise levels in decibels, as measured at the points of interest at zone/district boundaries [8].

His two available Convention/Conference Papers are those to the 1938 World Radio Convention, Sydney, on his "New Approach to Architectural Acoustic Design" [6], and to the 1971 AAS Noise Zoning Conference, Warburton, Vic on "The Economics of Noise Zoning" [8]. He was indeed a man of industry and imagination.

When in 1944 Ian Langlands was appointed CSIRO Officer-in-charge (from 1950 Division Chief) of Building Research he subsequently established an acoustics research group comprising Roy (later Dr) Muncey (from 1946), Arthur Nickson (1949), Werner Lippert (1950), Paul Dubout (1951) and Bill Davern (1957). As shown by their published papers, they embarked on an extensive research program into important aspects of architectural acoustics involving a judicious combination of pure and applied research.

Seven distinct aspects of this program can be identified : the acoustic properties of boundaries, acoustic models, room acoustics, sound amplification in auditoriums, miscellaneous building acoustics, community and other noise problems, and on the propagation of sound in air, ducts, etc. These CSIRO researches, largely based as they were on that of previous researchers, were a combination of both a review and confirmation of the earlier work under CSIRO laboratory conditions, and an extension of their conclusions into new areas. By 1960, this group had produced 40 research papers and reports.

Research into the acoustic properties of boundaries was undertaken because there were few data available on the absorption coefficients of the acoustic materials of that time. It was first concluded that coefficients should be calculated from measurements of the Specific Acoustic Impedance of each material. From earlier research there were eight methods then possible, of which the Transmission-Characteristic method was initially selected, and for which six carefully proportioned rectangular chambers were constructed having greatest chamber dimensions of 1.73, 0.864, 0.432, 0.216, 0.108 and 0.054m, for frequencies from 100 to 5000Hz, and normal and other angles of incidence [9]. With this equipment, specific acoustic impedances of materials either in situ or as samples could be measured. It was not until 1953 that an acoustic impedance tube was built for measuring the impedance of sound-absorbing material samples [10], including perforated facings backed with porous materials, with or without an intervening air space [11]. These latter were found to be very adaptable in that they could be designed for narrower or broader frequency band absorption characteristics, with maximum absorption coefficients around 0.9, and as high as 0.6 at 200Hz.

In 1950, the possibility of using architectural acoustic models for simulating room acoustics dated back to at least 1914, when W C Sabine did so as described in his paper (no. 7) on "Theatre Acoustics" [2]. However, much remained to be discovered. On the basis that the use of models (eg, around one-tenth full size) offered "tremendous possibilities for elucidating acoustic phenomena, for testing the acoustics of a new auditorium before its erection, and for making laboratory experiments and measurements", Roy Muncey et al, over a period of 6 years, demonstrated that a scale model of a room, with suitable bounding surfaces and interior atmospheric conditions, could, with accuracy to 0.05%, reproduce to scale the acoustical properties of the room. The overall "accuracy attained corresponded with the accuracy with which the surfaces were matched, and was considerably greater than that of the relation of objective testing and subjective impressions." [12]

Alongside the research on acoustic models, Roy Muncey, Arthur Nickson and Paul Dubout investigated several aspects of room acoustics, including auditorium reverberation times, listeners' judgments on room acoustics, and the degree to which listeners to speech or music were disturbed by echoes. With both speech and music echoes, they confirmed the "Haas effect" that an echo was not disturbing if it arrived within 30 to 50 ms of the initial sound, even if 10dB louder, an effect important both in the acoustic quality of auditoriums and in sound reinforcement [13].

Roy Muncey's and Arthur Nickson's work on sound amplification and reinforcement in auditoriums proceeded along two main lines, depending on whether or not the amplified sound as heard was later than the initial sound, and on the other characteristic of the Haas effect that the sound would appear to come from its source, however weak, as long as the amplified sound was heard just after the original. For the Melbourne Exhibition Building and medium size auditoriums and church interiors, a sound reinforcement system was found satisfactory provided that the loudspeakers (of a special column design to give maximum lateral and minimum vertical sound dispersion) were further away from listeners than the source. For large spaces such as the Myer Music Bowl, with the column loudspeakers placed close to the more distant listeners, suitable delays (to ca. 1s), calculated to use the Haas effect and simulate reverberation, were required. These delays were initially obtained through a magnetic tape recorder with continuous tape loop, later through other electronic means [14].

Researches into miscellaneous aspects of building acoustics were carried out to solve particular noise problems. Werner Lippert, in a paper on the latest developments [15], gave an account of the then current standards available, and the work done on designing walls and inter-floor partitions with improved sound insulation for multi-unit dwellings. Paul Dubout [16] described work done in predicting and reducing the interior noise levels from rain falling on metal roofing.

Their noise reduction work covered many aspects of both community and machine noise. In response to a request from the Melbourne City Council, an early noise problem worked on by CSIRO DBR staff was that of noise in the Degraves St subway, now Campbell Arcade, from trams in Flinders St overhead. The problem arose through the M&MTB re-constructing the tram track in solid concrete in intimate contact with the subway structure, without thought of the noise that wheel-on-rail vibration would cause in the subway. Against ambient noise levels of 65–70 dB(C) or 56–61 dB(A), tram noise levels in the subway were 85–102 dB(C) or 79–96 dB(A). The problem was remedied, and tram noise reduced by 13 to 15 dB, by spraying a vibration dampening rubber-based layer on subway duct work, disconnecting the shop walls from the ceiling slab, suspending the shop ceilings from these walls, and reducing the reverberation time in the subway to 0.5s [17].

If the tram rails had, instead, been supported on 20 mm deep longitudinally-fluted natural-rubber rail pads (of 40 IRH) and otherwise vibration-isolated from their concrete roadway (as currently over the Museum station concourse under LaTrobe St) the noise problem would not have occurred, for the vibration intensity in the slab would then have been reduced to one-tenth. This case illustrates a problem with which acousticians are continually faced, in that architectural, engineering and other designers too often fail, and sometimes even refuse, to take account of the acoustical and vibration implications of their designs, with the result that subsequent remedial work has to be undertaken, which invariably turns out to be significantly more costly than if noise and vibration reduction measures had been originally incorporated in the project or equipment.

While all CSIRO DBR acoustics staff were involved at one time or another in researches into the propagation of sound in air, ducts, filters, etc, as investigations supporting their other researches, much of it was described and recorded by Werner Lippert, who, between 1954 and 1965, published 15 papers, 11 in *Acustica*. Typical of these is his work on wave transmission around bends in rectangular ducts [18].

The acoustical work of Vivian Taylor and of the CSIRO DBR has been briefly described here because it has formed the basis of much continuing acoustical work, not only in architectural acoustics, but in the many aspects of noise and vibration measurement and reduction. It is only for reasons of space limitation here that the work of other Victorian acousticians, and groups such as at the Australian Acoustical Laboratory, Monash University, the PMG (later Telecom, now Telstra) Research Laboratories, RMIT, and of the numerous earlier and more recent acoustical consultants cannot be included here. However, accounts of some of their work can be found in AAS Conference *Proceedings* from 1968 onwards, and, from 1973, in the AAS *Bulletin* and its successor from 1984, *Acoustics Australia*.

REFERENCES

1. R. Thorne, *Cinemas of Australia via USA* Sydney, Arch. dept. Univ. of Sydney, 1981, 388 pp.
2. W.C. Sabine, *Collected Papers on Acoustics* Cambridge, Mass., Harvard University Press, 1922.
3. F.R. Watson, "Graphical representation of the reverberation equation" *J. Acoust. Soc. Am.* **1**(1), 47–55 (1929).
4. V.O. Knudsen, "The hearing of speech in auditoriums" *J. Acoust. Soc. Am.* **1**(1), 56–82 (1929).
5. W.A. MacNair, "Optimum reverberation time for auditoriums" *J. Acoust. Soc. Am.* **1**(2), 242–248 (1930).
6. H. Vivian Taylor, "A new approach to architectural acoustic design in relation to radio broadcasting, sound recording and reproduction" Paper no. 47 (of 51) in *Complete Proc. World Radio Convention*, Institution of Radio Engineers (Aust), Sydney, 1938, pp. 1–7.
7. Gerald Riley, "A forerunner of Australian acoustics" *Proc. 1999 AAS Conf. Acoustics Today*, pp 9–14.
8. H. Vivian Taylor, "Economics of noise zoning" Paper no. 15 (of 15) in *Proc. AAS Noise Zoning Conference*, Warburton, Vic, 1971, pp. 15.1–15.6.
9. A.F.B. Nickson, and R.W. Muncey, "Acoustic impedance measurement by the transmission-characteristic method" *Acustica* **3**, 192–198 (1953).
10. P. Dubout, and W.A. Davern, "Calculation of the statistical absorption coefficient from acoustic impedance tube measurements" *Acustica* **9**, 15–16 (1959).
11. W.A. Davern, "Perforated facings backed with porous materials as sound absorbers—an experimental study" *Applied Acoustics* **10**, 85(112 (1977).
12. A.F.B. Nickson, and R.W. Muncey, "Some experiments in a room and its acoustic model" *Acustica* **6**, 295–302 (1956).
13. R.W. Muncey and A.F.B. Nickson, "The listener and room acoustics" *J. Sound Vibr.* **1**(2), 141–147 (1964).
14. R.W. Muncey and A.F.B. Nickson, "Sound reinforcement at the Sidney Myer Music Bowl, Melbourne" *Acustica* **10**, 60–66 (1960).
15. W.K.R. Lippert, "Latest developments in evaluating building acoustics" *Aust. Building Science & Technology* 17–24 (May 1966).
16. P. Dubout, "The sound of rain on a steel roof" *J. Sound Vibr.* **10**(1), 144–150 (1969).
17. R.W. Muncey and A.F.B. Nickson, *Acoustic treatment of the Degraves St subway, Melbourne, Aust.* CSIRO DBR Report, 1956, pp. 1–11.
18. W.K.R. Lippert, "Wave transmission around bends of different angles in rectangular ducts" *Acustica* **5**, 274–278 (1955).

A HISTORY OF MUSICAL ACOUSTICS RESEARCH IN AUSTRALIA

Neville Fletcher

Research School of Physical Sciences and Engineering
Australian National University, Canberra 0200

Musical instrument making has a long history in Australia and continues to flourish and produce innovations. Research in musical acoustics has a much shorter history, but here too Australian researchers continue to make an impact. Most of these people began their research in other areas of physics, and continue to pursue these interests along with acoustics.

It is a little difficult to define precisely the scope of the field of musical acoustics. It could be taken to include everything from the design of concert halls, through the physics of musical instruments, to the psychophysics of musical perception and to musicology. For the purposes of this historical review, I will limit myself to recording my perceptions and memories of the development of research into the acoustics of musical instruments, and closely related topics. Even this field is large, and ranges from a study of the traditional instruments of the Australian Aboriginal people, through conventional Western musical instruments, to modern electronic means of music generation. It is unlikely that my survey will be complete, and for this I apologise in advance.

With one exception, there has been little but informal interaction between the researchers involved in this field. The notable exception was the International Symposium on Musical Acoustics, held in Wollongong in 1980 as an adjunct to the Sydney International Congress on Acoustics. This was a most successful occasion.

RESEARCH GROUPS

Musical acoustics is not a large-scale study and does not require particularly expensive equipment. For this reason research has mostly been carried on in university physics departments by individual staff members working with just a few students, rather than by larger groups. A brief survey traces the history of those groups of which I am aware. Many music departments have had related musicological interests, but for the most part these have not ventured very far into the realm of acoustics.

Perhaps the first group was my own, established in 1972 in the Physics Department of the University of New England as an adjunct to my then main interest in solid-state physics. The emphasis of the group was on nonlinear phenomena in musical acoustics, with applications firstly to wind instruments and then to strings, gongs, and cymbals. Four students completed PhD degrees during the 10-year life of the group, and members continued to do at least some work in the field in later years, producing three books [1-3] and some fifty journal papers between them.

Another group with a longer lifespan was developed by Gordon Troup in the Physics Department of Monash University, again initially as an adjunct to his principal research in solid-state physics. The emphasis of this group has been on the role of the vocal tract in wind instrument performance [4], and more recently on some aspects of vocal performance, and several PhD degrees have been completed in these fields. Throughout its history, this group has been closely related to the Melba Conservatorium of Music.

Musical acoustics in the University of New South Wales began with the work of Howard Pollard on the acoustic analysis of pipe organ sounds [5,6]. Since Howard's retirement, Joe Wolfe and John Smith have established a very active musical acoustics group with a focus on the real-time measurement of acoustic impedance, both for wind instruments such as the flute and also for the vocal tract [7]. A novel measurement system has been developed for this purpose [8]. Some work is also in progress on guitars, and also on musical perception by people fitted with cochlear implant hearing devices. The group has continuing a involvement with French researchers through visits by students. Once again, the researchers also have had other interests, in this case in cryobiology.

At Sydney University there are several groups with interests bordering on the area of this review. Fergus Fricke in the Department of Architectural Science has supervised projects on organ-pipe acoustics, as well as having a major interest in concert-hall acoustics, and Ian Johnston in the Department of Physics has an involvement in musical acoustics from a rather general viewpoint [9]. A comparatively new development is the National Voice Centre under the leadership of Pam Davis, who is a physiologist rather than a physicist. As its name suggests, the main focus of the Centre is on vocal technique, but research has also been carried out on the vocal tract in relation to flute performance.

LaTrobe University also had a small musical acoustics group led by Tony Lee and with primary interests in the acoustics of the piano [10], while the Department of Interior Design at RMIT currently has work in progress on several experimental musical instruments, and Hans Gottlieb leads a small group at Griffith University.

Finally, mention should be made of various musical instrument builders who have also contributed to acoustic understanding and innovation, some in quite major ways. I shall return to these people in later sections of this paper.

ABORIGINAL INSTRUMENTS

Most important among the musical instruments of the Australian Aboriginal people is the didjeridu (more often spelt didgeridoo and actually called a yiraki by the Aboriginal people). This is simply a tube, typically about 1.5 m long and with internal diameter flaring from about 30 mm at the blowing end to 40(80 mm at the open end in a more-or-less conical fashion. The didjeridu tube is almost a "found" object, since it is formed by the activities of termites eating the cores of young Eucalypt trees, most of the hand-work being devoted to smoothing and painting the exterior. It is played by lip excitation in the same way as the tuba, combined with "circular breathing" to produce a continuous sound. Although the didjeridu has only two notes, one a drone at about 70 Hz and the other the second mode of the pipe, typically at a little below 200 Hz depending upon the flare, skilled players can produce a multitude of startling effects by combined sounding of the drone and various vocal noises. Even the timbre of the drone can be substantially modified by changing the configuration of the vocal tract . The acoustics of the instrument have been well studied, but there remain many questions about performance technique [11]. Lloyd Hollenberg from the School of Physics at Melbourne University has a continuing interest in this subject.

Another family of instruments of current interest is that of "torsional aerophones." The kurnatja, generally called a "bull-roarer" by Europeans, is the most audibly spectacular. It is a simple, nearly flat, elongated elliptical wooden plate fixed by one end to a long string and whirled circularly by the player. The strip rotates continuously about its long axis in one direction for several seconds, producing a low-pitched roar with a decreasing frequency, then stops and reverses direction to repeat the process. The other instrument is the "gum-leaf" which is a simple leaf strip placed between two thumbs and blown to produce a rather piercing sound with a pitch that can be controlled by the longitudinal tension. In both cases, the operation depends upon non-steady aerodynamic flow and the associated lift and torque forces. This is being studied by Alex Tarnopolsky and the present author in the School of Aerospace and Mechanical Engineering at ADFA.

The Aborigines also have a few percussion instruments, in particular pairs of short wooden cylinders with pointed ends, or even pairs of boomerangs, that are clapped together to produce a rhythmic accompaniment to didjeridu sound. The acoustics in this case is straightforward, but there is considerable interest in the properties of the wood used.

EUROPEAN MUSICAL INSTRUMENTS

Pipe Organs

Australia has a wealth of historic pipe organs, mostly imported from England at the end of last century. Graeme Rushworth has published a survey of those located in New South Wales [12] which also identifies Australian builders, and there are many equally distinguished organs in other states. One of the most notable instruments is the Sydney Town Hall organ, built by William Hill of London in 1890, at which time it was the largest pipe organ in the world. It has been maintained unaltered, except for replacement of the hydraulic bellows by an electrically operated wind supply, and was recently renovated to original condition. One of its notable features is a full-length 64-foot pedal reed stop (contra-trombone) with a fundamental of 8 Hz for the lowest note. The pipes of this rank are of wood, quasi-conical but with square section, and the few longest ones are necessarily mitred to fit within the height of the hall.

Much more recent is the Sydney Opera House organ, designed and built by Ron Sharp of Sydney [13]. It is a five-manual instrument with complete mechanical (tracker) action, supplemented by electric couplers and computer-controlled stop selection. At the time of its construction it was the largest tracker-action organ in the world, and it contains many technical innovations. There are several other Australian organ builders who have produced, and continue to produce, instruments of excellent quality and fine design. Research on pipe organ sounds has been carried out by Howard Pollard at UNSW [5] and on more physically based acoustics by Suszanne Thwaites and myself at New England [14].

Pianos, Harpsichords, etc.

At one time, Australia had several piano manufacturers building instruments for the domestic market, some notable names being Paling and Beale. These operations have long since ceased because of competition from imports, but a remarkable renaissance of piano building has been initiated by Wayne Stuart, now at the Newcastle Conservatorium. His piano is a concert grand that competes with the great international names such as Steinway and Yamaha, and is recently receiving considerable attention from its use by Gerard Willems to record the complete Beethoven piano sonatas. The Stuart piano has several innovations in design: the keyboard is a full 8 octaves and extends down to F1 instead of the usual A1, there is an extra pedal to allow a different style of dolce playing, and the strings are clamped to the bridge in a novel manner using an agraffe so that they do not make the slightly zig-zag path typical of other instruments. Bob Anderssen of CSIRO is collaborating with the manufacturer to better understand the acoustics of the instrument.

Harpsichords and clavichords are also built by several Australians in various parts of the country. In such instruments, tradition is important, and design innovations unlikely to be welcome, though Bill Bright decorates the lids of his instruments with Australian rather than the typical European scenes! A few papers on the acoustics of harpsichords and clavichords were published by the New England group about 20 years ago [15]. There are also Australian builders of less common instruments such as dulcimers, among whom Gillian Alcock of Canberra is notable and also has a concern for the basic acoustics of the instrument.

Guitars

The story of guitar building in Australia is a very interesting one, with solid acoustical underpinnings. In the classical-music scene, most guitars are about the same size and differ primarily in the bracing pattern underneath the soundboard. There is a bass instrument among electric guitars, but we do not consider this further here.

There have been innovations within this tradition through the use of Australian wood for some instruments and, more significantly, through the introduction by Greg Smallman of light-weight graphite-epoxy bracing, which has proved popular with performers. The greatest innovation, however, has been the development by Graham Caldersmith of a four-member family of guitars of different sizes [16], following the pattern established in the United States by Carleen Hutchins in her development of the eight-member "New Violin Family."

The essence of designing such a family was to take a standard guitar as model and then, by appropriate scaling and re-design of body size, soundboard design, etc, to produce larger or smaller instruments with body resonances and cavity resonances appropriately matched to their different pitch. The result was a family of four instruments, scaled up or down in musical intervals of a fourth or a fifth, with one instrument (treble) smaller than the conventional guitar (which is the tenor in the quartet), and two larger instruments (baritone and bass). The result is very successful and has been used extensively in recordings made by the ABC of the Canberra School of Music group Guitar Trek [17].

Bowed-String Instruments

Australian luthiers have been active in violin making for at least a century, one of the founding fathers of the tradition being A.E. Smith of Sydney. Now there are many makers all around the country, some building by the traditions handed down from their teachers, some having studied in European violin-making schools, and some, like Graham Caldersmith, following the new scientific tradition established by Carleen Hutchins, in which vibration modes of the violin body are measured and then modified by careful shaving of the wood to approximate (or, if desired, differ from) corresponding modes measured on violins by Stradivarius, Amati, and other great makers. The same approaches can be followed for violas and cellos.

There has also been innovation in using Australian woods for crafting the instruments and in careful study of the physics involved [18]. It is necessary to use a light-weight straight-grained highly anisotropic timber for the top plate, and "King Billy" pine has been found to be suitable. The choices are larger for the ribs and back plate. Some fine instruments have been made by Graham Caldersmith and others but, as is to be expected, the tonal balance is rather different from that found for traditional timbers, if only because the high-frequency damping is different. Preference is a very individual matter among performers.

As far as I am aware, there has been little or no research carried on in Australia on the dynamics of bowed strings, on radiation transfer functions, or on computer simulation of bowed-string response, all of which are active research areas overseas.

Recorders and Flutes

The recorder is now a popular instrument among both amateur and professional musicians. Australia has a good record in research on the basic acoustics of the instrument and on performance technique [2,19], as well as in the collection of measurements of instruments by famous makers of the past [20]. Even greater is the reputation created by Fred Morgan of Victoria, whose instruments were prized by top players from around the world. Tragically, Fred was killed in a motor accident not long ago.

Study of flute acoustics was also undertaken by the New England group and is now being carried on by Joe Wolfe's group at the University of NSW. While the passive acoustics of the flute tube is simple in principle, there are many subtle effects of bore and tonehole configuration that affect tuning and tone quality. The mechanism of tone production by the air jet from the player's lips, however, still presents many unanswered questions, though the basic operation is quite well understood.

In relation to manufacture, we must distinguish between two types of flute: the tapered wooden flute with few, if any, keys that was used in classical times and survives in both early-music and folk groups, and the Boehm design of silver flute, with a cylindrical bore and sophisticated key system, which dates from the middle of the nineteenth century. Both have excellent makers around the country, such as Terry McGee of Canberra, who specialises in wooden flutes for Irish folk music but also makes flutes to classical design, and Mark O'Connor of Sydney who carries on the work begun by John Lehner, both having spent time with the Powell company of Boston. Both Terry and Mark collaborate with Joe Wolfe's group at UNSW. In addition, there are individuals specialising in the crafting of head-joints, which are the most critical and individual parts of the flute. The fact that many distinguished Australian flute players use head-joints made in Australia on flutes built overseas attests to the quality of the local product.

Reed Woodwinds

Oboes, clarinets, bassoons and saxophones are very little made in Australia for various reasons. The demand is small, except in the case of clarinets, and crafting the instruments is difficult. On the other hand, there is the opportunity to use Australian timbers, which, though scarcely affecting tone quality, can give a fine appearance and durability to the instrument. An example is the use of mulga wood and gold-plated keywork on the oboes made by Tom Sparkes of Sydney.

Mention has already been made of the work of Gordon Troup's group on the importance of vocal-tract configuration in instrument performance, and R.B. Johnston of that group has also examined the acoustics of the harmonica [21]. Some fundamental work on vibrating-reed valves was also done by the New England group and has now been extended by Alex Tarnopolsky and myself at ADFA. Nothing of direct relevance to reed woodwind performance is expected from this work, however.

Brass Instruments

As far as I am aware, brass instruments are not manufactured in Australia, and there has been little research on their acoustics, though this has been an active area overseas. The one exception is that of brass-instrument performance technique, in which the physiological stresses can be very high, leading to difficulties for the player, particularly in the high register of a trumpet. One significant study on this subject has been published recently [22].

Percussion Instruments

The variety of percussion instruments is very large, since the category includes bells, gongs, cymbals and drums, as well as numerous specialist items such as castanets, tambourines, etc. Many of these can be made with little specialist equipment, so that amateur makers are plentiful. In addition, there are many experimental designs that can be tried out, and many nice possible theoretical investigations.

One of the most interesting investigations of drum design was that of Hans Gottlieb and Hubert Aebischer of Griffith University. In a series of theoretical studies of the vibrational properties of an annular membrane, they gradually devised an annular kettledrum with a largely harmonic spectrum, and thus a greatly improved tonality [23]. Such an annular drum bears some relation to the Indian drums investigated by C.V. Raman, but advances the design and the technology. So far there has been no musical exploitation of this development that I am aware of.

Bells for churches and carillons have mostly been imported into Australia, but for a considerable time Hervey Bagot of Adelaide has been designing and casting his own bells for special purposes [24]. While the basic design of a bell determines the general location of its mode frequencies, the extent to which these can be tuned to a pleasant and harmonic sound when two or more bells are sounded simultaneously depends upon fine details. An excellent survey of bells in Australia has been published by John Keating [25].

A new type of tuned percussion instrument has come from the work of Sydney composer Moya Henderson and her scientific collaborators. Her initial idea was to make an instrument consisting of tuned steel triangles (of the orchestral type) connected to tubular resonators to enhance the low partials of the sound. The result was an impressive instrument with a range of about two octaves that she called the alemba [26]. Critical listening, however, led to dissatisfaction with the frequency alignment of some of the partials, and it was not possible to correct this because of the small number of geometrical parameters available in a symmetrical triangle. Modifying the triangle to a pentangle introduced more geometrical parameters and allowed as many as five partials to be tuned to harmonic relationship, including a minor third to give an appropriately bell-like sound [27].

The behaviour of gongs and cymbals was investigated [28] by Katherine Legge of the New England group, now at LaTrobe University, Bendigo, from a rather fundamental viewpoint, the interest being in nonlinear behaviour and the transition to chaotic oscillation. Insight was obtained into the phenomena of pitch glide in Chinese opera gongs, the "crash" of cymbals, and the impressive sound of the Chinese tam-tam. Other work on the design and analysis of gongs of the gamelan type has been done by Neil McLachlan of RMIT [29].

Electronic Instruments

The development of electronic instruments in Australia goes back to the time of Percy Grainger in the 1930s. He built a synthesiser using cut-out cardboard shapes on a travelling belt to control the frequency of an oscillator, and this instrument can still be seen in the Grainger Museum at Melbourne University.

More recent and much more successful has been the development of the Fairlight synthesiser by Peter Vogel and Kim Ryrie in Sydney during the 1970s. This instrument was remarkable for its versatility, allowing the use of both sampled natural sounds and also synthetic sounds, with the possibility of detailed editing of spectra, attack and decay transients, etc. The Fairlight was the instrument of choice for many performers around the world, and was used to provide background music for such prestigious films as "The last Emperor". The company now produces a wide range of professional audio and video equipment.

Another notable Australian achievment relevant to musical acoustics is the development by LakeDSP in Sydney of sophisticated signal-processing software to produce surround-sound and to simulate a variety of acoustic environments. These developments are likely to play an increasing role in music reproduction.

Electronic music now features in the activities of most university music departments, and it would be invidious to list just a few. One approach that is gaining popularity both here and overseas is the mathematical simulation of actual physical systems, such as struck metal plates for example, which can then be extended to immense size or otherwise modified and their sound output computed and recorded. The possibilities are unlimited, but convincing results depend upon physical understanding of the systems being simulated.

CONCLUSION

It has proved impossible in the brief compass of this article to give more than passing attention to the many interesting research studies and practical developments that have occurred in musical acoustics in Australia in the past quarter-century. I hope, however, that I have adequately reflected a wide and thriving enterprise, and that those whose work has been omitted will forgive my ignorance.

REFERENCES

The list of references below aims to give a broad view of the diversity of research work that has been published by Australians, and constitutes just a small sample of the total production.

1. N.H. Fletcher and T.D. Rossing *The Physics of Musical Instruments* Springer-Verlag, New York 1991, second edition 1998.
2. J. Martin *The Acoustics of the Recorder* Moeck-Verlag, Celle 1994.
3. R. Parncutt *Harmony: A Psychoacoustical Approach* Springer-Verlag, Berlin 1989.
4. P. Clinch, G.J. Troup and L. Harris "The importance of vocal-tract resonance in clarinet and saxophone performance — A preliminary account," *Acustica* **50**, 280–284 (1982).

5. H.F. Pollard "Loudness of pipe organ sounds" *Acustica* 41, 65–74 (1978).
6. H.F. Pollard "Timbre measurement" *Acoustics Australia* **18**, 65–69 (1990).
7. A. Dowd, J. Smith and J. Wolfe "Real time, non-invasive measurements of vocal tract resonances: Application to speech training," *Acoustics Australia* **24**, 53–60 (1996).
8. J. Wolfe, J. Smith, G. Brielbeck and F. Stocker "A system for real time measurement of acoustic transfer functions," *Acoustics Australia* **23**, 19–20 1995).
9. I. Johnston *Measured Tones* IOP Publishing, Bristol 1989.
10. M. Podlesak and A.R. Lee "Longitudinal vibrations in piano strings," *J. Acoust. Soc. Am.* **83**, 305–317 (1988).
11. N.H. Fletcher "The didjeridu (didgeridoo)," *Acoustics Australia* **24**, 11–15 (1996).
12. G.D. Rushworth *Historic Organs of New South Wales* Hale & Iremonger, Sydney 1988.
13. R. Sharp "The grand organ in the Sydney Opera House," *J. Proc. Roy. Soc. NSW* **106**, 70–80 (1973).
14. N.H. Fletcher and S. Thwaites "The physics of organ pipes" *Scientific American* **248**(1), 94–103 (1983).
15. S. Thwaites and N.H. Fletcher "Some notes on the clavichord," *J. Acoust. Soc. Am.* **69**, 1476–1483 (1981).
16. G. Caldersmith "Designing a guitar family," *Applied Acoust.* **46**, 3–17 (1995).
17. *Guitar Trek—Music for a Guitar Family* ABC Classics CD 432 698–2.
18. J.I. Dunlop "The acoustic properties of wood in relation to stringed musical instruments," *Acoustics Australia* **17**, 37–40 (1989).
19. J. Martin "The acoustics of the recorder," *Acoustics Australia* **14**, 43–46 (1986).
20. F. Morgan *The Recorder Collection of Franz Bruggen* Zen-on Music Co., Tokyo 1981.
21. R.B. Johnston "Pitch control in harmonica playing," *Acoustics Australia* **15**, 69–75 (1987).
22. N.H. Fletcher and A. Tarnopolsky "Blowing pressure, power, and spectrum in trumpet playing," *J. Acoust. Soc. Am.* **105**, 874–881 (1999).
23. H.A. Aebischer and H.P.W. Gottlieb "Theoretical investigation of the annular kettledrum as a new harmonic musical instrument," *Acustica* **72**, 107–117 (1990) and 73, 171–174 (1991).
24. H. Bagot "Bells, their design and tuning," *Acoustics Australia* **14**, 35–41 (1986).
25. J.D. Keating *Bells in Australia* Melbourne University Press, Melbourne 1979.
26. M. Henderson "The discovery of a new musical sound," *Acoustics Australia* **12**, 9–11 (1984).
27. M. Henderson and N.H. Fletcher "The Tosca alemba—Ringing the changes," *Acoustics Australia* **22**, 11–14 (1994).
28. K.A. Legge and N.H. Fletcher "Nonlinearity, chaos, and the sound of shallow gongs," *J. Acoust. Soc. Am.* **86**, 2439–2443 (1989).
29. N. McLachlan "Finite element analysis and gong acoustics," *Acoustics Australia* **25**, 103–107 (1997).

30-PLUS YEARS OF COMMUNITY NOISE STANDARDS AND REGULATIONS IN AUSTRALIA

Anita Lawrence
PO Box 78, Wahroonga, NSW 2076

This is basically a personal reminiscence, chiefly recalling the early development of community noise standards and regulations in Australia, and particularly in New South Wales.

One of the world's first major studies of community noise resulted in the publication of the "Wilson Report" in England in 1963. It was a grid-based study of the noise environment in central London and it found that at 80% of the locations, road traffic was the predominant noise source.

I quoted this report in a paper presented to the Third Australian Building Research Congress in 1967, and suggested that the noise emitted by individual vehicles should be controlled by the State registration authorities; aircraft noise should be the responsibility of the Federal government; other external noise should be dealt with by town-planning land-use zoning and that control of noise within buildings should be by means of a National Code of Practice. To some extent this is the way in which community noise controls have developed.

Standards Association of Australia formed an Acoustics Standards Committee in 1968. It had the task of overseeing the constitution and programmes of the various acoustic standards technical committees. I thought that it served a very useful purpose, but it has been disbanded and now the technical committees report to the Environment, Materials and Consumer Standards Board, which has oversight of all standards except those dealing with electrical and building matters. My concern is not just the lack of specific acoustic expertise of most of the members of this board, which may need to adjudicate on technical matters, but that there may be some areas of acoustical standardisation which are not being addressed.

At its 1968 meeting reports were presented by Committee AK/1 *Terms, Units and Symbols* which had a draft standard nearly ready for public review; AK/2 Instrumentation and Techniques for Measurement was at a preliminary stage and Committee AK/3 *Bioacoustics* and *Psychoacoustics* was divided into two subcommittees, AK/3.1 *Hearing Conservation* and AK/3.2 *Community Noise*.

I was asked to chair AK/3.2 and the first meeting was held in May 1969 at the University of New South Wales. The Secretary (as they were then called) was R.D. Mearns, who proved to be an excellent "networker". Work commenced on the drafting of a standard on "Noise Assessment with respect to Annoyance in Residential Areas". By the third meeting in March 1970 AK/5 became a fully fledged technical committee. At this meeting it considered a draft standard prepared by a working group on the measurement of noise from motor vehicles. This included a simplified roadside stationary test and more comprehensive moving vehicle tests.

In 1973 the first edition of AS1055 *Noise Assessment in Residential Areas* was published. The method of assessment was to compare the (adjusted) measured noise level with the "acceptable" noise level of 40 dB(A), adjusted for time of day and type of district. If the ambient (background) noise level was lower than the calculated acceptable level, the ambient noise level became the criterion. The measurements were made with a sound level meter set on Fast response and A-weighting. The expected public reaction to an exceedance of 0-5 dB(A) was "marginal".

Although it is now easy to criticise the somewhat simplistic approach of early drafts and standards, it should be remembered that in 1967 the International and British standards for sound level meters had only recently been published. Acousticians in Australia were gradually becoming organised and NSW and Victoria had formed unincorporated divisions of the Australian Acoustical Society by 1964; it was not until 1971 that incorporation of the AAS was achieved.

In 1971 the NSW State Pollution Control Commission (SPCC) was established and the State government formed a Noise Advisory Committee (of which I was a member) to assist the Commission in drafting the Noise Control Act. The Act was promulgated in 1975.

AS 1055 was revised and published in 1978. It was a little more sophisticated, but still relied on sound level meter measurements. It also provided a table of "calculated background sound levels for different areas containing residences" to be used in cases where the existing background sound levels were inappropriate as criteria.

In the meantime, the International Standards Organisation was drafting ISO 1996 *Acoustics—Description, Assessment and Measurement of Environmental Noise*. I was a member of the drafting committee and AK/5 decided to use the ISO drafts for its next revision of AS 1055. The document was divided into three parts—*General, Application to Specific Situations, and Data Pertinent to Land Use*. The 1984 revision of AS 1055 maintained the same basic assessment methods, but tightened up some previous "loose ends". However, by this time the various State environmental control departments had been formed, each with their own legislation and methods of noise assessment.

The State departments joined to form the Australian Environment Council and in 1983 the Council was concerned that the proposed 1984 version of AS 1055 was too "academic" and that it would not be adopted unless it was revised to serve "practical uses". If this revision did not occur they would draft their own document.

This opinion added to the already somewhat strained relations between Standards and State government bureaucrats because some of them objected to the table of "Acceptable sound levels". They said that Standards should not be including such material as it was the prerogative of governments to set levels. This was an unfortunate outcome, in my view, as not only does the adoption of an Australian Standard ensure uniformity across the country, but the technical committee members (usually) consist of the country's best experts in a given area. The NSW Noise Advisory Committee was itself disbanded in 1986, thus ending what many thought had been a fruitful contribution by outside experts to a government department.

AS 1055 was revised and published again in 1989 (this version included the use of the equivalent continuous A-weighted sound level and more sophisticated instrumentation, including data loggers. The latest version, published in 1997 tries to placate the regulators. It states "The object of this revision is to reflect the rapid technological advances in acoustical measurement techniques...This Standard is not a regulatory document and users should ascertain, from the relevant regulatory authority, details of specific requirements laid down in each State or Territory… This Standard aims at providing authorities with materials for the description of noise in community environments. Based on the principles described in this Standard, acceptable limits of noise can be specified and compliance with these limits can be controlled."

As mentioned earlier, road traffic noise was first highlighted as a problem by the 1963 Wilson Report and the Greater London Council developed a programme for improving the sound insulation of local government flats. (This programme had originally been designed to reduce the effect of aircraft noise, but it was found that the residents were usually more concerned about road traffic.) In 1977 I spent part of a university sabbatical in the GLC's noise section, which I found very useful. (A second part of that sabbatical I spent with the US EPA in Washington, DC and I was most disappointed to find that most of the people in the office of noise control were solicitors. One or two in the office had some acoustical training, but most of the technical work was done, at great expense, by outside consultants.)

Road traffic was also recognised in Australia as an important source of community noise. In 1979 the NSW SPCC formed a traffic noise subcommittee to advise the Noise Advisory Committee on the preparation of strategies for reducing the impact of traffic noise and the formulation of guidelines and regulatory controls under various acts. By 1984 AS 2702 *Methods for the Measurement of Road Traffic Noise* had been published and three years later AS 3671 *Road Traffic Noise Intrusion—Building Siting and Construction* was available. This was a unique Australian standard, giving guidance as to sites where traffic noise was likely to be unacceptable to the occupants of various types of building. It then provided a method for selecting suitable building construction, so that at least inside the levels should not be considered excessive.

As far as controlling the noise emitted by individual vehicles is concerned, the responsibility for new vehicles lies with the Commonwealth government. Its Advisory Committee on Safety in Vehicle Design was augmented with a few acousticians (myself included) and a new Australian Design Rule dealing with vehicle noise levels was published. It has gradually reduced permissible noise levels, but it did not require too much effort on the part of manufacturers for compliance. Meanwhile the NSW SPCC had promulgated maximum noise levels for in-service vehicles and had completed a dedicated motor vehicle noise testing facility. Officers also had the power to undertake roadside testing, but from my experience they do not have nearly enough resources to "catch" the worst offenders.

Aircraft noise assumed great prominence with the introduction of jet aircraft (particularly the earliest, straight-through jets). It was recognised that a small market such as Australia's could not hope to have much influence internationally, but at least the Federal government became involved with ICAO (the International Civil Aviation Organisation). Standards Australia's Committee AK/6 *Aircraft Noise* had a watching brief on developments, but it realised that it could not really do anything about individual aircraft noise levels. Instead, a subcommittee of AK/4 Architectural Acoustics published AS 2021 *Acoustics—Aircraft Noise Intrusion, Building Siting and Construction.* (This predated the similar standard dealing with road traffic noise.) This standard, which has been revised several times, uses the Australian Noise Exposure Forecast (ANEF) system to assess whether or not a site (or building) is subjected to a sufficient number of noisy aircraft to need special construction so that interior acceptable sound levels an be achieved. If the site is within ANEF 25 then its location with respect to the airport's runways is determined and the actual maximum expected flyover noise levels from specific aircraft are found from tables derived from the Sydney Airport noise monitoring system. Recommended interior levels for different types of occupancy are also given, as is a method for selecting suitable building construction.

At present, with the political comings and goings around Sydney Airport, either trying to concentrate or to "share" aircraft noise, ANEF information is unreliable to say the least. However, there is a programme to provide improved insulation to the worst affected buildings.

In conclusion, community noise standards and legislation have progressed considerably over the last 30 years. We have better instrumentation and more professionally trained acousticians. Australian Standards have been updated and cover many areas of community noise; there is noise control legislation in all of the States. However, there are so many political and economic aspects that affect planning and enforcement, that it would be difficult to conclude that Australia is a quieter place, in spite of all our efforts!

THE CALAID: AUSTRALIA'S OWN HEARING AID

Laurie Upfold* and Ray Piesse**
***M.A.C. Audiology Service, 5/35 Fourth Avenue, Eastwood NSW 2125**
****Technical Adviser, SHHH, 1334 Pacific Highway, Turramurra NSW 2074**

The Calaid hearing aid was introduced in 1948/9 to provide assistance to hearing impaired children, war veterans and (from 1968) eligible pensioners. Designed and manufactured by the Commonwealth Acoustic Laboratories (CAL), later the National Acoustic Laboratories (NAL), the aid was redesigned a number of times until it was phased out in 1992/3.

During the more than 40 years of its production, over one million Calaids were produced. Designed on the basis of in-house and internationally published research, the aids were a vital part of one of the world's most significant Audiological services, and provided results which were at least equivalent to those obtained with the best of the world's commercially designed and manufactured products.

At the completion of World War II, Australian health authorities were confronted with two new and quite disparate groups of hearing impaired people.

One group consisted of the thousands of ex-service persons returning to civilian life with war caused hearing damage. This group generally exhibited the mild to moderate loss of sensitivity to higher frequency sounds resulting from exposure to excessive loud noise.

The second group comprised young children, born with hearing impairment after an Australia wide epidemic of rubella during the early years of the War. Investigations of these children, initially by Gregg (1941), led to the first realisation that in-utero conditions could have effects on the child. The known children were typically severely to profoundly hearing impaired, with little or no speech. They were born to parents who had normal speech and language, and wanted their children to grow up in an oral, auditory world.

Apart from placement in a manual language school for deaf children, no model existed anywhere in the world for management of the problems presented by the 2 groups. Accordingly, the National Health and Medical Research Council was asked for advice, and a branch of the Council, the Acoustic Research Laboratory issued a Report recommending the establishment of a dedicated facility to research and provide service. This led to the formation of the Commonwealth Acoustic Laboratories, soon known as CAL. According to the Acoustic Laboratories Act, given Royal Assent in June, 1948, the Laboratories were "...for scientific investigation including that in respect of hearing aids and their application to the needs of individuals, and in respect of problems with noise as it affects individuals."

The title and status of the Laboratories has changed over time. Originally the Commonwealth Acoustic Laboratories (CAL), the name was changed to National Acoustic Laboratories (NAL) in 1974. In 1993, the term NAL was restricted to the research arm of the new Australian Hearing Services (AHS), which took responsibility for service delivery, and, in turn, became Australian Hearing (AH) in 1997.

Initially service by the Laboratories was provided using hearing aids imported from the U.S.A. These were found to be highly expensive, particularly for repair parts, which, because the users were young children, were frequently required. Further, there was a scarcity of U.S. dollars to pay for imports. Consequently, the decision was taken that hearing aids would be designed and manufactured in Australia, by the CAL. Thus was the Commonwealth Acoustic Laboratory Aid, the Calaid, born.

One of the first projects of the Laboratories was the development of an extremely accurate and reliable system for acoustic measurement. This involved standardisation of the measurement of sound pressure level derived from the reciprocity calibration of Western Electric 640 AA microphones. Before the availability of test chambers for measuring the acoustic performance of hearing aids, CAL's measurement system involved applying essentially constant sound pressure signals, over the frequency range of interest, through the small cavity formed by covering the hearing aid microphone with a MX/41AR cushion and Permaflux PDR3 earphone. The output of the hearing aid earphone was measured in a NBS 2cc coupler, which simulated its use in the ear. This system, the rigorous standardisation of which was a characteristic of the Laboratories history, became the basis of design and quality control of the Calaid, at a time when few other countries in the world could boast such refinements.

The first Calaid designed and manufactured by the Laboratories was first used in 1948/9. As with all hearing aids of the time, this was a body level type with a button earphone attached by a cord. The aid was based on 3 valves, and used a piezoelectric microphone and electro magnetic earphone. The aid came in 3 power ranges, with power determined by the battery voltage of 45, 33 or 22.5 volts. No record of the maximum power, or peak clipping levels, is available, although the 3 levels are presumed to have approximated 115, 120 and 125 dB SPL average level as measured in a 2cc coupler or artificial ear. The frequency response of the aid was dictated by the characteristics of the microphone and earphone, but 3 tone controls, including a high frequency control, were included.

The introduction of the transistor in the mid 1950s gave the opportunity for a much smaller and more convenient aid with a more efficient amplifier. Further, the transistor aid could be used with a 1.5 volt penlight battery, allowing great savings in size and battery costs. Initial production of a transistor aid, the Calaid T, began in 1955/6.

The Calaid T was also a body level aid, housed in a stainless steel, screw together case. The aid was based on 3 transistors, and included an induction coil for telephone and induction loop use. It was produced in four power configurations. This aid had numerous advantages over its predecessor. Worn high on the body, in shirt pocket or clipped to an undergarment strap, the Calaid T was smaller, more convenient to use, more economical, more reliable and easier and less costly to repair. During its life, the aid underwent 2 subsequent redesigns, although it retained the same case. Altogether, the Calaid T satisfied all the Laboratories' requirements for hearing aids for almost 10 years, then, after the introduction of an ear level aid, met all the requirements for body aids for a further 10 years.

The Calaids Valve and T both had the disadvantages of all body worn aids. Body baffle accentuated low frequency and decreased high frequency amplification. Body shadow further decreased high frequency input of signals from the sides or behind the listener (Byrne, 1972). Broad band masking resulted from the sounds of clothes rub on the aid case. Further, in common with most aids manufactured before the mid 1960s, the electro acoustic performance of the aid was significantly influenced by the findings of the Harvard Report (Davis et al, 1947). Among a number of recommendations, this Report indicated that one frequency response, a 6 dB per octave upward slope from 300 to 4000 Hz, would be suitable for most, if not all, hearing aid wearers. The Report also recommended that the maximum power of the aid should be as high as the wearer could tolerate "without undue discomfort". This was aimed at providing "head room" between the amplified peak levels of hearing aid processed signals and the level at which peak clipping occurred. Compression limiting was not recommended because of the loss of approximately 6 dB from the maximum output.

The effect of these problems and design influences was that the lowest maximum power of any hearing aid was approximately 115dB. This, coupled with the gently upward sloping frequency response, meant hearing aids in general were only suitable for the relatively small proportion of persons with moderate to severe degrees of hearing loss, affecting all frequencies equally. The aids were most successful with persons with conductive (middle ear) impairments, in which there is normally a wide dynamic range between hearing threshold and loudness discomfort. Aids were usually too noisy for the majority of people with hearing impairment, who have sensorineural (inner ear) impairments, usually mild or moderate in degree, typically being worst for high frequencies, and almost inevitably exhibiting recruitment. That is, the difference between hearing threshold and loudness discomfort is small, and audition is characterised by intensity distortions and loss of frequency discrimination, which lead to loss of speech discrimination, particularly in adverse signal to noise ratios.

The state of the hearing aid art changed during the 1960s. Research demonstrating that hearing aid microphones should be located on the head, led to the development of smaller microphones and earphones, capable of inclusion in small aids worn on the head. The availability of integrated circuits and smaller batteries also made on the head aids more feasible. Such aids were expected to avoid the problems of body baffle, body shadow and clothes rub, and provide additional benefits such as signal enhancement from head diffraction and microphone placements. These advantages were expected to provide improved speech recognition and listening comfort by providing a wider frequency response, enhancement of high frequency output and reduced masking.

Two basic designs of an on the head aid were attempted around the world. One design consisted of an aid worn behind the ear, the other an aid worn wholly within the ear.

Initial attempts to make a behind the ear aid encountered a number of problems, particularly with mechanical and acoustic feedback. These problems were accentuated because the designers continued the search for "head room" to avoid harmonic distortion from peak clipping. Attempts to overcome feedback led to variable placements of the aid microphone, including backward facing from the centre of the aid case, and, finally, downward facing from the bottom of the case. These attempted solutions had the effect of reducing the potential benefit of the on the head aid, making it more sensitive to sounds originating behind the listener than to those from the front, and imposing further undesirable shadows.

In the face of these problems, the CAL elected to produce an aid worn wholly within the ear. This allowed the microphone to be forward facing, and be located within, or at the edge of, the pinna. This was aimed at taking as much advantage as possible of head diffraction and pinna effects, as well as to fit in with the usual listening tactic of the hearing aid wearer, which is to look at the person to whom they are speaking. The aid featured a one stage impression/earmould, in which a dynamic earphone was buried and sealed as far from the magnetic microphone as possible. The amplifier was based on a 3 transistor integrated circuit, and the aid was powered by a size 13 battery. The aid also included a user operated attenuator switch rather than a conventional volume control. First used in 1964/5, this was the Calaid E.

The Calaid E was in production, and was the most commonly fitted aid in the Laboratories' service for 10 years, being used in 75% of all fittings. During this 10 years there were 2 redesigns to take advantage of the rapid improvements in the components becoming available. In addition, a version was produced in which the earphone was located on the opposite side of the head to the microphone and amplifier. This allowed the head to act as a baffle, reducing acoustic feedback. It also allowed reduction or removal of head shadow, so that sounds detected on one side of the head were heard in the contralateral ear.

The Calaid E, because of its smaller earphone, was less powerful than the preceding body aids, and was hence more adaptable for use with milder hearing losses. Further, despite the attempt to keep them as far apart as the earmould would permit, the proximity of the earphone and microphone increased the risk of both acoustic and mechanical feedback, dictating that the range of available gain was restricted. These two limitations on output meant the aid was much more suitable than body aids for the mild to moderately hearing impaired. As a consequence, the number of people who could be helped by hearing aids was dramatically increased.

The availability of the low power/low gain Calaid E was a critical factor in the Federal Government's 1967 decision to provide free hearing aids to all pensioners and their dependents. This decision was to be implemented by an expansion of CAL. It would have been extremely difficult, if not impossible, to implement such a decision using only a body level hearing aid. As it turned out, the range of performance options provided by the Calaid E and Calaid T was such that they were able to fully satisfy the requirements of the Government's hearing aid schemes until the mid 1970s.

The next step in the history of the Calaid came about as a result of a number of research and other findings. The late 1960s and early 1970s was a period of great interest in the real ear as opposed to sound field and 2cc coupler performance of hearing aids. Flowing from the open mould technique of the Contralateral Routing of Signals ("CROS") aid (Harford and Barry, 1965), earmould vents and tubing modifications (such as diameter changes, horn effects and attenuators) were introduced as methods of controlling the real ear response of aids. Much of the work involved in the investigation of these response controls was performed within the Laboratories (e.g. McCrae, 1981; 1982). Interest in real ear response led to development of methods for measuring real ear performance, particularly real ear gain. Aided and unaided soundfield thresholds, and aided and unaided acoustic reflex thresholds (Tonisson, 1975) were used as measures of real ear gain. Finally, in the 1980s, ear canal probe tubes became the method of choice for real ear measurement.

The ability to control, and predict, real ear aided responses and to measure the outcomes, were important aspects in the development of a standardised hearing aid gain/frequency response selection procedure. A number of these were developed throughout the world, with the most influential and widely used being that known as the NAL procedure (Byrne & Tonisson 1976, revised Byrne & Dillon 1986). This procedure, based upon audiometric pure tone thresholds, led to development of a required performance specification for hearing aids, finally superseding the 1948 Harvard Report.

While these audiological developments were taking place, new hearing aid microphones were being developed. The Ceramic microphone was quickly followed by the Electret. Among other advantages, these microphones were virtually vibration free, which allowed them to be mounted close to the earphone without producing feedback. This permitted behind the ear aids to be produced with top mounted microphones and with much higher gains and power than before, extending the range of hearing losses which could benefit from on the head listening.

The opportunities presented by the audiological research and the improved microphones led the Laboratories to produce a range of new aids. In particular, the movement was away from the Calaid E to behind the ear aids, to give more versatility in performance (particularly venting and tubing modifications), and to extend the range of hearing losses which could be fitted with on the head devices.

The first of CAL's behind the ear aids was the Calaid H, first issued in 1974. This aid, using a top facing microphone, was made in three power ranges and was suitable for hearing levels up to approximately 85 dB (re audiometric zero). It included a choice of two microphones, one offering a steeper low frequency roll off than the other, as well as a user operated low tone cut. The aid could be used with a full range of acoustic modifications. This aid quickly took over from the Calaid E as well as taking a significant proportion of the body aid usage.

To supplement the Calaid H, and provide a higher powered aid, particularly for profoundly hearing impaired children, the Laboratories, in 1976, purchased by tender a number of commercially manufactured high powered behind the ear aids, called the Calaid RE. This purchase in turn was supplemented by an aid of the Laboratories own design in the same commercial case, which was to be known as the Calaid P. The success of these aids led to further purchase of very high powered behind the ear aids for use particularly with very deaf children.

While the behind the ear aids had by now taken over most of the fitting load, there was still a requirement for approximately 10% of body level aids, for people unable to manipulate the behind the ear type. and for the very profoundly deaf, for whom the maximum power of the behind the ear aid was still not sufficient. After more than 20 hears of service the Calaid T range was replaced by a new lightweight body aid known as Calaid G. This aid, again in four power ranges, included the most powerful of Calaids, the Calaid G12G.

In 1978, the Australian Bureau of Statistics issued a report outlining details of hearing aid possession and use in Australia (1978; Upfold and Wilson, 1980). Among other findings, this Report indicated that, regardless of whether the aid was privately purchased or was a CAL/NAL provided Calaid, 22.1% of persons with a hearing aid used it less than once a week, or never used it.

These findings, together with further audiological research results, led to a number of changes in NAL's approach, including a decision to develop behind the ear aids further. A new aid type, the Calaid V, was introduced featuring a forward facing microphone, and three potentiometers for adjustment of maximum gain, maximum power output, and low frequency roll off. The Calaid V was introduced in the early 1980s and remained the most frequently used aid in NAL's service for the next 10 years. Designed for use with hearing losses ranging from mild to profound, the aid was produced in three power ranges, each of which was adjustable downward by potentiometer. One effect of this was that it was possible to fit aids for milder impairments than before (Upfold, 1988). In turn, this created a need for an aid which employed output compression limiting, rather than peak clipping, to minimise harmonic distortion and further reduce the maximum power output. The Calaid V was soon changed to output compression limiting, which became the standard fitting mode throughout the Laboratories for all but the most severely and profoundly deaf, who required the additional power available with peak clipping.

During the later 1980s, the commercial advertising of all-in-the ear styles of hearing aids led to a demand by consumers for the suggested cosmetic advantages and possible potential acoustic advantages of this aid type. NAL conducted an extensive study of the comparative advantages of behind the ear versus in the ear aids (May, Upfold & Battaglia, 1990; Upfold, May & Battaglia 1990) which concluded there was justification for an in the ear aid, largely because some elderly people found it easier to manipulate. Accordingly, the NAL developed two versions of an in the ear aid, known as Calaid J. These aids were employed for about two years until the Calaid range ceased production with the commencement of a joint venture between NAL and a well established hearing aid manufacturer.

Throughout its history the Calaid was designed by CAL/NAL, its components were individually specified and purchased by CAL/NAL and assembly was performed by several Australian companies under periodic contracts.

The question which must be asked is how successful was this concept of a range of hearing aids designed and manufactured by one Government organisation to satisfy its own requirements for hearing aids to fit to a market consisting of the very young and the elderly? Absolute answers are impossible, but some conclusions may be drawn from available sources. Firstly, there is the number of aids produced. From an initial 200 aids a year the number grew from 2,285 a year in 1966 to 14,679 in 1970 to 36,876 in 1980, to 86,600 in 1992. Secondly, the ABS 1978 survey allowed comparison of client usage of Calaids and client usage of privately purchased aids commercially produced by most of the world's major manufacturers. This comparison showed there was no difference in use rates (measured in hours per day) by the two groups. This was found even though the Government group was much older than the private group, and even though the private group included only those who actually purchased an aid after trying it (Upfold & Wilson, 1982). Thirdly, battery use figures by Calaid users indicated an increase in mean hours of use from 6.4 hours a day to 9.6 hours a day between 1978 and 1981, an increase ascribed to improved audiological fitting techniques with the Calaids (Upfold & Wilson 1982). These aid use figures indicate that Calaids were being used as much as most aids produced throughout the world (Stevens, 1977). Fourthly, surveys of persons obtaining a Calaid as a replacement aid in 1976 and 1981 showed that the majority of persons previously using a private commercial aid felt their new Calaid was better than their old aid (Upfold & Wilson 1982). Similarly, studies of client satisfaction was Calaids invariably showed satisfaction levels to be high (Dillon et al 1991a, 1991b).

In the period of its production, from 1947 to 1993, well over a million Calaids were produced and fitted to a population of the very young and the elderly throughout the nation. Supported by an active and internationally acclaimed research programme, the Calaid was a significant part of Australia's health and acoustic history.

REFERENCES

Australian Bureau of Statistics (1978). *Hearing and the use of hearing aids (persons aged 15 years or more)*. September Cat no 4336.0 Canberra.

Byrne, D.J. (1972). "Some implications of body baffle for hearing aid selection." *Sound*, **6**, 86–91.

Byrne, D.J. & Dillon, H.A. (1986). "The National Acoustic Laboratories (NAL) new procedure for selecting the gain and frequency response of a hearing aid. Ear," *Hear*. **7**, 257–265.

Byrne, D.J. & Tonisson, W. (1976). "Selecting the gain of hearing aids for persons with sensorineural hearing impairments." *Scand. Audiol*., **5**, 51–9.

Davis, H., Stevens, S.S., Nichols, R.H., Hudgens, C.V., Marquis, R.J., Peterson, G.E. and Ross, D.A. (1947). *Hearing aids: An experimental study of design objectives* (first edition), Harvard Univ. Press, Cambridge Mass.

Dillon, H., Koritschoner, E., Battaglia, J., Lovegrove, R., Glinis, J., Mavrias, G., Carnie, L., Ray, P., Forsythe, L., Towers, E., Goulios, H., Macaskill, F. (1991a). "Rehabilitation effectiveness 1: Assessing the needs of clients entering a national hearing rehabilitation program." *Aust. J. Audiol*. **13**, 55–65.

— (1991b). "Rehabilitation effectiveness II: Assessing the outcomes for clients entering a national hearing rehabilitation program." *Aust. J. Audiol*. **13**, 68–82.

Gregg, N. McA. (1941). "Congenital cataract following german measles in the mother." *Trans. Opthmal. Soc. Aust*., **3**, 35(46.

Harford, E. & Barry, J. (1968). "A rehabilitative approach to the problem of unilateral hearing impairment: The contralateral routing of signals (CROS)." *J. Speech Hear. Disord*. **30**, 121–138.

May, A., Upfold, L., Battaglia, J. (1990). "The advantages and disadvantages of ITC, ITE and BTE hearing aids: Diary and interview reports from elderly users." *Brit. J. Audiol*. **24**, 301–309.

Macrae, J.H., (1981). "A new kind of earmould vent - the high-cut cavity vent." *Hear. Instr*. **32**, 10–18.

Macrae, J.H., (1982). "Techniques for evaluating the effectiveness of earmould vents." *Aust. J. Audiol*. **4**, 18–20.

Stephens, S.D.G., (1977). "Hearing aid use by adults: a survey of surveys." *Clin. Otololaryngol*. **2**, 385–402.

Tonisson, W. (1975). "Measuring in-the-ear gain of hearing aids by the acoustic reflex method." *J. Speech Hear. Res*. **18**, 18–30.

Upfold, L.J. (1988). "Children with hearing aids in the 1980s: etiologies and severity of impairment." *Ear Hear*. **9**, 75–80.

Upfold, L.J., May, A.E., Battaglia, J.A. (1990). "Hearing aid manipulation skills in an elderly population: a comparison of ITC, ITE and BTE aids." *Brit. J. Audiol*. **15**, 181–188.

Upfold, L.J. & Wilson, D.A. (1980). "Hearing aid distribution and use in Australia: the Australian Bureau of Statistics 1978 Survey." *Aust. J. Audiol*. **2**, 31–36.

Upfold, L.J. & Wilson, D.A. (1982). "Hearing aid use and available aid ranges." *Brit. J. Audiol*. **16**, 195–201.

AUSTRALIAN CONTRIBUTIONS TO MEDICAL DIAGNOSTIC ULTRASOUND

D. E. Robinson
383 Burraneer Road, Coomba Park, NSW 2428

The Ultrasonics Institute of the Commonwealth Dept of Health provided a focus in Australia for the development of technology and techniques for medical ultrasonic imaging. The Institute was one of the early participants in the development of the technique, and has made a number of contributions to the development of the field. These include transducer theory and technology, ultrasonic imaging system design, the study of artifacts, computer processing and Doppler signal processing. The introduction by the Institute of the grey-scale technique provided the basis for successful high-quality imaging from real-time systems, which now form the basis of ultrasonic imaging. The Institute worked closely with medical specialist collaborators in each diagnostic area.

INTRODUCTION

The commencement of research in medical ultrasound in Australia was due to the vision and entrepreneurial skills of the Director of the Commonwealth Acoustic Laboratories, Mr. Norman Murray. The Laboratories were within the Commonwealth Department of Health, and concerned with hearing conservation, industrial noise measurement, and the design, manufacture and provision of hearing aids to ex-servicemen and children. In the mid-1950s, Murray recognised that there was a gap in awareness of ultrasonics in Australia, and identified a number of areas for research [1]. One of these was the use of pulse-echo ultrasound for diagnostic imaging, particularly visualising the uterine contents in pregnancy, without the potential harmful effects of X-rays to the fetus.

In late 1959, a newly graduated engineer, George Kossoff, was appointed to the staff of the Laboratories, and, assisted by a technical officer, began a number of projects, including development of a scanner for providing cross-sectional images of the pregnant uterus and fetus. In mid-1961 the author and a second technical officer were appointed to expedite the development of the diagnostic imaging scanner. The first images of the pregnant uterus and fetus were shown at an international conference in the USA in 1962 and proved to be equal to or better than any others shown at the conference [2]. This was the start of Australia's continuing contribution to the development of ultrasonic medical diagnostic imaging.

TECHNICAL CONTRIBUTIONS

Transducers and early scanners

At the outset, knowledge of transducer theory and the ultrasonic properties of tissue was sparse, the ultrasonic appearance of tissue was unknown, and the required performance challenged the ability of current technology. This was indeed a fertile area for research! Design and construction of the scanner for examination of the pregnant uterus involved work in three main areas; transducers and their beams, signal processing of ultrasonic echoes from tissue, and design of electronic circuits using cutting edge technology.

The work on transducers involved analysis of the effect of backing and matching on transducer performance [3], and the investigation of the beams obtained from weakly focussed transducers [4]. These papers are considered landmarks, and have been referred to consistently since that time. The use of transducers with excellent properties contributed substantially to the quality of images obtained, and thus the success of our early scanners.

The design of the electronic system of the scanner presented its own challenges. Use of water path scanning permitted use of an optimal transducer beam pattern, but rendered the system liable to multiple echoes or reverberation within the water bath, requiring specific logic circuits for their removal. The scanning accuracy requirements on the electronics of 0.1% was equivalent to measurement laboratory accuracy of the time. The display system was required to store echoes from a number of lines of sight acquired over a period of up to thirty seconds. Display storage tubes were just being developed, and we were using prototypes, with no useful technical information available regarding the associated circuitry. The currently available vacuum tubes were being replaced by transistors.

Following the successful establishment of the program of imaging the pregnant uterus [5,6], scanners using the same principles, but differences in scanner geometry and operating frequency, were designed for other regions of the body; the eye [7], breast [8] and, using time-motion (M-mode) display, the heart [9].

Artifacts

The study of reverberations in the water coupling bath of the scanner led to the recognition of artifacts occurring due to reflection and refraction within tissue. Artifact is the term used when the appearance of the image is incorrect, due to variations in the propagating properties of tissue. The first paper published on the subject came from our work in Australia [10]. The study of artifacts has become a major subject in the education of clinical practitioners who interpret ultrasonic images, and must recognise them to avoid errors in diagnosis.

Grey-scale

It was soon found that the dynamic range of received echoes was extremely large, and the ability of the display device to display this range was limited. The orientation of the scan plane was carefully selected and compound scanning (with many overlapping and intersecting lines of sight) employed.

In this way, as far as possible each interface between adjacent organs was intersected at right angles somewhere in the scan.

In the late 1960s, Kossoff espoused the concept that the image would be better if, instead of concentrating on the outlines of the organs, the system was optimised to display the lower amplitude of echoes from within the tissue of each organ. This required considerable compression to match the even wider echo signal dynamic range of interest, but more importantly, a considerably better performance of all parts of the signal processing chain to avoid the large signals from tissue boundaries overloading the system and obscuring the smaller echoes of interest. Thus, the transducer, pre-amplifier, compression amplifier, display amplifier and display device all required extensive modification [11].

The weakest link in this chain at the time was the display. The best grey scale was obtained from a time-exposed film, but the scanning had to be done "blind", although Polaroid "instant" development film system was used. Careful control was required of the scanning rate, scan line density, screen brightness and contrast and camera aperture settings. Despite the operational difficulties of this system, the images showed considerable improvement, with a more complete rendition of the scanned anatomy, and less dependence on compound scanning to display the complete image. The grey-scale technique was quickly adopted for all UI scanners [12, 13, 14], and its role in ultrasonic imaging demonstrated [15].

The grey-scale technique was "exported" to the U.K. during the two-year posting of David Carpenter to the Royal Marsden Hospital in London in 1972-3 [16]. He implemented the technique in the skin-contact scanner developed there, demonstrating that the superior images were due simply to the application of improved techniques.

Developments in technology, particularly the analogue (and later digital) scan converters, made the technique more "operator friendly", and by the late 1970s, it was soon employed on the commercial scanners which were becoming available at the time. More importantly, the use of grey-scale made it possible to obtain meaningful images with simple scans, with the ultrasonic lines of sight from a single direction, rather than the previous compound scan. This in turn meant that real-time scanning with simple scans were still able to image organs and regions even without seeing echoes specifically from the boundaries of the organs. The current state of the art in medical ultrasonic imaging uses real-time simple scanning first made practical by the Australian demonstration of the grey-scale approach to signal processing.

Octoson

In the early 1970s, all commercially available ultrasonic scanners relied on manual scanning of a transducer. We began to develop an automated water-bath compound scanner, to provide each image in a precise plane, accurately registered with all the other images, and acquired with an automated repeatable scan motion. The device consisted of a large water tank with a flexible plastic window on the top to which the patient's body surface was applied. Inside the tank was an arm holding eight transducers, which all scanned in synchronism, with ultrasonic pulses being transmitted from each transducer in turn before the set of transducers advanced to the next angular position. The arm could be move it in three translation directions, and two rotations, allowing an image to be obtained at any orientation and position, and accurately registered with all other scans. A single image was acquired in about two seconds, and consecutive scans providing a series of slices could be performed rapidly, and provide the clinician with an accurate 3-D representation of the region. A further serial set in another direction, or a number of oblique scans through particular structures could be obtained to provide further information if required. The prototype was completed in 1974, and with its eight transducers and living in a pool of water, it was named the "Octoson" [17]. It was used for examining the pregnant uterus, abdomen, heart and breast.

The commercial potential for this machine was apparent, and after considerable negotiations with a number of interested parties, the rights were let to the Nucleus Group, an active Australian medical equipment company. The company Ausonics was formed as a subsidiary to Nucleus to manufacture and sell the Octoson. Other companies in the Nucleus Group were Telectronics, and later Cochlear. Approximately 200 commercial Octosons were sold for $100,000 each, or total sales of $20M. Of these 90% were exported, mostly to the USA, but others also to Japan, Italy, France, Sweden, China, and Holland. A second system was derived from the Octoson approach specifically for the breast, called the System 1, with approximately 100 units sold. It was designed in Australia, and after some time, production was moved to Japan, where it was manufactured under licence.

The Octoson provided a broad image of the anatomy scanned, allowing the position, orientation and relationship of the various body components to be easily appreciated. It was suitable for a wide variety of organs and regions, but did not cope well with overlying bone or air-containing tissue. Thus it was impeded in the thorax by lung and ribs, and in the lower abdomen by bowel gas unless this could be displaced or replaced with liquid. In the areas where imaging was possible, the image quality was superior to that available from either the current manually operated skin-contact scanners, or the emerging real-time scanners.

At the time that the Octoson became available commercially, two factors limited its widespread acceptance. The release of X-ray Computed Tomography provided an automated cross-sectional imaging modality, which offered a wide field of view but was not limited to particular areas. The Octoson was left to compete on its better information in some conditions, its greater safety in pregnancy and its lower cost. The image quality obtained from commercial real-time ultrasonic scanners had improved due to the adoption of grey-scale and improvements in transducer and beam- and image-forming technology. Although they lacked registered serial scans and had a restricted field of view, the feedback afforded by the manipulation of the real-time scan plane by the operator was an attractive way of gaining the 3-D appreciation of the scanned region. The real-time scanners also had a cost advantage over the Octoson. In the fullness of time, the last surviving Octosons in the clinical environment were used as front-ends for computer or other research systems.

Computer processing, image formation and tissue characterisation.

Our first computer for processing ultrasonic signals and images was installed in 1972. Again, it pushed the bounds of current technology and could only record the envelope of the detected ultrasonic signals, as the upper limit of sampling was 3 MHz. With this system, the first ultrasonic 3-D rendition of serial section ultrasonic image planes was achieved [18].

The Octoson provided an ideal "front-end" for acquiring ultrasonic data. The automated scan with well-identified scan line origins, positions and orientations greatly assisted in image re-construction algorithm development. Methods were developed for interpolation between scan lines to reduce the number of lines needed to obtain a real-time image, and hence increase the maximum acquisition rate, which were subsequently used in commercial real-time scanners.

The ability to record a scan and its accompanying ultrasonic signals was of great assistance in acquiring signals for ultrasonic tissue characterisation. This was a subject of great interest in the 1980's. Its promise was to provide an ultrasonic "pathology" to identify diseased from healthy tissue. Considerable effort was expended on this subject at our laboratory and in many others around the world [19]. Unfortunately, no significant method has yet passed the "acid test" of being used at an institution other than the one(s) at which it was developed.

Doppler processing for total flow

The Doppler frequency shift resulting from reflection of ultrasonic signals from moving structures (and particularly red blood cells) had been used for fetal pulse detectors, and for assessing the apparent rate (velocity) of flow in vessels and heart chambers. Our contribution was to combine imaging of the vessel with the use of a broad Doppler beam encompassing the entire vessel and appropriate signal processing to obtain quantitative measurement of blood flow within a vessel. [20]

With its well-registered and controllable scan planes, the Octoson formed an ideal platform for the total volumetric flow studies in a number of areas. Much of the work was on the measurement of blood flow in the fetus in order to identify those at high risk of birth complications. Other studies were on the vessels of the abdomen, in particular the liver and spleen. As the Octoson was not freely available, the technique was not taken up widely, although further development has been directed towards implementation in real-time scanners, where commercial development is possible.

CLINICAL APPLICATIONS

From the outset, the group of engineers and physicists at the Laboratory worked closely with medical consultants in each area of application. In the early development of each project, there was a need to interpret the information on the ultrasonic images, which were often of poor resolution, and providing images of structures not previously able to be imaged. The scanner settings and design decisions in implementing the signal processing system significantly influenced the appearance of the images. Recognition of the structures displayed, and more importantly the structures missed in the image, led to design modifications to improve this aspect of imaging performance. On the clinical side, studies were performed of the reliability of imaging various organs, and the reliability of measurements made on the images. This required close collaboration between the equipment designer and the clinician, leading to a fruitful cross-fertilisation of ideas, with the clinician suggesting equipment enhancements and the engineer suggesting clinical applications.

This close collaboration between the clinician and the design engineer in both the equipment design and image analysis led to long-lasting professional relationships, and joint publications in both technical and clinical journals. The close multi-disciplinary approach was unusual for its time, or even for the present day.

It was unusual for a single group to develop apparatus for many different areas of application. The group of medical specialists with whom we worked came from a number of specialties. They became the nucleus for the formation of the Australasian Society for Ultrasound in Medicine (A.S.U.M.) and the establishment of scientific and education meetings to spread knowledge in ultrasound to other specialists.

Separately from the Laboratory, medical specialists from throughout Australia began to investigate ultrasound using commercially available equipment [21]. The two strands of development were brought together by the formation in 1970 of A.S.U.M. The standard of clinical practice of ultrasound in Australia is very high by world standards. This is due in no small part to the activities of A.S.U.M. in education and certification activities.

ORGANISATIONAL ARRANGEMENTS

In 1975, the Ultrasonics Research Section of C.A.L. was changed to a separate Branch of the National Health and Medical Research Division within the Commonwealth Department of Health and called the Ultrasonics Institute. At its formation it had a staff of 24, and 10 medical collaborators.

During the mid 1980s, the Department of Health became aware that the Ultrasonics Institute, although achieving significant scientific and commercial results, was not directly supporting any of the Department's authorised functions. Following extensive negotiations, the Institute, along with its funding allocation and all its staff were transferred to the CSIRO Division of Radiophysics in 1989, as the Ultrasonics Laboratory within the Division. Following amalgamation of the Divisions of Radiophysics and Applied Physics into a Division of Telecommunications and Industrial Physics in CSIRO in 1998, the staff members of the Ultrasonics Laboratory have been incorporated into the Division.

With the transfer to CSIRO came a change in culture, and the required emphasis of the work. No longer was it enough to provide improvements in health care. The work needed to have measurable impact on the subject, preferably demonstrated by the uptake of the developed techniques (and associated royalties), or even better by direct funding of the research effort. This was in a climate of increasing research and development effort by the commercial manufacturers. They were reluctant to entrust the success of their new equipment to an outside body, and research funds were not sufficient to maintain the effort at its previous levels. Some research work has been performed for one of the major medical ultrasound equipment manufacturers, resulting in incorporation of Doppler signal processing techniques developed at our laboratory in their current equipment. It is anticipated that this relationship will continue.

There has been an expansion in the scope of research by staff previously from the Laboratory. Our medical and computer technology was applied to projects to assess beef quality on the hoof, funded by the Meat & Livestock Research Authority. The Dept of Defence funded development of technology to image the surface of underwater objects in turbid water in the range one to six metres using Megahertz ultrasound. Other projects involve image processing in other medical imaging areas, using skills and background knowledge in medical imaging developed in ultrasound.

CONCLUSION

When our work commenced on diagnostic ultrasonic equipment, there were only a handful of groups working in the area. Following our success (measured by image quality) at the initial meeting, the publications from our group were closely watched by our international colleagues. Because of our geographical remoteness, interaction was limited to the written word, with occasional visits in association with scientific conferences. The early interactions led to a series of longer visits by laboratory staff, during which the work of the Laboratory became more widely known. From that time on, the Australian work was well represented at overseas conferences. The group has contributed 580 publications to the archival scientific literature. In later discussions with contemporary researchers, it was learnt that they felt that our early papers provided the "existence theorem" for the capabilities of ultrasonic imaging.

The Ultrasonics Institute formed a nucleus of expertise which attracted considerable medical interest and led to the formation of the Australasian Society for Ultrasound in Medicine. The activities of the Institute and of the Society have resulted in the standard of practice of ultrasound in Australasia being very high by world standards.

Medical ultrasound imaging is now the most commonly used medical imaging modality after plain X-ray, and is the largest market within medical imaging. It is a source of considerable personal pride for all members of our staff of that we had the opportunity and ability to make a contribution to a subject which has so dramatically changed the face of medicine within our professional life-times.

The significant impact of the Australian contributions on the development of medical ultrasonic imaging are credit to all of the staff of the Laboratory in all its guises who made it happen, and a tribute to the vision and entrepreneurial skill of its instigator, Norman Murray, without whom it would never have begun.

REFERENCES

1. G. Kossoff, "How Research Into Medical Ultrasound Began in Australia" *Bul. Aust. Soc. Ultrasound Med.* December (2000).
2. G. Kossoff, W.J. Garrett, D.E. Robinson, "An Ultrasonic Echoscope for Visualizing the Pregnant Uterus" in *Ultrasonic Energy: Biological Investigations and Medical Applications* ed. E. Kelly, (University of Illinois Press, Urbana 1965) 365–376.
3. G. Kossoff, "The Effects of Backing and Matching on the Performance of Piezoelectric Ceramic Transducers" *IEEE Trans. Sonics Ultrasonics;* **SU-13**, 20–30 (1966).
4. G. Kossoff, "Design of Narrow-Beamwidth Transducers" *J. Acoust. Soc. Am.* **35**, 905–912 (1963).
5. G. Kossoff, D.E. Robinson, W.J. Garrett, "Ultrasonic Two-Dimensional Visualization Techniques" *IEEE Trans. Sonics Ultrasonics* **SU-12**, 31–37 (1965).
6. G. Kossoff, D.E. Robinson, W.J. Garrett, "Ultrasonic Two-Dimensional Visualization for Medical Diagnosis" *J. Acoust. Soc. Am.* **44**, 1310–1318 (1968).
7. H. Hughes, M.J. Dadd, "The Application of Ultrasonography to the Examination of the Eye" *Med. Journal of Australia* **2**, 848–850 (1969).
8. J. Jellins, G. Kossoff, F.W. Buddee, T.S. Reeve, "Ultrasonic Visualization of the Breast" *Medical J. Aust.* **1**, 305–307 (1971).
9. G. Kossoff, D.E.L. Wilcken, "The CAL Ultrasonic Cardioscope" *Med. Biol. Eng.* **5**, 25–32 (1967).
10. D.E. Robinson, G. Kossoff, W.J. Garrett, "Artefacts in Ultrasonic Echoscopic Visualization" *Ultrasonics* **4**, 186–194 (1966).
11. G. Kossoff, "Improved Techniques in Ultrasonic Cross Sectional Echography" *Ultrasonics* **10**, 221–227 (1972).
12. M.J. Dadd, G. Kossoff, "Grey Scale Requirements for Ophthalmological Echograms" In: *Digest 9th International Conference on Medical and Biological Engineering* eds. N. Cass, T. Fenelon, J. Mainland, P. Petty (Int. Federation for Medical & Biological Engineering 1971) p. 61.
13. W. J. Garrett, G. Kossoff "Film Echoscopy in Obstetrics In: *Digest 9th International Conference on Medical and Biological Engineering* eds. N. Cass, T. Fenelon, J. Mainland, P. Petty, Int. Federation for Medical & Biological Engineering. (1971) p. 59.
14. J. Jellins, G. Kossoff, T.S. Reeve, B.H. Barraclough, "Ultrasonic Grey Scale Visualization of Breast Disease" *Ultrasound Med. Biol.* **1**, 393–404 (1975).
15. G. Kossoff, W.J. Garrett, D.A. Carpenter, J. Jellins, M.J. Dadd, "Principles and Classification of Soft Tissues by Grey Scale Echography" *Ultrasound Med. Biol.* **2**, 89–105 (1976).
16. D.A. Carpenter & K.J.W. Taylor, "Grey Scale Echography in the Diagnosis of Intrahepatic Disease" *J. Clin. Ultrasound* **1**, 4, 284–287 (1973).
17. D.A. Carpentere, G. Kossoff, W.J. Garrett, K. Daniel, P. Boele, "The UI Octoson —A New Class of Ultrasonic Echoscope" *Aust. Radiol.* **21**, 85–89 (1977).
18. D.E. Robinson, "Display of Three-Dimensional Ultrasonic Data for Medical Diagnosis" *J. Acoust. Soc. Am.* **52**, 673–687 (1972).
19. D.E. Robinson, J.C. Bamber, B.D. Doust, M. Fukuda, J.F. Greenleaf, F. Lizzi, J. Ophir, J.M. Reid, J.M. Thijssen, L.S. Wilson, "Tissue Characterisation at WFUMB '85" *Ultrasound Med. Biol.* **12**, 725–728 (1986).
20. R.W. Gill,. "Pulsed Doppler with B-mode imaging for quantitative blood flow measurement" *Ultrasound Med. Biol.* **5**, 223–235 (1979).
21. P.W. Verco, "Diagnostic Ultrasound" *Aust. Radiol.* 25th Anniversary Issue 115–123 (1981).

OTHER BRANCHES OF ACOUSTICS

Neville Fletcher
Journal Editor

Australian researchers and practitioners have contributed significantly to most branches of acoustics over the past decades. This final note gives references to articles in which much of the history of other branches of acoustics is related.

It has proved impossible, within the compass of a single issue of this journal, to relate the history of all fields of acoustics in Australia. An omission does not imply a judgment on the importance of any field, but rather a recognition that some have been the subject of recent review articles in this journal or, in some cases, the simple unavailability of an appropriately knowledgable author within the timescale of preparation of this special issue. This final note, therefore, gives references to previous articles and other resources from which much of the history can be gleaned. A brief survey article on acoustical research in Australia [1] was published in this journal in 1997 and provides a more extensive, though brief, account.

THE NATIONAL ACOUSTIC LABORATORIES

Human hearing is of prime importance to all of us, and it is a sad fact that many children are born with hearing defects, many people suffer noise injuries to their hearing, and most of us suffer a decline in hearing abilities as we age. The charter of the National Acoustic Laboratories is to help prevent noise injuries and to assist those whose hearing has been damaged through the development and provision of appropriate hearing aids. Some of this history has been related in connection with the CALAID, as described in this issue. An outline of the history of the Laboratories is also provided in a recent brief "time-line" article [2], while a survey of current research is given in the Special Topic of *Acoustics Australia* for 1993 [3].

COCHLEAR IMPLANTS

The multi-channel cochlear implant known as the Bionic Ear was developed by Professor Graeme Clark and his collaborators over the past thirty years, and now gives hearing to thousands of people, particularly children, who without it would be profoundly deaf. The Australian company Cochlear manufactures these instruments and distributes them throughout the world through its subsidiaries, and indeed dominates the world market with something like 75% or all implants used.

The personal story of this remarkable achievement has been told by Professor Clark in his recent book *Sounds From Silence* [4]. Earlier and more formal publications include the edited book *Cochlear Implantation for Infants and Children* [5] and an article in the special "Hearing" issue of *Acoustics Australia* in 1993 [6].

THE NATIONAL MEASUREMENT LABORATORY

Another major Australian involvement in acoustical research is through the various divisions of the CSIRO. The Division of Building, Construction and Engineering is concerned mainly with architectural and industrial acoustics, as its name suggests, while the national Measurement Laboratory, now a part of the Division of Telecommunications and Industrial Physics, maintains Australia's national measurement standards in acoustics and investigates the applications of acoustics in a variety of industrial fields.

The calibration and standardisation activities of the Laboratory were surveyed in a special issue of *Acoustics Australia* in 1989 [7]. Since that time the activities of the Laboratory have turned increasingly towards industrial applications of acoustics, with major projects in ultrasonics and in non-destructive testing of composite panels for aircraft.

ULTRASONICS

A major and very different field of acoustics is that of ultrasonics. Ultrasonic techniques are applicable to the non-destructive testing of structures, to medical imaging, and to condensed-matter physics. A history of the use of medical diagnostic ultrasound is given in this issue, many of the techniques having been devised at the Ultrasonics Institute while this was associated with the National Acoustics Laboratories and before its transfer to CSIRO. A more wide-ranging discussion was given in the Ultrasonics Special Issue of this journal in 1991 [8] and again in 1999 [9].

SIGNAL PROCESSING AND ANALYSIS

Other important practical applications of acoustic techniques are in the fields of signal processing, active noise control, and machine condition monitoring. There are active groups in machine condition monitoting at Monash and the University of New South Wales, and Australian research in this area was reviewed in a Special Topic issue in 1994 [10]. The related topic of active noise control, in which the group at Adelaide University has been particularly productive, was reviewed in an article in 1992 [11]. Acoustic signal processing is, of course, of general importance, but particular mention should be made of the "surround sound" and other techniques developed commercially by Lake DSP in Sydney.

UNDERWATER ACOUSTICS

The use of acoustics techniques to explore the ocean bottom is of increasing importance, particularly in Australia with our long and largely unexplored coastline. A survey of work in this field was presented in a Special Topic issue in 1992 [12] and more recent issues have contined papers on particular subjects in the field.

CONCLUSION

This brief addendum fills out, to a limited extent, a catalogue of the range of activities in acoustics that are being pursued in Australia. A detailed account of their history over even the last few decades would fill many issues of this journal. Perhaps, however, this brief account will incite those who know more of the detailed history to write such an account for us.

REFERENCES

1. "Acoustical research in Australia" *Acoustics Australia* **25**, 49–63 (1997)
2. National Acoustic Laboratories and Australian Hearing Services "50 years of helping people hear" *Acoustics Australia* **25**, 113–114 (1997)
3. Special Topic issue "Hearing" *Acoustics Australia* **21**, 73–97 (1993)
4. G.M. Clark *Sounds From Silence* (Allen and Unwin, St Leonards NSW, 2000)
5. G.M. Clark, R.S.C. Cowan and R.C. Dowell *Cochlear Implantation for Infants and Children* (Singular Publishing Group, San Diego & London, 1997)
6. G.M. Clark "The University of Melbourne / Nucleus multiple-channel cochlear implant" *Acoustics Australia* **21**, 91–97 (1993)
7. Special Topic issue "Acoustics at the National Measurement Laboratory" *Acoustics Australia* **17**, 53–71 (1989)
8. Special Topic issue "Ultrasonics" *Acoustics Australia* **19**, 1–21 (1991)
9. Special Topic issue "Ultrasonics" *Acoustics Australia* **27**, 77–101 (1999)
10. Special Topic issue "Condition Monitoring" *Acoustics Australia* **22**, 73–95 (1994)
11. N.C. Mackenzie and C.H. Hansen "A review of controller hardware and control algorithms for active noise and vibration control" *Acoustics Australia* **20**, 5–10 (1992)
12. Special Topic issue "Underwater Acoustics" *Acoustics Australia* **20**, 69–101 (1992)

Obituaries...

VALE GRAEME YATES

It is with great sadness that we report the death of Graeme Yates. Graeme died in October 2000 after a prolonged illness. The society extends its condolences to his family, wife Marilyn and daughters Jennifer, Elisabeth, Katherine and Carolyn and to his many colleagues and friends.

Graeme was born in 1944, gained a B.Sc. (Hons) (Physics) from the University of Western Australia in 1970, and achieved a Ph.D (Physiology) from UWA in 1976. He maintained continuous contact in a teaching role at this university from 1982 onwards.

Graeme's major area of work over the past 20 years was as NHMRC Senior Research Fellow, at The Auditory Laboratory, Department of Physiology at the University of Western Australia. It was through his work in research that Graeme achieved a National and International profile. Recent activities included:

- Guest speaker at symposium "The Cellular Basis of the Cochlear Amplifier", 2000 Midwinter Meeting of the Association for Research in Otolaryngology, and
- Invited speaker NAS Colloquium "Auditory Neuroscience: Development, Transduction and Integration", 19-21 May 2000, Irvine, California.

In his career he authored / co-authored a total of 48 refereed journal articles in international journals, and presented 22 conference papers. He also authored/co-authored a chapter in 4 separate publications. He also achieved high recognition as an educator with influence in post graduate and undergraduate teachings at the UWA.

Graeme had a significant involvement in acoustics within Australia over many years. He was a founding member of the Western Australian Division of the Australian Acoustical Society in 1971 and maintained close and executive involvement throughout this period. He was treasurer of the WA Division from 1987 to 1992, Chairman from 1996 to 97, and Federal President from 1997 to 1999. Graeme will be remembered for his drive to set future goals for the Society. As Vice-President, and especially when he became President, he was forward looking and urged Council meetings to spend more time considering matters of acoustic policy, rather than the day-to-day issues of the Society. For this purpose he introduced the idea of a telephone link up between council members a few weeks before the main meeting, to consider the more minor matters. This freed time at the main council meeting for more controversial topics. He was keen to see the Society take an active role in international acoustics, and to determine whether it should be a "professional" or a "learned" society. The still unresolved issue of accreditation of members by the Society is an area where he led the way and where his expertise and insight will be sorely missed.

To his Western Australian colleagues in acoustics he had elder statesman status. Graeme had the unique ability to grasp the science of an acoustic issue and, in a helpful way, discuss and clarify the scientific principles. He will be missed and remembered for many personal attributes but also for his love of acoustics and the way he used his scientific skill to challenge and extend people around him in all fields of acoustics.

Compiled by colleagues in WA

GENTLEMAN ACOUSTICIAN DIES

MARK EISNER sustained fatal injuries in a motor vehicle accident on 12 September 2000 in transit between Canberra and the south coast of New South Wales. His wife, Judith, was also seriously injured in the accident but she is now recovering.

Mark was born in Warsaw, Poland on 6 May 1933 . At the age of six years he arrived in Sydney and began primary tuition at Beecroft Grammar School. During his secondary school life, Mark attended Kings School, Parramatta as a boarder.

He later took up tertiary studies at the University of Sydney where he gained a Bachelor of Engineering (Mechanical and Electrical) and continued on to complete a Masters Degree in Building Science under Professor Cowan. His thesis was entitled "Noise Problems in Medical Centres". This was probably the beginning of a lifelong passion for acoustics although he also loved good music and possessed a fine tenor solo voice.

During the period from 1959 to 1966 when he was a Director and Chief Mechanical Engineer for the Arcos Group of Companies, he spent some time in the United Kingdom where he was awarded an Engineering Certificate from the Nuclear Engineering School in Harwell.

In 1965 he married Judith Bazzan in Sydney. Two years later they travelled to New York, where Mark worked in the office of Bolt, Beranek and Newman until 1970, at which time he had become a senior consultant with the firm. Before retuning to Australia, Mark and Judith travelled extensively around Europe for several months. On returning to Sydney, Mark joined Carr & Wilkinson, one of the leading Acoustical Consultants in Australia at that time. In 1971, Mark set up an office in Canberra to act as Associate Director and Canberra Manager for Ron Carr & Company, Acoustical Consultants. Then in 1979, Mark formed his own practice in Canberra; Mark Eisner & Associates.

After relocating to Canberra, Mark and Judith were blessed with two wonderful children; a son Jason who is now working in New York and a daughter Kym (recently deceased).

Mark was respected for his intellectual approach to acoustic issues and for his independence of scientific thought. But most of all, he was a gentleman with social skills which are rare in this modern, fast world.

Despite the difficult times in Mark's life after Kym's death, he was always able to offer sincere and wise words of encouragement to his many colleagues and friends.

Mark was a Member of the Australian Acoustical Society and a Member of the Acoustical Society of America. His firm was a Member of the Association of Australian Acoustical Consultants (AAAC). He was always a valuable contributor to all AAAC matters and also a keen supporter of its aims and Code of Ethics.

Mark has provided professional acoustic services for over 30 years. He has been directly responsible for many major projects in acoustics, noise and vibration control, environmental engineering and energy thrift and conservation projects. These have included major aircraft and traffic noise studies and design of military and civil airport projects, noise abatement programs in defense of transport noise including, aircraft, rail and road traffic in Australia, USA and Canada. The projects have encompassed both noise measurements and noise predictions. His work has also included blast monitoring and predictions associated with quarries and industrial projects

His clients have included many of the federal, state and local government departments and other major clients in the private sector. He used the latest technology, instrumentation and effective techniques for solving acoustic problems and was committed to provide quality and excellence of service.

Mark will be sadly missed by the member firms of the AAAC and many others in the acoustical field in Australia.

Book Review...

The Science and Applications of Acoustics

Daniel R. Raichel

AIP Press / Springer, New York, 2000,
598 pp., ISBN 0-387-98907-2, hardcover. Distributor DA Information Services,
648 Whitehorse Rd, Mitcham 3132, Australia, tel 03 9210 7777, fax 03 9210 7788, Price A$147.26

Acoustics is a wide-ranging subject, and this book attempts the ambitious task of giving an account not just of the basic theory but also of most of its major applications. The target readership is at advanced undergraduate or early graduate level, and the pedagogical aim is reinforced by inclusion of a few worked examples and a dozen or so problems at the end of each chapter. Competing books with which I am familiar were all written many years ago — the classics by Beranek (Acoustics, 1954), by Olson (*Acoustical Engineering*, 1957), and by Kinsler et al. (*Fundamentals of Acoustics*, 1982) — and the present volume covers rather different ground.

The basic theory — strings, rods, plates, waves, tubes, etc — is covered in a capable fashion in the first third of the book and provides a suitable background for the applications that follow. My only quibble is the use of $\exp(i\omega t)$ instead of either the physics convention $\exp(-i\omega t)$ or the engineering convention $\exp(j\omega t)$, which causes minor confusion about wave propagation directions, impedances, etc., at least in my mind. Three Appendices give some data tables, details of the properties of Bessel functions, and (surprisingly) an extended treatment of Laplace transforms.

The applications treated span a wide range — acoustic measurement, human hearing, architectural acoustics, noise control, underwater acoustics, ultrasound, music, and vibration control. Each of these topics gets a single chapter, except for architecture and noise control, each of which gets two. The chapter on noise control becomes detailed enough to discuss regulations in several countries, while the architectural acoustics chapters examine several famous halls. The treatment is generally up-to-date and at an appropriate level, though it is necessarily limited in detail. It is, however, surprising to see rather little about microphones — only the standard measurement microphone is discussed — or about loudspeakers. Another surprising omission is any treatment of horns. But no book of modest length can cover everything!

As might be expected in such a diverse book, there are some things with which a reviewer will not agree. I found a few minor errors of fact, and rather too many instances of poor English expression or grammatical errors. The book uses a mixture of metric and Imperial units in some chapters, which is confusing (can you guess immediately what dB/kyd means?), but a two-page conversion table is provided in the Appendix (where you can revise conversion of slugs to kilograms weight and similar diversions!).

I can recommend this book to anyone who wants a compact introduction to various aspects of applied acoustics. The selective reference lists at the end of each chapter — mainly to books — can then be consulted for more detailed information. The book would be suitable as a text at advanced undergraduate level in physics or engineering, though I fear we have few acoustics courses of this type in Australia. It gives a good feel for the scope and practical importance of the subject..

Neville Fletcher

Neville is a Visiting Fellow in the Research School of Physical Sciences and Engineering at the Australian National University

New Products

RION
Sound Level Meter.

The new Rion NA-26 sound level is designed for use by those with limited experience with sound level meters. The meter has a single measurement range from 30 dB to 130 dB with a large LCD display for easy visibility. The additional bar graph indicator makes changes in sound levels easy to follow.

The NA-26 is a Type 2 meter designed to measure instantaneous sound pressure levels and includes a maximum hold feature. By depressing the maximum hold button, the user automatically reads and holds the maximum sound pressure level that is present. By depressing the maximum hold button a second time, the user automatically returns to real-time decibel reading. A second button allows the user to switch between A and C frequency weightings and a third button enables the user to vary the time measurement setting between Fast and Slow.

Further Information:
Acoustic Research Laboratories.
tel 02 9484 0800. fax 02 9484 0884
or your local branch of ARL or view the details on the NA-26 now on the web at www.acousticresearch.com.au

CSR

Laminated Service System

The new CSR Laminated Service System is the design solution for easy and effective installation of fire rated shaft walls. It consists of a light steel frame and three layers of CSR Gyprock fire rated plasterboard laminated. All components of the system are screw fixed, or screw and adhesively fixed which means a fast, inexpensive installation with no need for welding or bolting. Acoustic ratings for the systems range from Rw (STC) 36 - 38 designed to provide acoustic separation between shaft walls and building occupants.

Acousticon

Acousticon is designed to reduce noise under metal roofing and can be installed with any metal roofing system. It is a 75mm thick bond of lightweight fire resistant CSR Thermofoil with Bradford glasswool insulation. Acousitcon reduces external noise such as rain, road, traffic and aircraft and absorbs unwanted internal reverberant noise. Tests have indicated a noise reduction coefficient of 0.65. It also controls condensation and offers superior thermal performance.

Acoustilag

Acoustilag is a simple cost effective solution for all pipe noise applications and can be used on all types of hot and cold pipes. It comprises three main layers: outer layer of reflective, tear resistant CSR thermofoil, middle layer of flexible Soundlagg Barium coated vinyl and a third layer of CSR glasswool insulation. Acoustilag systems are designed to meet STC 30 and STC 45 requirements.

Acousticlad

Acousticlad is a pre-insulated wall panel system designed to deliver efficient acoustic and thermal performance. It consists of a layer of Bradford Fibretex 350 Rockwool fixed to a pre-formed perforated metal sheet. Each panel interlocks with the next to form a structurally reinforced joint. Tests have shown a noise reduction coefficient of up to 1.05. Because it is more resilient than face board it is ideal for use in areas demanding higher impact resistance such as factories, warehouses schools and sports centres. When used in conjunction with Mylar or Melanex wrap Acousticlad ensures that no fibres are released making it ideal for the food industry. It is available in a variety of attractive finishes and is designed and manufactured for each individual project.

Further Information:
CSR Gyprock.
tel 1800 678 068
www.csr.com.au/gyprock

Gyprock Guide Book

The popular Gyprock Fire and Acoustic Design Guide, also known as the "Red Book" has been relaunched with new plasterboard systems and performance specifications. It provides a quick and easy reference to the performance of an extensive range of CSR Gyprock fire and acoustic wall, ceiling and column/beam assemblies. All STC ratings have been changed to Weighted Sound Reduction Index (Rw). Eight new systems and their rain noise reduction performance in commercial buildings have also been included.

Further information Marketing Elements,
tel 02 99699 9301, fax 02 9690 2534

BRON
Portable Fan

Amass portable fans include innovative dual wall plastic construction and the case is anti corrosive, anti scratch, anti rust and of high quality manufacture. The aerodynamic features include an inlet impeller nose cone, down stream guide vanes, tapered radial arms and a true aerofoil section impeller all of which are necessary for maximum acoustic benefits. It has rubber anti vibration mounts. It is ideal for confined spaces such as manholes, sewers and utilities work places, construction and demolition sites, ship building and general manufacturing, and any uncomfortable environments that require sensitive labour cooperation.

Further Information:
Bron & Co.
tel 02 4568 2090, 0418 229 896,
fax 02 4568 2053
bronco@hawknet.com.au

SYSNOISE Rev 5.5

LMS SYSNOISE, the world's leading solution for vibro-acoustic design troubleshooting and optimisation, delivers new modules and enhancements for noise and vibration analysis. The Engine Acoustics module allows engine designers to evaluate complete engine signature acoustics in less than a day. This new release is part of the LMS mission to deliver CAE and testing products that improve and streamline the design analysis and manufacturing process."

Three new modules are available with LMS SYSNOISE Rev 5.5 and are based on the concept of Acoustic Transfer Vectors, the main building block for SYSNOISE Rev 5.5. The new modules include: Numerical Engine Acoustics, Inverse Numerical Acoustics, Panel Acoustic Contribution Analysis.

Additionally LMS SYSNOISE Rev 5.5 offers a wide range of user requested enhancements including: Faster solution times, Dynamic memory allocation, Binary compatible databases, FlexLM licensing mechanism, Automatic database merge for frequency level parallel runs, Peak value contour plotting, Integrated value contour plotting, Complex mass density (for DBEM, MDDBEM and FEM fluid), Frequency dependent mass density and speed of sound for all modules.

Further Information: Qinghui Zhong,
Compumod Melbourne tel (03) 9642 0333
or qzhong@mel.compumod.com.au.

MULTISCIENCE PUBLISHING

Acoustics Archive

The Acoustics Archive CD-ROM contains 5 years worth of Acoustics Abstracts - nearly 20,000 references from over 400 sources. The full text monthly version of Acoustics Abstracts will still be available but the new CD ROM utilises modern technlogy. The first CD ROM covers from March 1995 to February 2000. Releases will then be on an annual basis covering the previous 5 years.

Further information
Multiscience Publishing, 5 Wates Way, Brentwood, Essex CM15 9TB, UK, fax 44 1277 223453, mscience@globlnet.co.uk

AUTOSEA 2

Extension Modules

Quickscript, a visual Basic compatible language, allows AutoSEA2 users to create their own custom software or interface. Typical users include automatic model-building, automated report writing, linking of AutoSEA2 to corporate data bases, parametric variation and mire.

The Foam module extends AutoSEA2's functionality by enabling analytical modeling of a general class of poro-elastic, layered materials, including the full range of structural-acoustic foams commonly used for noise control applications.

Further information:
www.vasci.com/products
Vipac Engineers &Scientists,
tel 03 9647 9700, fax 03 9646 4370,
Kersting@vipac.com.au

CIRRUS

Sound Level Meter

The 800A sound level meter is the first of a new generation of instruments from Cirrus and provides all of the functions and features demanded from a modern sound level meter. The menu operation and keypad provide a simple user interface, making the instrument easy to use - an essential requirement for today. A wide range of options and accessories are available for the new instrument which allows the range of measurements to be enhanced. These include 1 and 1:3 octave band filters, type 1 option as well as a complete measurement kit

Further information:
Air Check Pty Ltd, 1/1 Poplar Street, Caulfield South, Victoria 3162, tel 03 9528 4568, fax 03 9532 4306, c.williams@aircheck.com.au

New Members

NSW

Member	Mr Raymond Tumney
	Mr Derek Langgons
	Mr Warwick Williams

QLD

Graduate	Ms Rebecca Ireland
	Mr Mark Caslin

VIC

Member	Ms Finola Reid

Past Conference Proceedings

Louis Fouvy is seeking copies of past AAS Conference Proceedings as part of his work on the history of acoustical activities in Australia. He would be glad to hear from any readers who have any of these and no longer need them.

241 Cotham Rd, Kew, 3101, tel 03 9817 1881.

Future Conferences

Acoustics 2001

This conference, organised by the Australian Acoustical Society (AAS), is being held from 21 to 23 November in Canberra, the seat of Federal Parliament. It is therefore appropriate to take noise and vibration policy as a theme for the conference. Recently there have been many changes and revisions of policies and this conference provides an opportunity for discussion of the various issues along with other aspects of acoustics.

The keynote speaker at the opening will provide an overview of the noise and vibration policies and provide a personal view of the way forward. For each of the sessions addressing various aspects of noise and vibration policy the session leader will be invited to summarise the current situation. Contributed papers related to the theme and to other topics on sound and vibration are invited. Each paper will be allocated 15–20 minutes. Papers related to the themes will be allocated in the sessions indicated in the preliminary program. Papers on other areas of acoustics will be in the parallel sessions.

All sessions, the technical exhibition and the social functions will be held at RYDGES CANBERRA. All registrants are encouraged to stay in the conference hotel and a special room rate has been negotiated. The conference will combine contributed papers, technical presentations, awards and a range of social activities included in the delegate registration fee such as welcome buffet, conference dinner and farewell lunch.

Further information: Acoustics 2001, Aust Defence Force Academy, Canberra, ACT 2600, tel:02 6268 8241 (0402 240 009), fax:02 6268 8276 m.burgess@adfa.edu.au and www.users.bigpond.com/Acoustics

ICA

The 17th International Congress on Acoustics (ICA) will be held in Rome, Italy, 2-7 September 2001. The congress will be held at the Engineering Departments in San Pietro in Vincoli, next to the Colosseum, in the centre of Rome. A preliminary application form is available via the www and the pages will be regularly updated. Deadlines are: February 15 for receipt of abstracts and for hotel early booking, May 30 for receipt of manuscripts and for advanced registration.

The ICA is the only congress devoted to all aspects of acoustics, where any acoustician should find him/herself at home. In addition to few selected plenary sessions, a large number of structured sessions are planned on many different topics, organized by coordinators that will stimulate the participation of active scientists, and thus will produce a natural overview of acoustics in the many fields of use. Contributed papers may either fit into structured sessions, or may find proper allocation in parallel planned sessions. The Congress has also been, since the very first one in its history, a moment where - not only people - but organizations, institutions and groups, do meet.

Further information: http://www.ica2001.it/ or Secretariat, ICA 2001, Dipartimento di Energetica, University of Rome "La Sapienza", Via A. Scarpa, 14, 00161 Rome, Italy. fax: +39 06 4976 6932, ica2001@uniroma1.it

ISMA 2001

The Interuniversity Center of Acoustics and Musical Research (CIARM) and the Catgut Acoustical Society (CAS) are pleased to present a joint International Symposium on Musical Acoustics (ISMA). This will be a satellite symposium of the 17th ICA and will be held September 10-14 in Perugia (Italy): the beautiful chief town of the Umbria region. In keeping with previous conferences in this series, ISMA 2001 will bring together international leaders in the musical acoustics field. The symposium will be held in 2001 and will be joint with "Perugia Classico": a noteworthy Italian exhibition and market of acoustic instruments, which will give musicians, instruments makers and acousticians the opportunity to meet and discuss any topic of musical acoustics from an interdisciplinary point of view. The leading theme will be Musical Sounds from Past Millennia, which will be accompanied with a leitmotif: The Preservation and Promotion of our Musical Acoustic Heritage.

Further information: http://www.cini.ve.cnr.it/ISMA2001 or Musical Acoustics Laboratory, Fondazione Scuola di San Giorgio - CNR, Isola di San Giorgio Maggiore, I-30124, Venezia,Italy, Fax: +39 041 5208135, isma2001@cini.ve.cnr.it

Internoise 2001

Internoise 2001, the 30th International Congress on Noise Control Engineering to be sponsored by I-INCE, the International Institute of Noise Control Engineering, will be held in The Hague, The Netherlands, August 27-30. The theme of Internoise 2001 will be Costs & Benefits of Noise Control. Technical papers in all areas of noise control engineering are welcome. An extensive technical exhibition will be held.

To receive regular email updates on the conference you can register with listserv@dto.tudelft.nl with subscribe internoise in the body of the email.

Further information: http://www.internoise2001.tudelft.nl or Congress Secretariat, P.O. Box 1067, NL-2600 BB Delft, The Netherlands, fax +31 15 2625403, secretary@internoise2001.tudelft.nl

ICSV8

The Eighth International Congress on Acoustics and Vibration sponsored by IIAV, the International Institute of Acoustics and Vibration, will be held in the Hong Kong Special Administrative Region, China, from 2 to 6 July 2001. IIAV is an international non-profit scientific society affiliated to the International Union of Theoretical and Applied Mechanics (IUTAM). ICSV8 is part of a sequence of congresses held in the USA (1990 and 1992), Russia (1993 and 1996), Canada (1994), Australia (1997), Denmark (1999) and Germany (2000), each attended by several hundred participants worldwide.

The keynote presentations will be "Systems approach to the design, construction and maintenance of railways", Glenn Frommer (Hong Kong), "European Airframe Noise Research - An Overview," Hanno Heller (Germany), "Physics of reverberation," Jie Pan (Australia) and "Wave propagation and sound transmission in sandwich composite panels," Anders Nilsson (Sweden)

Further information from http://www.iiav.org or ICSV8, Dept Mechanical Engineering, Hong Kong Polytechnic University, Hunghom, Hong Kong, China, fax: +852 2365 4703, mmicsv8@polyu.edu.hk

WESPAC 8

On behalf of the Australian Acoustical Society, the Victoria Division made a successful bid to hold the next conference of the Western Pacific Commission for Acoustics to be run in 2003. To secure the bid, Vice President of the Society and Chairman of the Victoria Division, Charles Don, attended a meeting of the Western Pacific Commission for Acoustics just prior to WESTPRAC 7. Members of the board praised the bid document, which was prepared in conjunction with Melbourne Convention and Marketing Bureau. The conference will be held in Melbourne from 7-9 April 2003, with registration starting on Sunday 6. For information updates, watch the AAS web page: http://www.users.bigpond.com/Acoustics

Meeting Reports

WESTPRAC 7

Kumamoto, in the south west of Japan, was the venue for the Seventh Western Pacific Regional Acoustics Conference, known as WESTPRAC 7. Largely organised by the Acoustical Society of Japan in conjunction with the Institute of Noise Control Engineering of Japan, the three day conference attracted almost 500 delegates along with 20 accompanying delegates. There were 301 paper delivered in up to seven parallel sessions.

The first plenary lecture was by the foundation chairman of the Western Pacific Commission, **Ken'iti Kido.** He explored the relation between acoustics and the emerging discipline of information science, noting that while the energy carried by sound is almost negligible it is the information contained by the signal that is the crucial factor.

Neville Fletcher gave the second plenary lecture, taking up the theme of the conference, "Pan-Pacific Winds, Filling the sails of acoustics for the 21st century", by choosing the topic of wind instruments. Flute-like, reed- and lip- driven instruments were discussed and demonstrated during a fascinating talk which included mention of the didgeridoo.

Musical acoustics and electro-acoustics were two of the special sessions at the conference, along with architectural acoustics, noise and vibration, psychological and physiological acoustics including the psychological evaluation of noise, physical effects of sound and underwater acoustics. There were four distinguished lectures, in the areas of underwater acoustics research, brain mechanisms of sound location, noise evaluation based on hearing sensations and new technologies leading towards multi-lingual speech communications to break language barriers. Delegates came from 17 countries and included representatives from Europe, Russia, the USA as well as the Western Pacific rim countries.

There was no instrumentation or product display associated with the conference, although a number of manufacturers made use of the poster sessions to inform delegates of their wares. A lavish buffet-style banquet was held during the evening of the second day, and included demonstrations of Japanese martial arts and local dances.

Associated with the Conference was the meeting of the Western Pacific Commission for Acoustics and Professor **Toshio Sone** of Akita Prefectural University, Japan, was elected Chairman. The newly created post of Chairman elect went to the AAS representative, **Charles Don**, with the expectation that he will take up the Chairman's position after the next conference to be held in 2003. At the Commission meeting, it was decided that the R, for regional, should be removed from the acronym for future conferences. This was because the word "regional" suggested that the conference participants came from a limit area, whereas delegates were being drawn world wide. However, removing just the R posed a problem, especially in Australia, as the resulting acronym is the name of a banking company. After some discussion it was decided that henceforth the name would be WESPAC, and that Melbourne would host WESPAC 8 during April, 2003. A video promoting Australia, with an emphasis on Melbourne as a tourist destination, was shown to delegates at WESTPRAC 7 after the announcement of the next conference venue was made at the closing ceremony.

Charles Don

Acoustics 2000

The annual conference for the Australian Acoustical Society for the Year 2000 was held at the Joondalup Country Club, about 30kms north of Perth city, Western Australia, between the 15 and 18th of November. Over a hundred delegates from all states of Australia and quite a few from overseas, gathered to take part in a full program.

The first event of the Conference was a visit to the Defence Science Technology Organisation facility at Garden Island Naval Base followed by Registration and a Welcome BBQ on a terrace overlooking the pool and golf course at the Joondalup conference venue.

The Conference started next morning, with Charles Don, officially opening proceedings and introducing Ken Aplin from the FrogWAtch program at WA Museum. The Conference committee of the WA chapter of the Association had chosen to donate some of any profits made by the Conference to a local program known as 'FrogWAtch'. This is a program, set up by WA Museum and funded by Alcoa collecting information on frog numbers and distribution within our state. Some members of the Society have been involved, using our interest and knowledge of acoustics to develop a computer program by which data collected in local wetlands by various groups including community and school groups can be analysed and frogs identified by their calls. Eventually, we hope to use this information identify environmental problems through their relation to the wildlife of an area. We hope this went some way to explain the general theme for the conference and why everyone had a picture of a frog on the name badges etc.

The key note address was delivered by Bill Kuperman of Marine Physical Laboratory/SIO on Time-Reversal Acoustics. Following this most interesting address, delegates were able to follow two streams over the next two days.

Keynote speaker Bill Kuperman receiving presentation from WA Division Chairman, Daniel Lloyd

Broadly, the two streams were air and water acoustics. It was fascinating to hear the ways familiar scientific principles could be applied in unfamiliar ways, the role of acoustics in the future of world communication - from a frog croaking in a bush creek to transpacific data transmission. Apart from formal presentation of papers, there were several interesting, informative and useful workshops where problems encountered in everyday workplace situations could be thrashed out among similarly interested parties and regulatory government authorities. These discussions and many others continued in the warm spring sunshine on the terrace overlooking the pool and golf course during many casual conference and meal breaks.

At the Conference Dinner on Thursday night Charles Don presented the President's Prize to Colin Hansen for his paper (with Colin Kestell and Ben Cazzolato) on "Virtual Sensors in Active Noise Control". Daniel Lloyd, WA Chairman also announced that Ken Aplin and FrogWAtch would also receive a guaranteed \$5000.00 in proceeds from the Conference.

With the unexpected passing of Dr Graham Yates, the local organizing committee probably exceeded their own expectations for the smooth running of the Conference as a small tribute to the memory of Dr Yates. This was possibly, in no small part due to the organizing work already completed by Graham even as he coped with his own medical difficulties. The inspirational value of his efforts to those with whom he came in contact during his life but in particular during what was to become his final months (he attended a committee meeting within one week of his death) cannot be overstated.

A number of co-opted members and friends of the society provided much needed extra assistance to help cover the gap also caused by the sudden hospitalization of Tien Saw, now thankfully well on the road to recovery.

Lynton Storer

Charles Don presenting the Presidents Prize to Colin Hansen (co authors Colin Kestell and Ben Cazzolato)

Fox Studios Meeting

The AGM for the NSW Division was held at the Fox Studios in Moore Park, Sydney on 3 August 2000. The first floor of the Fox & Lion bar was obviously a popular venue as approximately 55 members and guests were present. Unfortunately the ground floor was occupied by a noisy crowd and even the minds of the estimated 40 or more qualified noise control engineers couldn't come up with a temporary fix for the noise transmission up the stairwell!!! After the AGM a technical talk was presented by RFA Acoustics who had been involved in the acoustical design of the film complex. **Bob Fitzell**, who was responsible for the Noise Management Strategy, started with an outline of the scope of the problem. The Heritage site had a long history of noise complaints from local residents and the object was both to stop the noise from annoying the neighbours as well as keeping noise from trucks, aircraft and general traffic from entering the film studios. The Noise Management Strategy involved establishing zones and time frames for certain noise ranked activities. Bob reported that despite the potential difficulties this worked really well. **Sue Ridler** took up the talk explaining that her role was the acoustic design of the film studios. Her main task was to make external truck movements around the site with LA1's of 80 dBA meet NR25 internally within the budget! A good test was the rock group U2 sound check in the nearby Sydney Cricket Ground. Sue described in some detail the building construction which enabled STC's of around 54 to be achieved. Aircraft and cricket ground noise is inaudible within the studio, and nearby fireworks can only just be heard. The results were well received with the studios being booked out for the next 2 years. **Val Bray** finished the talk with a description of the noise reduction between the 11 cinemas on the complex. Seven of the cinemas are on the ground floor and four are on the first floor. Here STCs of 65 were the goal, with noise reduction in the low frequencies of 35 to 40 dB. Eight layers were required to achieve the required performance including, of course, the ubiquitous acoustic seals. The only fine tuning that was required was adding joists at 300 mm centres as opposed to 600 mm centres to reduce the noise of children running up and down the cinema aisles. The evening was completed with a range of 'finger food', a few drinks at the bar and a chance to catch up with old friends in conversation on one of the most interesting topics in the world - acoustics.

Ken Scannell

Building Acoustics Standards Meeting

At a Victorian Division meeting on 23 August, at which 15 were present, **Ken Cook** and **Graeme Harding** described the revising of Australian Standards AS 1191–1985, *Acoustics—Method for laboratory measurement of airborne sound transmission loss of building partitions*, and AS 2460–1981, *Acoustics—Measurement of reverberation time in enclosures*. Recent Standards Australia practice in issuing standards has been to endorse the ISO standard if that is deemed satisfactory for Australian conditions; otherwise a specifically Australian Standard is issued, based more or less on the corresponding ISO document.

Ken Cook, in describing the revising of AS 1191 (via DR 00335), noted that it required revision because the term, *Sound Transmission Loss* (STL), has been replaced by *Sound Reduction Index* (SRI), and that, although it is based on ISO 140-1:1997, *Part 1: Requirements for laboratory test facilities with suppressed flanking transmission*, which defines the test room conditions, and ISO 140-3:1995, *Part 3: Laboratory measurement of airborne sound insulation of building elements*, which describes the methods of test, it differs from them in certain significant respects. The recently revised AS/NZS 1276.1-1999, *Acoustics—Rating of sound insulation in buildings and of building elements, Part 1, Airborne sound insulation*, which is identical with ISO 717-1:1996, (same title as AS/NZS 1276.1), is a companion standard but contains two appendices appropriate for Australian and NZ conditions. Both the revised AS 1191 and AS/NZS 1276.1 will be regulatory references in the *Building Code of Australia* (currently under revision).

The significant differences between AS 1191 and ISO 140, parts 1 and 3 are that, first, in the laboratory test requirements, while ISO 140-1 requires flanking transmission to be suppressed, and sufficient tests to determine the maximum SRI, AS 1191 requires flanking transmission to be minimized, and accurate determination of the SRI. Secondly, with the laboratory test methods, while ISO 140-3 allows a test room volume as low as 50m³ (which can lead to a non-diffuse sound field and therefore poor measurement precision), and specifies a considerable number of sound source positions, AS 1191 requires a desirable minimum test room volume of 100m³, and preferably of 200m³, and specifies only one sound source position and sufficient tests for a statistically stable result.

As a result, it is considered that the AS 1191 test conditions enable at least as good precision as with ISO 140, but at less cost to those requiring the tests.

Graeme Harding, in describing the revising of AS 2460 (via DR 98084), said that although the revised edition is based on ISO 3382:1997, *Acoustics—Measurement of reverberation time of rooms with reference to other acoustical parameters*, it also differs from ISO 3382 in several important respects, including the title which is to be ......time ***in*** rooms..... not ***of*** rooms, to allow for times, contrary to ISO 3382, to be measured at any desired point in a room, including under auditorium balconies, thus still requiring the ***in*** of the AS 2460–1981 edition.

Other differences from ISO 3382 are that AS 2460 does not use confusing terminology such as T_{20} or T_{30} ; specifies the use of either an omni-directional sound source (without too rigid specification), or horizontally-directed source if appropriate for auditoriums limited to amplified speech ; and allows use of a variety of measuring methods, including computer programs which "condition" the measured data, provided that the test report clearly specifies and describes the methods by which the results were obtained.

At this meeting, also, **Neil McLachlan** and **Lawrence Harvey** of the *Australian Forum for Acoustic Ecology* spoke to introduce the *acoustic ecology movement*, which originated in Vancouver. In brief, their prime aim is to encourage us to ***listen*** to the sounds around us, remember them, and be fully conscious of our acoustic environment, in order that we come to know our environment and the world through its many and varied sounds (as also did Jonathan Mills when he opened Acoustics 99). After discussion, all speakers were thanked with acclamation.

Meeting on Low Frequency Noise

The Victoria Division AGM for 1999/2000, at which 22 were present, was held on 27 September at Vipac, in conjunction with a technical meeting at which **Dr Norm Broner** spoke of his continuing investigations (for ASHRAE) into the loudness and annoyance of low frequency noise.

At the AGM the audited financial statements were presented and received, and the following committee elected for 2000/2001 : Charles Don, Elizabeth Lindqvist, Louis Fouvy, Geoff Barnes, Norm Broner, Mark Debevc, Kerry Dumicich, Keith Porter and Paul Tierney.

Norm Broner, in describing his work on the low frequency "rumble" noise in offices, emanating from such plant as the variable air volume boxes of heating, ventilating and air conditioning (HVAC) systems, introduced his subject by saying that the widely held assumption that the loudness and annoyance

of sounds are the same is not always valid, especially at low frequencies, as was recognized, for example, by Laird and Coye (*J Acoust Soc Am*, 1929, pp 158-163). What is sought is a comfortable, non-intrusive office background sound which is neutral, without excessive rumble (noise below 125 Hz), roar (125–500 Hz), whoosh (500–2000) or hiss (>2000).

Experience has shown that background sound with a constant percentage bandwidth spectrum slope of around –5 dB/octave is satisfactory. However, current noise criterion/rating curves are generally not satisfactory in rating sounds with significant low frequency content. Some modified Room Criterion and Low Frequency Noise Rating Curves with spectrum slopes closer to the desired –5 dB/octave slope were proposed.

As part of the continuing research, he arranged, through a group of psycho-acoustic tests with 8 typical HVAC noise, and 4 synthesized spectra, and using the method of Absolute Magnitude Estimation, for a group of subjects to rate separately the loudness and annoyance of these 12 noise stimuli. From all this he concluded that

(i) with low frequency noise, loudness and annoyance differ significantly,

(ii) though the A-weighted sound levels of the 12 stimuli were well correlated with their rated and computed loudness, they were poorly correlated with their annoyance, and

(iii) dB(A) and the earlier noise rating curves (including the Beranek NCB) did not predict low frequency annoyance at all well.

Afterwards, several Vipac staff conducted those present on a tour to see something of the work currently in progress there. At the end of the meeting, Charles Don's thanks to Norm Broner and his staff was carried with acclamation.

Colonial Stadium Meeting

The Technical Meeting held on 18 October took the form of a combined AAS/ANCE site visit to the Melbourne Colonial Stadium at which 28 (16 AAS) attended. To begin, the Stadium Sound Technician described the arrangements made for several musical performances (including that of Barbra Streisand) at the Stadium, together with the numerous preparatory tests needed to obtain optimum audio volume and tonal balance of the amplified sound. Some acoustic treatments (eg, felts laid over some spectator seats), also, were needed to minimize undesirable reverberations and echoes.

The spectator seating areas are provided with numerous groups of auxiliary loudspeakers to boost the 200 to 4000 Hz sound (primarily for clearer speech distribution). The audio signal to these groups of auxiliary speakers is delayed (by the computer IQ system) by times determined by the airline distance between center-ground (the usual sound source location) and each group of loudspeakers, so that (according to the Haas effect) the amplified sound is heard just after that from the source.

The visit concluded with a tour of the spectator area to see various function and other rooms, and the main audio and video control rooms with their control panels for the very comprehensive system for distributing both audio and video signals to the spectator areas and function rooms. At the close, Charles Don (Div Chairperson) moved a vote of thanks to the Stadium staff for their demonstration, which was carried by the applause of all those present.

Louis Fouvy

FASTS

Afer a successful event in 1999 FASTS organised a second Science Meets Parliament Day. The Minister for Industry, Science and Resources, Senator Nick Minchin told the gathering of more than 150 scientists that innovation is the key to achieving global competitiveness in the future. He said that that the Government was committed to science issues and welcomed the opportunity to engage in a policy dialogue with the science community.

"Australian scientists are world class producing leading edge basic research that has fundamental and far reaching implications for scientific research, innovation, public health and economic prosperity. The Government remains committed to investing in scientific excellence, recognising its important contribution to the development of new industries and the renewal of established industries which have been the backbone of our nation," he said.

This year's event coincided with the impending release of the final report of Australia's Science Capability Review, The Chance to Change. The Government is also considering Innovation, Unlocking the Future, a report by the Innovation Summit Implementation Group. The Government will draw together its response to the Innovation Report and the Chief Scientist's report in the form of an Innovation Action Plan. The plan will focus on achieving innovation outcomes including higher business investment in R&D, increased rate of commercialisation of research, and job creation.

Standards

During 2000 Standards Australia moved the head office to 286 Sussex St, Sydney with the postal address GPO Box 5420, Sydney 2001, tel 02 8206 6000, fax 02 8206 6001 and customer service tel 1300 65 4646, fax 1300 65 4949. The electronic contacts remain the same at mail@standards.com.au and www.standards.com.au

Railway Noise

The effects or rail related noise on the community must be considered when a new railway line is planned or when a development near an existing railway line is proposed. AS 2311-1980 methods for the measurement of airborne sound from railbound vehicles is intended primarily for type testing of rail vehicles. The methods can also be used for monitoring tests to check that the levels are within specified limits. They are not generally sufficient for environmental assessments. Committee EV/10 has initiated a project to revise AS2377. For information jill.wilson@standards.com.au

Letter...

Seeking employment

I will be arriving from UK late 2000 and immediately seeking short or long term employment an acoustician. As well as being flexible about location my attributes include:-

* Associate Member Institute of Acoustics (U.K.)
* Masters Degree in Environmental Acoustics
* Local Authority Environmental Health experience
* Consultancy experience

Contact details keithronh@hotmail.com

Keith Hewett

News

Acoustics Research Letters Online

The Acoustical Society of America (ASA) has recently launched its second archival journal, Acoustics Research Letters Online (ARLO). ARLO is an international electronic letters journal. The submission and review process are handled with ASA's new online Manuscript Management System, which enables publication in as little time as one month. The abstracts of all articles will also appear in print in the Journal of the Acoustical Society of America (JASA), and full articles will appear on the JASA CD-ROM.

ARLO accepts colour and multimedia content (for example, audio, video, and computer animations). These are part of the reviewed manuscript. ARLO is published and archived by the American Institute of Physics (AIP) on behalf of ASA. AIP also provides searching and linking functions to titles, authors, abstracts, key words, and references through its Online Journal Publishing Service.

ARLO is free to all individual readers with an internet browser (Netscape or Internet Explorer). There is no subscription fee. ARLO is financed by authors who pay a $350 publication fee for accepted manuscripts, and by libraries and institutions that are charged a modest annual fee ($150) to support the archiving and the migrating of multimedia material to new formats.

Details: http://ojps.aip.org/ARLO

Clunies Ross National Science & Technology Award 2001

Award recipients will be publicly honoured at a formal ceremony and dinner to be held at Hotel Sofitel, Melbourne on Wednesday 28 March 2001. This annual Award has now honoured 52 special Australians who have made an outstanding contribution to the application of science and technology for the economic, social or environmental benefit of Australia.

More Information: Mary Bolger
tel (03) 9854 6266, icr@crnet.com.au or http://www.cluniesross.org.au

FANTECH have appointed two new directors. **Paul de Bruin**, has been appointed Marketing Director working out of the Melbourne and **John Bent** has become the new Sales Director based in Sydney. Further information Fantech Pty Ltd, tel (03) 9560 2599, fax (03) 9561 4428, info@fantech.com.au

Bruel & Kjaer have launched a new web site at www.bksv.com. This includes access to product details as well as items out of recent magazines and other promotional material.

Darren Jurevicius has been appointed as manager for Vipac's Hunter Valley office, formerly known as Caleb Smith Consulting. He has been relocated from the Adelaide office of Vipac and has long experience in the field of acoustics.

The Academy of Science has set up a new **science education** home page at www.science.org.au/scied as part of its website. The aim is to bring together diverse educational information on the site and links include Nova, primary investigations, good science books for children etc.

Diary...

2001

January 14 -17, PATRAS
EURONOISE 2001
http://euronoise2001.upatras.gr/ or LFME: Laboratory of Fluid Mechanics and Energy, University of Patras, P.O.BOX 1400, 26500 Patra, Greece, fax: +30 61 996344, euronoise2001@upatras.gr

*** February 7-9, MELBOURNE**
7th Annual Conference
Assoc Ocup Health & Safety Educators
Colin Findlay, OH&S Group, RMIT Applied Chemistry, PO Box 71, Bundoora Vic 3083

April 6-8, CAMBRIDGE
Noise Pollution and Health
www.ucl.ac.uk/noiseandhealth

June 4-8, CHICAGO
141st Meeting of Acoustical Society of America. http://asa.aip.org, ASA, 500 Sunnyside Blvd, Woodbury, NY 11797-2999, USA, Fax: +1 516 576 2377,

July 2-6, HONG KONG.
8th ICSV
http://www.iiav.org/, mmicsv8@polyu.edu.hk Dr K M Li, Dept Mechanical Engineering, Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, Fax: + 852 2365 4703

Aug28 - 30, THE HAGUE
INTER-NOISE 2001
http://www.internoise2001.tudelft.nl or Congress Secretariat, P.O. Box 1067, NL-2600 BB Delft, The Netherlands, fax +31 15 2625403, secretary@internoise2001.tudelft.nl

September 2-7, ROME
17th ICA
http://www.ica2001.it/ or A. Alippi, 17th ICA Secretariat, Dipartimento di Energetica, Universitá di Roma "La Sapienza", Via A. Scarpa 14, 00161 Roma, Italy, Fax: +39 6 4424 0183,

September 10-14 , PERUGIA
ISMA 2001 ,
CIARM & Catgut Acoust Soc
http://www.cini.ve.cnr.it/ISMA2001, Musical Acoustics Laboratory, Fondazione Scuola di San Giorgio - CNR, Isola di San Giorgio Maggiore, I-30124, Venezia,Italy, Fax: +39 041 5208135, isma2001@cini.ve.cnr.it

October 7 - 10, ATLANTA
2001 IEEE Int Ultrasonics Symp joint plus World Cong on Ultrasonics.
http://www.ieee-uffc.org/2001, fax: +1 217 244 0105

*** November 21-23, CANBERRA**
Acoustics 2001 AAS Annual Conference
http://www.users.bigpond.com/Acoustics, Acoustics 2001, Aust Defence Force Academy, Canberra, ACT 2600, avunit@adfa.edu.au

03 - 07 December, FT. LAUDERDALE
142nd Meeting of the Acoustical Society of America.
http://asa.aip.org, ASA, 500 Sunnyside Blvd, Woodbury, NY 11797-2999, USA, fax: +1 516 576 2377

2002

19 - 23 August, MOSCOW
16th International Symposium on Nonlinear Acoustics (ISNA16).
O. Rudenko, Physics Department, Moscow State University, 119899 Moscow, Russia, isna@acs366b.phys.msu.su

16 - 21 September, SEVILLA
Forum Acusticum 2002 (Joint EAA-SEA-ASJ Symposium)
http:/www.cica.es/aliens/forum2002, fax: +34 91 411 76 51

30 Nov-8 Dec, MEXICO
1st joint meeting of ASA, Iberian Fed. Acoustics, Mexican Inst Acoustics
http://asa.aip.org/cancun.html

WWW Listing
The ICA meetings Calendar is available on http://gold.sao.nrc.ca/ims/ica/calendar.html

ACOUSTICS FORUM

Beginning in 2001, each issue of Acoustics Australia will include a new section with the title "Acoustics Forum". This is intended to provide an opportunity for members of the Society, or other readers of the journal, to raise matters for discussion, to describe recent achievements, or to seek advice on acoustics questions.

While there will be no formal refereeing process, the Editors reserve the right to rule on the acceptance of contributions for publication, and to make such editorial changes as are necessary. The length limit for contributions is one journal page, though shorter contributions are also welcome. One page is equivalent to about 1000 words, with each normally sized illustration counting as 300 words. The contribution should be submitted either as an e-mail or on disk, with the text in plain-text format or as an attachment in Microsoft WORD. Illustrations may be submitted either as hard copy, or in electronic form as .EPS or .BMP files. For further information, consult the Acoustics Australia pages of the Society's web site www.users.bigpond.com /acoustics/journal

While every effort will be made to ensure prompt publication, this cannot be guaranteed. The normal deadlines for receipt of contributions to this section of the journal will be 1 March for the April issue, 1 July for the August issue, and 1 November for the December issue.

INDEX
Volume 27, 2000

ACOUSTICS 2001
Noise & Vibration Policy
21 to 23 November 2001
Canberra, ACT
Information: AVU, ADFA,
CANBERRA 2600
Tel: 02 6268 8241, 0402 240009
Fax: 02 6268 8276
avunit@adfa.edu.au
www.users.bigpond.com/Acoustics

AUSTRALIAN ACOUSTICAL SOCIETY ENQUIRIES

NATIONAL MATTERS

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

General Secretary
AAS– Professional Centre of Australia
Private Bag 1, Darlinghurst 2010
Tel/Fax (03) 9887 9400
email: watkinsd@melbpc.org.au
http://www.users.bigpond.com/Acoustics

SOCIETY SUBSCRIPTION RATES

For 2000/2001 Financial Year:

Fellow and Member	$103.40
Associate and Subscriber	$82.50
Retired	$34.10
Student	$23.10

Including GST

DIVISIONAL MATTERS

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

AAS - NSW Division
Professional Centre of Australia
Private Bag 1,
DARLINGHURST 2010
Sec: Mr D Eager
Tel (02) 9514 2687
Fax (02) 9514 2665
david.eager@uts.edu.au

AAS - Queensland Division
PO Box 760
Spring Hill Qld 4004
Sec: Michael Caley
Tel: (07) 3367 3131
Fax: (07) 3217 0660
ronrumble@uq.net.au

AAS - SA Division
C/–Department of Mech Eng
University of Adelaide
SOUTH AUSTRALIA 5005
Sec: Robert Koehler
tel: (08) 8303 3556
Fax: (08) 8303 4367
rkoehler@mecheng.
adelaide.edu.au

AAS - Victoria Division
PO Box 417
Collins St. West
PO MELBOURNE 8007
Sec: Elizabeth Lindqvist
Tel (03) 9925 2144
Fax (03) 9925 5290
elind@rmit.edu.au

AAS–W A Division
PO Box 1090
WEST PERTH 6872
Sec: Mr J Macpherson
Tel (08) 9222 7119
Fax (08) 9222 7157
john_macpherson@environ.gov.au

ACOUSTICS AUSTRALIA INFORMATION

GENERAL BUSINESS

Advertising Subscriptions

Mrs Leigh Wallbank
PO Box 579, CRONULLA 2230
Tel (02) 9528 4362
Fax (02) 9523 9637
wallbank@zipworld.com.au

ARTICLES & REPORTS NEWS, BOOK REVIEWS NEW PRODUCTS

The Editor
Acoustics Australia
Acoustics & Vibration Unit, ADFA
CANBERRA ACT 2600
Tel (02) 6268 8241
Fax (02) 6268 8276
email: acoust-aust@adfa.edu.au

PRINTING, ARTWORK

Scott Williams
16 Cronulla Plaza
CRONULLA 2230
Tel (02) 9523 5954 Fax (02) 9523 9637
email: print@cronullaprint.com.au

SUBSCRIPTION RATES

	Aust	Overseas
1 year	A$ 57.20	A$ 64
2 year	A$ 96.80	A$112
3 year	A$137.20	A$161

Australian rates include GST.
Overseas subscriptions go by airmail
Discounted for new subscriptions
20% Discount for extra copies
Agents rates are discounted.

ADVERTISING RATES

B&W	Non-members	Sus Mem
1/1 Page	$605.00	$550.00
1/2 Page	396.00	357.50
1/3 Page	302.50	275.00
1/4 Page	258.50	242.00

Spot colour: $110 per colour
Prepared insert: $275 (additional postage may apply)
Column rate: $19.80 per cm (1/3 p 5.5cm width)
All rates include GST

Discounted rates for 3 consecutive ads in advance
Special rates available for 4-colour printing
All enquiries to: Mrs Leigh Wallbank
Tel (02) 9528 4362 Fax (02) 9523 9637
wallbank@zipworld.com.au

ACOUSTICS AUSTRALIA ADVERTISER INDEX - VOL 28 No 3