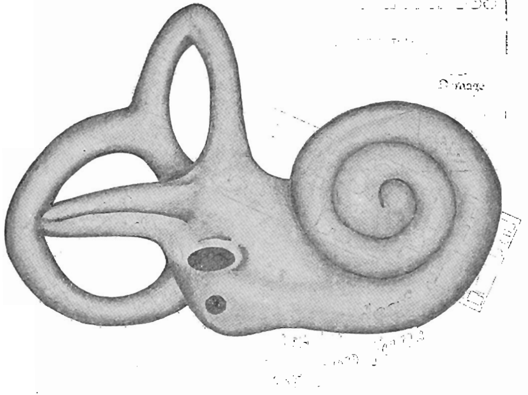
The Bulletin

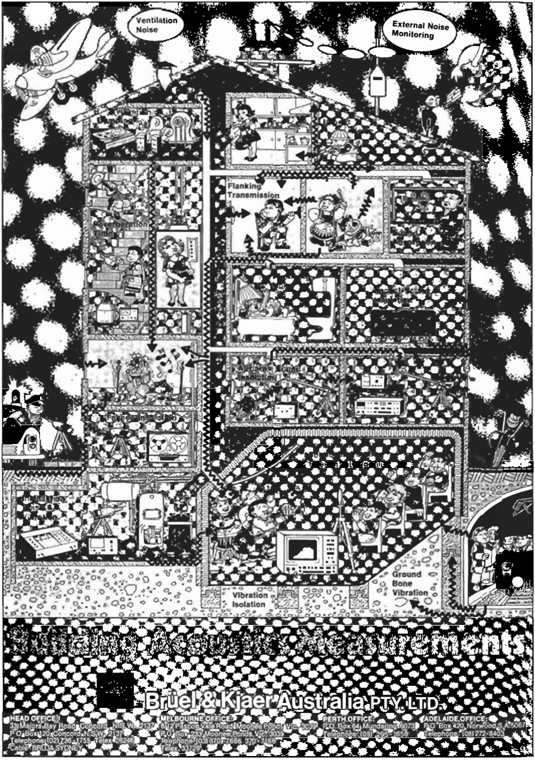
AUSTRALIAN ACOUSTICAL SOCIETY

Vol. 11 No. 2 August, 1983 Pages 49-88



Digital Techniques

Hearing Damage and Loud Music



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From the President

Council met in Tanunda, South Australia, after the AAS Annual Conference and one of the main fruits of the meeting, the Guidelines for Admission and Grading of Members, was published in the April issue of the Bulletin. An updated membership application form and information sheet is now under consideration by the Divisions. Members will also be pleased to learn that Council has finally agreed on the design of membership certificates. The South Australia Division has undertaken to produce these which will be sent to Sustaining Members, Members and Affiliates in due course.

At the time of writing I am just preparing to leave for a very quick visit to Europe to attend Internoise 83 in Edinburgh and the 11th ICA in Paris, as one of a number of AAS members hoping to form a reasonable "Australian contingent". International Standards Organisation and International Electrotechnical Commission meetings follow the ICA in Paris, but unfortunately clash with academic commitments. Regular and consistent Australian representation on ISO and IEC working groups is very difficult to arrange, which is a particular cause of concern now that the Standards Association of Australia has adopted a policy of endorsing international standards for use as Australian Standards wherever possible.

I would like to urge all members to take as active a part in the Society's affairs as possible. One important contribution is to become one of the ten Committee members who usually meet once a month to look after the affairs of each Division, and from whose ranks are drawn the Councillors who meet twice a year to decide on AAS policy. The AAS is affiliated with the Committee on Physics of the Australian Academy of Science, it is a member society of the International Commission on Acoustics (a Commission of the International Union of Pure and Applied Physics) and a member of the International Institute of Noise Control Engineering. Thus, as well as having an input to the local acoustics scene, active members have a chance to contribute, through Council, on a national and international scale.

ANITA LAWRENCE

Editorial

The playing of loud amplified music is almost certain to produce a hostile reaction wherever it occurs. Apart from the annoyance aspect, the possibility of loud music causing permanent hearing loss has often been debated. The article by **Dick Waugh** of NAL in this issue looks into the considerable body of evidence that has already been accumulated on this subject. Dick's article is based on a talk given to the Audio Group of IREE Aust. on 4th May, 1983.

The final instalment of **Bob Harris's** paper on digital techniques introduces some novel methods of analysis such as MESA and MIMO. The rapid expansion and development of digital technology is clear from an inspection of the facilities now provided on each new spectrum analyser that is announced. One aspect of the art that has so far been reserved for the human operator is that of interpretation of the results of measurement but even that could be under attack before we are too much older if the possibilities of artificial intelligence are realised.

The quaint object on the cover is an antero-lateral view of the right bony labyrinth of the ear, derived from an illustration in M. L. Barr, The Human Nervous System.

We have been pleased to receive the first issue of the new Chinese Journal of Acoustics published in England by the Acoustical Society of China. This is one of many publications we are now receiving from acoustical societies and other organisations as a result of arrangements made by the Australian Acoustical Society for exchange of information. All publications received in this way will be acknowledged in the Bulletin and then placed in the Society's library which is located in the library of the National Acoustic Laboratories, Sydney. Members are encouraged to consult or borrow books and periodicals from this collection by contacting the Librarian at NAL.

From time to time we hope to print a group of reports from a particular state or institution to give members an opportunity to learn more about the wide range of acoustical activities being pursued in various nooks and crannies around Australia. We will not attempt to assemble a comprehensive catalogue of activities since this is already being prepared periodically by the Australian Academy of Science (the last such listing was published in 1981). Rather we prefer to present a number of sample reports containing a reasonable amount of detail. The first set in this series, dealing with Victorian activities, has been assembled by **Jim Fowler,** Convenor, Victorian Bulletin Reporting Sub-committee, and includes reports prepared by Ian Taylor, Ian Lane and Robin Alfredson published in this issue.

HOWARD POLLARD

COUNCIL of the AUSTRALIAN ACOUSTICAL SOCIETY

Correspondence on NATIONAL matters should be addressed to: The General Secretary, Australian Acoustical Society, Science Centre, 35 Clarence Street, Sydney, N.S.W. 2000.

Correspondence on REGIONAL matters should be addressed to the appropriate Division Secretary.

Divisional Committees

Address correspondence to: L. C. Kenna, 310A Bobbin Head Road, North Turramurra, N.S.W. 2074.

Address correspondence to: J. H. Watson, c/- Carr Acoustic Group Pty. Ltd., 444 Burwood Road, Hawthorn, Vic. 3122.

Address correspondence to: Dr. A. D. Jones, c/- Hills Industries Ltd., P.O. Box 78, Clarence Gardens, S.A. 5039.

Address correspondence to: Dr. M. P. Norton, c/- Department of Mechanical Engineering, University of W.A., Nedlands, W.A. 6009.

INFORMATION for CONTRIBUTORS

Articles for publication in the Bulletin may be of two types:

(a) Short articles which will appear as a Report or Technical Note;

(b) Long articles which may take the form of a discussion, review, tutorial or technical paper. A referee's report will be sought for the latter

Forthcoming closing dates for the receipt of these articles are as follows:

Vol. 11, No. 3 — Long articles: September 16
Short articles: October 31

Vol. 12, No. 1 — Long articles: January 13
Short articles: February 29

Contributions should be sent directly to the Chief Editor. Manuscripts should be typed with double spacing and should have ample side margins.

Articles should include a title, author's name, address and organisation (if applicable), and, in the case of long articles, be accompanied by an abstract of approximately 200 words.

The *body of the text* should be divided into numbered sections and preferably contain frequent subheadings, which greatly assist the reader in following the development of the paper. Any standard system of referencing is acceptable.

To assist the printer, footnotes should be avoided. Instead, place additional material in brackets or include in reference section. Equations, tables and figures should be numbered sequentially. A list of captions for figures should be supplied on a separate sheet. It is recommended that captions give a complete explanation for each figure, thus obviating the need to refer to the text for identifying details.

Drawings and **photographs** may be prepared to any convenient size and will normally be reduced proportionally to single column width. Authors are requested to plan the proportions of diagrams so that they will fit preferably into a single column width. Drawings may be supplied with or without lettering. If lettering is added, please allow for the proportional reduction in size and thickness that will be necessary. In general, typed lettering is unsatisfactory.

Reprints of papers may be ordered at cost prior to publication by request to the Chief Editor.

Advertising information may be obtained from Mrs. Betty Torok on (02) 523 5954.

Australian News

• SOUTH AUSTRALIA

Divisional Notes:

1. The conference at the Weintal Conference Centre, Tanunda, was very successful. More than 60 delegates from S.A. and interstate attended to hear the keynote speaker, Dr. Eric Bender, from Bolt, Beranek and Newman, as well as over a dozen papers. Summaries of the papers are available in book form through the Secretary (Dr. Adrian Jones, C/- Hills Industries, P.O. Box 78, Clarence Gardens 5039).
2. The committee has produced a letterhead logo for all our divisional correspondence.
3. The committee is currently developing and printing the membership certificate which will be issued by federal council to all members.

Divisional Meetings — 1983:

The programme for this year is as follows:

April 20	— "The Acoustics of Studio Control Rooms at the A.B.C." (Peter Swift).
May 17 or 24	— "Aural perception of phase anomalies — or demonstrating the improved perception of sound in speaker design" (John Dunlavy — Joint meeting with the Australian Audio Engineering Society).
June 15	— "Aspects of Future Noise Control and Legislation for S.A." (John Lambert).
August 17	— To be advised.
October 19	— "The philosophy and design of pianos — or From Clavichord to the Modern Concert Grand" (Lucien Parent).

— Social meeting to be advised. November

Technical Meeting:

20 April 1983

At the April meeting, **Peter Swift** explained the principles of achieving a "dead" room by balancing the low and high frequency absorption on the surfaces, the design of the absorption surfaces, the significance of "sound colouring" if normal room modes are not taken into account and the anomalies which arose from using the Sabine calculation of reverberation time instead of the Eyring-Norris method. Members were able to examine rooms before and after treatment for a practical demonstration of the design.

BOB WILLIAMSON

• NEW SOUTH WALES

Technical Meeting:

1 June 1983 —

A technical meeting of the N.S.W. Division was held on the evening of Wednesday, 1st June, at the Auditorium of the Institution of Engineers, Australia. The meeting was concerned with **environmental noise assessment** and was jointly organised by the AAS and the Noise and Vibration Panel of the IE Aust. It took the form of a panel discussion, and followed a formal seminar on the topic which the IE Aust. had conducted during the afternoon.

The meeting was chaired by *Meredith Rogers*, and the panel members were *Anita Lawrence, Norm Parris, Tony Hewett* and *Louis Challis*.

While there were a few questions from the audience concerning the relationship between sound levels assessed using the methods described in AS 1055 and the subjective reactions of people, most of the discussion centred on the roles of the Victorian EPA and the New South Wales SPCC in solving community noise problems. On the subject of enforcement of the noise regulations, both bodies are satisfied with the rate of resolution of noise complaints using persuasion rather than legal powers. It also appears that the quickest way to obtain action on a complaint is to write to the Minister.

About thirty people were present, with perhaps half being members of the Society. The evening roll-up was a little disappointing, with only three arriving who had not been at the seminar. The IE Aust. provided light refreshments for those arriving for the evening meeting, but although they tried valiantly, the three members had to leave a large quantity of food untouched.

LEIGH KENNA

Technical Meeting Programme:

17 August

A.G.M. and "Blasting Criteria"
6.00 p.m. - 8.30 p.m.
S.P.C.C. Conference Room — Barry Murray, Brian Scrivenor and John Mazlin to lead discussion.

26 October

"The Social Effects of Deafness"
6.00 p.m. - 8.30 p.m.
S.P.C.C. Conference Room.
Speaker from the Australian Deafness Council.

Mid November

"Sydney Town Hall Organ"
6.00 p.m. - 7.30 p.m.
A combined technical meeting and social function.
Robert Ampt, City Organist, will conduct a tour through the recently restored organ and will play a short demonstration programme. Afterwards, an end-of-year dinner will be arranged for members, families and friends.

TONY HEWITT

• WESTERN AUSTRALIA

Divisional Notes

Dr. **Valerie Alder,** Department of Ophthalmology, University of Western Australia, was granted six months' study leave by the National Health and Medical Research Council to work in the Max Planck Institute fur Hirnforschung in Frankfurt, West Germany, between the months of September 1982 and February 1983. Her stay in Europe had two purposes; one, to learn the techniques for iontophoretic deposition of biochemicals onto specific retinal regions; and the other was to learn the technique of isolated eye perfusion. Both these techniques will be used to further the progress of Dr. Alder's research project: "Microelectrode recording techniques in the analysis of retinal disease". In addition during her time away she visited other relevant research laboratories in Switzerland, France, Germany, the Netherlands and the U.K.

A paper detailing the work carried out in Frankfurt has been accepted for publication by the journal "Brain Research".

Dr. **Derek Caruthers** has recently returned from study leave which included a tour of European concert halls and attendance at the Conference of the European Federation of Acoustical Societies, which was held as a joint meeting with the German Acoustical Society in Gottingent in September 1982. He subsequently spent four months working at the School of Architecture in Cambridge, where Dr. Michael Barron is undertaking an objective study of the acoustics of concert halls and theatres, mainly in the United Kingdom.

The techniques used in this project, which is sponsored by the SERC, are different, depending on the function of the hall. For concert halls, measurements are made of the *early energy fraction*; that is the ratio of energy received at a test seat in the first 50 ms, to the overall energy; and the proportion of *lateral energy*, which is felt to be important for a source of "spaciousness". In theatres, measurement is also made of the *modulation transfer function* after methods developed in the Netherland by Houtgart and Steeneken. Houtgart has shown that a measure of modulation transfer correlates well with the intelligibility of speech. In this technique, white noise modulated at speech syllable repetition rates is propagated into the hall and the depth of modulation measured.

In opera houses, all techniques are used and in addition, measurements are made with the source in the orchestra pit.

Among the halls tested during Dr. Caruthers' visit to Cambridge were the Queen Elizabeth Hall; Festival Theatre, Chichester; the Maltings at Snape; the Octagon in Reading and the Royal Opera House, Covent Garden.

The results are to be used in conjunction with subjective assessment of the halls by normal audiences.

The Cambridge Group is also concerned with 1/50th scale modelling and Dr. Caruthers was involved in the model testing of a new auditorium for Hong Kong.

MICHAEL NORTON

• VICTORIA

Technical Meetings

16 March 1983

On the 16 March members of the Division had the opportunity to visit the officers and laboratories of the Audiological Department of the **National Acoustics Laboratory in Melbourne.** The Department's stated main role is the selection and fitting of hearing aids for children and pensioners.

Mrs. **Glenda Alder,** the Acting Assistant Director for Audiological Services, began the evening with an informal and informative talk on the procedures used in assessing hearing impairment, the selection of the aid and the assessment of the fitted aid for possible "fine tuning". Mrs. Adler described several problems encountered by persons with hearing loss, for example, recruitment, which is the reduced range in level between audability and discomfort, and also the loss of high frequency hearing which exacerbates the problem of masking by the low frequencies.

After the talk, members were divided into several small groups. **Hector Hart,** Senior Technical Officer for the Department, demonstrated the N.A.L. designed semi-automatic equipment which enabled the frequency response and power limitation of a particular aid to be checked. **John Galt** and Mrs. **Alder** demonstrated the audiometric booths normally used for the assessment of hearing loss in adults. **Vivienne Matheson** demonstrated the way impressions are made and explained how slight changes in the shape of the plug between the aid and the ear canal can be used to modify the overall frequency response. **Elizabeth Rofe** demonstrated the large booth for the assessment of children. Elizabeth also gave us some insight into the problems of assessing the hearing loss in children and in particular those who may also have full or partial blindness.

7 June 1983

A visit was made to Radio Australia's new complex in Burwood East on the evening of the 7 June. The complex, the largest of its type in the southern hemisphere, has been operating for about six months and is the source of the Australian Broadcasting Corporation's international short wave service.

Radio Australia Centre, as it is known, is built on three levels. The studios are on levels 2 and 3 in the centre of the building and provide a direct link to the two wings. Each studio has an external outlook or an overview of the main foyer. There are five production studios, each with its own adjacent control room, six announcer booths and two news reading booths.

The floors in the building are 250 mm concrete slab floors. Construction of the walls between studios is lightweight but quite sufficient for the purposes for which they were designed. A feature of this design is the demountable absorption panels which not only allow the acoustic character of the studios to be adjusted for a particular purpose, but also enables future electrical services to be easily and neatly installed. All studios have carpeted floating floors. The studio doors have been fitted with rising butt hinges and the frames incorporate "refrigeration door" type seals. The doors do not require locks or other hardware to ensure an adequate seal. The acoustic design work for the complex was done by Louis Challis and Associates Pty. Ltd.

Other technical facilities viewed were the cartridge/tape preparation room, for dubbing and multiple copying, and the computerized master switch room. This room controls the switching of all programme lines between studios before each programme is sent to the transmitting stations at Shepparton, Carnarvon and Lyndhurst.

Our thanks to J. McNeish, J. Nerg and P. O'Neill of Radio Australia.

JIM FOWLER

• AUSTRALIAN ACOUSTICAL SOCIETY ANNUAL CONFERENCE

The Economics of Noise Control
Tanunda, S.A., 24-28 February, 1983

About 80 delegates attended this Conference in the Barossa Valley, timed for one week after the bushfires and one week before the floods! The Conference was opened by the Hon. **Anne Levy,** MLC, and the keynote speaker was Dr. **Erich Bender** from Bolt, Beranek & Newman, Boston, whose topic was the Economics of Controlling Noise at the Source. He concluded that it is more cost effective to control noise at the source for new equipment than to retrofit. However, not all manufacturers or users benefit from noise control and in cases where it is chiefly the public that benefits public investments in noise control R & D through government-sponsored programmes is the most promising approach.

Sixteen other papers were presented dealing with such diverse matters as noise control in the steel industry; the viewpoint of Unions whose members work in noisy industries; the economics of noise control in an oil refinery; the benefits of noise control for quality of life; noise reduction inside passenger cars; energy conservation versus noise control in mechanical services; the community cost of noise control; product development as a way to reduce noise control costs; sound power modelling for major complexes; vegetation — attenuation for the birds?; local government noise control schemes as a cost-effective approach to noise control; the cost of noise in residential areas; costs of traffic noise abatement; economical control of motor vehicle noise by tyre and tread design; traffic noise reduction of facades containing windows and a consultant's approach to solving noise problems.

The South Australia Division is to be congratulated in organising a very interesting and successful Conference — the choice of an out-of-town venue worked very well — the only complaints were the lack of time to be able to actually sample the delights of the Barossa Valley (although few who were not there will probably believe this!).

The Proceedings are available through the South Australia Division.

ANITA LAWRENCE

• CHANGE OF NAME

Would all who wish to communicate in writing with Graeme Harding (of PEOPLE fame) please note that his company is NO LONGER Knowland Harding Fitzell Pty. Ltd. but is now **Graeme E. Harding & Associates Pty. Ltd., 22a Liddiard Street, HAWTHORN, VIC. 3122, Tel. (03) 819 4522.**

(Ed. We understand that this particularly applies to the editorial team!)

We have been advised that **Ron Carr & Company Pty. Ltd.** have moved their office to the 9th Floor, 60 Albert Road, South Melbourne. New telephone: 690 8933. Telex No.: AA 32071.

• PSYCHOLOGICAL ACOUSTICS IN AUDIO EDUCATION

A private company, the **Victorian Audio Education Centre** Pty. Ltd., Director **Vyt Karazija,** was formed during 1982 and is located at Richmond, Victoria. It is a sister company to the South Australian Music and Audio Education Centre Pty. Ltd., Director **Peter Brook,** MAAS, which commenced operations during 1978.

The aim of both schools is to provide a background for prospective sound engineers for their industrial apprenticeships in sound reinforcement, the production of sound recordings, film sound tracks and sound for radio and television broadcasting.

A report in "The Bulletin" for April 1979 (Vol. 7, No. 1) described an introductory course in phychological acoustics that was designed by Australian Broadcasting Corporation engineer, **Donald Woolford,** MAAS, and presented by him in collaboration with lecturers from the Sturt College of Advanced Education, Dept. of Communication Disorders.

This S.A. course is still being presented once annually by Mr. Woolford, who has now organised a similar course for the Victoria School. He will continue his involvement by visits from S.A. or forwarding lecture material to cover the music and recording/broadcast aspects.

The new School has been fortunate to obtain the services of Dr. **John Bench,** Head, School of Communication Disorders, Lincoln Institute of Health Sciences, Carlton, Victoria, and his colleagues, **Rick Osborne** and Dr. **Rob Rodegeair,** who will introduce students to the anatomy and physiology of hearing, psychophysics, speech production and perception, hearing measurement and the effects of noise on man.

Practical sessions in the listening room in the production of stereo recordings will be by **Alan Ireson** of the ABC.

The psychoacoustics subject can be studied separate to the Sound Engineering Course and it is considered that the material presented should be useful for practising sound engineers and acousticians.

For information please contact the Schools at 1-3 Gordon Street, Richmond, Vic. 3121, phone (03) 428 1190 or 212 Hindley Street, S.A. 5000, phone (08) 212 5955.

DON WOOLFORD

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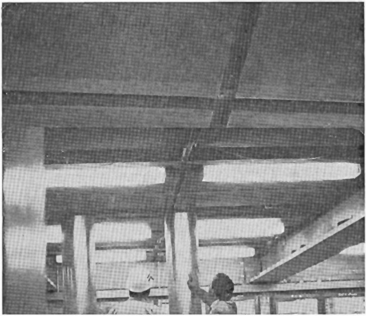

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GRAEME CLARK HONOURED

Graeme Clark is probably very well known amongst our members for his many years of work in deveoping what is popularly called a **bionic ear.** Graeme has addressed the Victoria Division on at least two occasions in the last twenty years describing his work; we are pleased therefore to see that he was honoured in the Queen's New Year Honours and was admitted to the Order of Australia in recognition of his work in developing hearing for the deaf.

* * *

WHY NOISE CONTROL ?

Why do factories get motivated to reduce noise?

Most of us know most of the reasons, but recently **Sound Attenuators** had an enquiry from a factory arising from the installation of a new machine. And was the machine very noisy?; it must have been, because the factory were complaining that since the installation of the new machine they had had to increase the level of the background music. No, they were not complaining about the noise of the machine or the noise of the background music, only that they could not make their background music loud enough to still hear it over the machine without excessive distortion!

I am indebted to John Blackshaw of Sound Attenuators for the above.

* * *

MORRY JEFFERIES LEAVING ACOUSTICS ?

Morry Jefferies is definitely one of the "characters" of acoustics in Australia. Recently your People Columnist has heard rumours, or been fed rumours, that Morry Jefferies is thinking of leaving acoustics and retiring. When Morry had cause to call on our office recently I put these suggestions to him and the answer was no.

Whilst having Morry captive we asked him how things were going with NAP generally, and what we learnt is included in some of the items below.

* * *

NAP-SILENTFLO AMALGAMATION

Noise Abatement Products Pty. Ltd. and BTR Silentflo Pty. Ltd. have amalgamated to form **NAP-Silentflo Pty. Ltd.** The two companies formerly known just as NAP and Diesel Silencer Co. had both earlier become subsidiaries of British Tyre & Rubber; and as they both manufacture noise control equipment it comes as no surprise that they have amalgamated. They have sent to your People Columnist a press release setting out details of their amalgamation and their product range which includes all sorts of noise control devices. For anybody not familiar with their product range I am sure NAP-Silentflo at 21 Browns Road, Clayton, Victoria, or 28 Short Street, Auburn, N.S.W., will be only too happy to provide details.

* * *

TIM MARKS OVERSEAS

Tim Marks from NAP-Silentflo is currently overseas visiting the United Kingdom, France and Germany to learn more about current trends in noise control in those countries.

* * *

NAP SILENCERS FOR THE NEW PARLIAMENT HOUSE

The last bit of information I learnt from Morry Jefferies is that NAP-Silencers have been selected for Areas 4, 5 and 6 of the new Parliament House.

Once again it seems appropriate at this stage to mention to all readers of the People Column that if they have similar bits of information about people and other acoustical doings they should contact the People Columnist as all such bits of information will be gratefully received and may be used in this column.

* * *

RUGGED INSTRUMENT HEY WHAT !

A long time ago when this column was the gossip column we mentioned the difficulties we had had with one of our own instruments malfunctioning and the costs that we had incurred in getting the instrument repaired whilst still under warranty. Whilst we never mentioned the manufacturer's name, he recognised the story as fitting him and made representations to your then Gossip Columnist about what a nasty thing it was to print these stories.

Now that same instrument manufacturer can rejoice!

That very same instrument of ours recently underwent an impact test which it came through with smashing success. More specifically the instrument was dropped from the great height of some 12 metres (or 36 feet in old language) to fall on very hard concrete. One of the batteries from inside the instrument was a write off, the plastic battery holder was a write off, one wire off the battery test push button broke, and the instrument side panels were damaged. In other respects the instrument is operative which is some testimony to its durability; Oh I forgot, there was another 50 cents for a new meter glass.

* * *

ARAM GLORIG TO COME TO AUSTRALIA

Aram Glorig is now about 70 years old, but is still as outspoken as ever. Readers may recall Aram Glorig's previous mention in this column when he made derogatory remarks about Telecom telephonists.

Aram is being brought out to Australia by the Australian Association of Better Hearing and will be in Victoria from September 26 to September 30 and will probably address the Victoria Division at their Annual General Meeting on September 28 or 29.

* * *

Dr. FRANK FAHY FROM I.S.V.R. TO VISIT AUSTRALIA

Dr. F. J. Fahy, who is Senior Lecturer at the Institute of Sound and Vibration Research, University of Southhampton, U.K., has indicated that he is interested in coming to Australia later this year (around October-November) for a period of approximately six weeks. He will spend a portion of this time in the mechanical engineering department at the University of Western Australia, and will give a series of specialist seminars on statistical energy analysis and acoustic intensity measurements as part of a noise control course. Dr. Fahy has had a meteoric rise.

Dr. Fahy has mentioned that he is very keen to visit other Australian Universities and Research Organisations which are currently involved in noise and vibration control, and is prepared to present a series of specialist seminars/short noise control courses at the respective Institutions that extend an invitation to him.

This information comes from **Dr. Michael Norton** from the Department of Mechanical Engineering, University of Western Australia, who will be pleased to hear from any organisations wishing to invite Dr. Fahy or to contribute towards his visit to Australia.

LOUD NOISE . . . THE DEAF OF YOU

Through the sponsorship of the Lions Clubs International Association the **Deafness Foundation (Victoria)** has produced a slide/tape presentation on the health and hearing dangers of noise, especially workshop, factory and machine noise. The kit contains 80 full colour slides with matching commentary on an audio cassette plus teachers handbook and student worksheets aimed at alerting apprentices and students to the risks of noise induced or industrial deafness.

Further information may be obtained from the Hearing Conservation Education in Schools Project, Suite 3, 34 Swan Street, Richmond 3121, phone (03) 428 1526, or kits may be ordered at $40 per kit from the Deafness Foundation (Victoria), 340 Highett Road, Highett, Victoria 3190, phone 555 8816.

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CAROLYN MATHER RESIGNS FROM THE A.A.S.

Some members may remember **Carolyn Mather** as the young girl who gave a paper titled "A study of noise in office buildings" at the Society's International Acoustic Symposium at the Wentworth Hotel in Sydney in 1968. At that stage Carolyn had completed her Bachelor of Architecture and Master of Building Science degrees.

Throughout most of the seventies Carolyn worked for the Public Works Department of Western Australia and it rapidly became apparent that Carolyn was hard working, dedicated and intelligent. Carolyn was active in the Australian Acoustical Society, being Chairman of the Western Australia Division and President of the Society for two years. Carolyn was also very active in the Standards Association of Australia and was the dominant contributor to many standards.

In the latter half of the seventies Carolyn moved to Melbourne to head the Noise Control branch of the Environment Protection Authority. Progressively, however, Carolyn moved from working in acoustics towards working in administration. This was obviously recognised by the Public Service Board, and she is now a full-time member of that board. Recognising that she was no longer working in acoustics, Carolyn ultimately resigned from the Society.

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VIBRATION AND NOISE PANEL NEWSLETTER RE-APPEARS

As the Editorial of the 10th issue of the newsletter of the Vibration and Noise Panel says, it is more than 12 months since the last issue. This issue contains interesting summaries of the following:—

Analysis of aircraft vibration data: this requires measurement of vibration modes frequencies and damping at various aircraft speeds in flight.

Laser induced structural vibration testing: This technique is being developed for exciting transient vibrations in a structure by, using laser beams to vaporise material from targets attached to the structure.

Failure of Liddell 500 MW turbo alternators: An interesting article discussing several theories advanced to explain the cause of failure of three of the four base load 500 MW turbo alternators at Liddell, New South Wales.

Other topics mentioned include the evaluation of silencer performance using short pulsed-noise signals; verification of analytical evaluation of water tower vibration; developments of a procedure for testing the security of screwed fasteners in masonry; and a discussion of progress of various standards committees.

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FRANK WICKHAM RETIRES FROM THE A.A.S.

Frank Wickham, known for years around Australia for his work with the Departments of Construction at Yarra Street, Hawthorn, has retired from the Departments (now the Departments of Housing & Construction) and has in consequence retired from the Australian Acoustical Society.

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BOB RANDALL IN THE U.S.A.

Bob Randall will be known to the members of the Society not only for his many articles in the B & K technical review but also for the books published by B & K, such as "Frequency Analysis". Bob has always maintained his membership of the Australian Acoustical Society and presumably intends one day to return to Australia. We hear from the address on his subscription form that he is currently not in Denmark but in the U.S.A.

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MOBILE EDITORIAL TEAM

Marion Burgess, our Managing Editor, wishes to correct the impression we gave in the last issue that she was in England on study leave. It appears that for "study leave" we must read "long service leave". Actually, Marion went to England to test the efficiency of the medical services. She managed to break a bone in her leg escaping from (correction: walking with) her husband Mike and has been hobbling around in a plaster cast since. She even managed to give a lecture at Surrey University with the aid of two chairs, one for the leg.

Doug Cato of RANRL, who is also our cartoonist, is overseas attending the ICA in Paris where he presented a paper on his theory of the generation of underwater noise by the roughness of the surface. (His theory is similar to the Longuet-Higgins model but predicts an extra 3 dB for the noise level.) Doug also visited the NATO-sponsored SACLANT Anti-Submarine Warfare Centre in La Spezia, Italy (near the Italian Riviera!), to talk about their work in underwater acoustics (he probably took his swimsuit as well).

Dr. **Bill Hunter** has been posted to the position of Councellor, Defence Science at the Australian Embassy in Washington for a period of three years. His position as Director, R.A.N. Research Laboratory will be taken over by Maurice Frost. Bill has also been the Bulletin's consulting editor for underwater and physical acoustics. The latter task will now be undertaken by Dr. **Marshall Hall,** to whom we give a warm welcome to the editorial team. Our best wishes go with Bill and his wife during their long "exile" in the U.S.A.

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KNOWLAND HARDING FITZELL WON'T DIE

It is interesting how hard it is to kill an old name. From Howard Pollard, the Editor of the Bulletin, we receive letters addressed to Knowland Harding Fitzell Pty. Ltd.; from Telecom we receive not just bills for the telephone service addressed to Knowland Harding Fitzell, but even advertisements in the yellow pages.

So once again let all would-be suppliers of information for the People Column send them to me at **Graeme E. Harding & Associates Pty. Ltd., 22a Liddiard Street, Hawthorn, telephone 819 4522.**

GRAEME E. HARDING

INTERNATIONAL NEWS

Chinese Journal of Acoustics

The Acoustical Society of China, with whom we have a publications exchange arrangement, have now started to publish the Chinese Journal of Acoustics in English.

The Editors comment: "The Acoustical Society of China was inaugurated in 1964 and the first volume of Acta Acustica in Chinese was published in the same year. Since then, the Chinese community has grown by many folds and the field of activities enlarged to all branches of acoustics. In 1980, when a large number of acousticians from China took part in the 10th International Congress on Acoustics for the first time, it was deemed important to promote the international understanding and collaboration in the field of acoustics by publishing part of the material in English. This is the raison d'être of the Chinese Journal of Acoustics.

In the Chinese Journal of Acoustics, it will be published the research papers and technical notes on all aspects of acoustics, theoretical or experimental, purely scientific or applied, and acoustical news in China. It is inevitable that most material will be the work done in China, but contributions from guests and friends from abroad are also solicited."

Distribution outside China is being handled by Scientific and Technical Books Service Ltd., P.O. Box 197, LONDON WC2N 4DE, England.

The Contents of Vol. 1, No. 1, July-September 1982, include papers on: Theory of nonlinear interaction of finite amplitude random sound waves; Reflection and refraction of plane sound waves in moving stratified media; Turning-point convergence-zones in underwater sound channels (II) A generalised ray theory; A new method of adaptive array processing for signals of unknown characteristics; Acoustical method for classification of seafloor sediments; Long-range reverberation and bottom scattering strength in shallow water; Analysis of loaded ultrasonic amplitude transformer by means of Mobius transformation; Scattering of BG wave by a groove on the surface of a 6 mm crystal; Study on duration of Chinese consonants; Characteristics of a uniform pipe array and its application to infrasonic reception; FM-evoked responses and FM-tonotopic characteristics in the auditory cortex of the cat; Acoustic properties of rigid closed-cell plastic foams.

Flushing in Concertland

The continuing saga of major problems connected with major concert halls continues in London according to a recent note from Marion Burgess. London newspapers report that: "Just a year after its gala opening, London's £153 million Barbican Centre is about to announce the appointment of a new acoustician to tackle severe and unremitting sound problems in its concert hall." The 2,000 seat hall was designed for large scale musical performances but concerts have been disturbed by intrusive noises, "such as flushing of distant toilets, squeaking descent of bar shutters and the hum of air conditioning".

The London Symphony Orchestra has complained about a "loss of resonance in the bass register when it plays loudly". The acoustic consultant considers the problem is related to "the topology of the seats and their design. The solution could be to replace the seats but that would affect the air conditioning" and may cost a million pounds or more.

Highway Noise Screens

From the CETE (Centre d'Etudes Techniques de l'Equipement) Normandie Centre comes the following request:

"For one of our studies, we are now looking for documents concerning highway noise barriers or screens.

We are particularly interested in the treatment of the diffraction's edge of screen.

We are trying to know the results of construction experiments of noise screens using means able to improve the diffraction's efficiency such as: porch-roof, caps, crenels, absorbent on the top of the wall, etc. . . .

If your association has documents concerning these experiments can you send us some documents?"

If any members can assist, please write to F. Lemariey, C.E.T.E.B.P. 245 BIS-247, 76120 GRAND-QUEVILLY, France.

Polish National Conference

The 30th Open Seminar on Acoustics — Annual National Acoustical Conference will be held in Gdansk, Poland, from Monday, 5th September to Friday, 9th September, 1983. The conference will cover all fields of acoustics. Debates will be held in suitable sections in parallel. For details contact Lech Lipinski, Instytut Telekomunikacji Politechniki Gdanskiej, 80-952 GDANSK, Poland.

INTER-NOISE 84

The Board of Directors of the Institute of Noise Control Engineering (INCE/U.S.A.) has announced that INTER-NOISE 84 will be held in Hawaii on December 03-05 next year. INTER-NOISE 84, the 13th International Conference on Noise Control Engineering, will be sponsored by the International Institute of Noise Control Engineering (I/INCE) and will be organized by INCE/U.S.A. in co-operation with INCE/Japan. More than 500 specialists in noise control are expected to participate at the 1984 meeting which will be devoted to the latest technical developments in this rapidly-expanding field of world-wide importance.

INTER-NOISE 84 will be the first international conference to be jointly organized by two member societies of International INCE. Honolulu was chosen as the site for INTER-NOISE 84 as it is approximately halfway between the West Coast of the U.S.A. and Japan. With the theme "International Co-operation for Noise Control", participation is expected from more than 20 countries in addition to large delegations from the U.S. and Japan.

The three-day conference will be held at the Hotel Ilikai, a complete resort hotel at the end of Waikiki Beach, just a few minutes from Honolulu International Airport with its excellent air connections around the world. The Ilikai was selected for the conference because it offers excellent meeting facilities for INTER-NOISE 84.

A Call for Papers for the conference will be issued next July. In the meantime, additional information may be obtained from the INTER-NOISE 84 Secretariat, P.O. Box 3469, Arlington Branch, Poughkeepsie, N.Y. 12603, U.S.A.

ISVR 20th Anniversary

The Institute of Sound and Vibration Research, University of Southampton, celebrated its 20th birthday in June 1983. Many members of the Australian Acoustical Society have had the pleasure of working at ISVR over the years and would like to extend their congratulations and best wishes for the future to all the staff of the Institute including, especially, **Dr. R. G. White,** the new Director of ISVR.

Future Events

AUSTRALIA

1983

August 29-30, SYDNEY
Applied Fourier Analysis Course
University of New South Wales
Details: Dr. John Fenton, Fourier Analysis 1983, School of Mathematics, University of N.S.W., KENSINGTON, N.S.W. 2033.

August 31-September 2, SYDNEY
Fourier Techniques and Applications Conference
University of New South Wales
Details: Dr. John Fenton, Fourier Analysis 1983, School of Mathematics, University of N.S.W., KENSINGTON, N.S.W. 2033.

October 19, ADELAIDE
South Australia Division meeting
"The philosophy and design of pianos — or From clavichord to the modern concert grand".
Lucien Parent

October 26, SYDNEY
New South Wales Division meeting
"The social effects of deafness"
SPCC Conference Room.
Speaker from the Australian Deafness Council

November, SYDNEY
New South Wales Division meeting and Annual Dinner
"Sydney Town Hall Organ".
Robert Ampt, Sydney City Organist

INTERNATIONAL

1983

September 4-7, LONDON
4th Conference of the British Society of Audiology.
Details: above society, M. C. Martin, The Secretary, 105 Gower Street, LONDON WC1E 6AH.

September 5-9, GDANSK
Annual National Acoustical Conference, Polish Acoustical Society
Details: Dr. Lech Lipinski, Instytut Telekomunikacji Politechniki Gdanskiej, 80-952 GDANSK, POLAND.

October, HIGH TATRA, CZECHOSLOVAKIA
22nd Acoustical Conference on Electroacoustics and Signal Processing.
Preliminary Information: Acoustical Commission of Czechosl. Academy of Science, Secr. Dr. I. Januska, Provaznicka 8, 11000 PRAGUE 1.

November 7-11, SAN DIEGO
Meeting of the Acoustical Society of America.
Chairman: Robert S. Gales, Code 5152, Naval Ocean Systems Centre, SAN DIEGO, CALIFORNIA 92152.

1984

May 7-11, NORFOLK, VIRGINIA
Meeting of the Acoustical Society of America.
Chairman: Harvey H. Hubbard, Acoustics and Noise Reduction Div., NASA Langley Research Center, Langley Station, Mail Stop 462, HAMPTON, VIRGINIA 23665.

August 21-24, SANDEFJORD, NORWAY
FASE 84 — 4th Congress of the Federation of Acoustical Societies of Europe.
Secretariat: FASE 84, Secr. Gen. J. Tro, ELAB, N-7034 TRONDHEIM-NTH, NORWAY.

October 8-12, MINNEAPOLIS
Meeting of the Acoustical Society of America.
Chairman: W. Dixon Ward, Hearing Research Laboratory, University of Minnesota, 2630 University Ave., S.E. MINNEAPOLIS, MINNESOTA 55414.

October, HIGH TATRA, CZECHOSLOVAKIA
23rd Acoustical Conference on Speech and Music in Environment.
Secretariat: House of Technology, Ing. L. Goralikova, Skultetyho Street, 881 30 BRATISLAVA.

December 3-5, HONOLULU
INTER-NOISE 84
Organised by INCE/U.S.A. in co-operation with INCE/Japan. Secretariat: P.O. Box 3469, Arlington Branch, Poughkeepsie, N.Y. 12603, U.S.A.

How Much Hearing Damage Does Loud Music Cause?

Dick Waugh
National Acoustic Laboratories
5 Hickson Road, Millers Point, N.S.W. 2000

ABSTRACT: Much of the popular press and some of the scientific literature lead one to believe that there must be an epidemic of hearing damage among rock music listeners and musicians. Yet in line with several overseas studies a recent National Acoustic Laboratories survey of nearly 1000 young Sydney people failed to find evidence of such an epidemic. The NAL and overseas research findings and the discrepancy between expectations and evidence are discussed. It is argued that when objectively interpreted, sound level measurements at discos and similar venues do not imply an epidemic of the magnitude predicted by some earlier writers and are thus consistent with the findings of the hearing surveys. While there is a small risk of hearing damage among listeners and a larger one among musicians and ancillary staff, other recreational (e.g. gunfire) and especially occupational exposures pose far greater threats.

1. INTRODUCTION

When high degrees of amplification became established in popular music in the 1960's it was only natural that questions about the possible auditory hazards of this new trend should be raised. Sound pressure levels (SPLs) at discos and concerts of 110, 115 and even 120 dB were reported (16) and the popular press soon picked up the story. A certain amount of sensationalism occurred. Headlines such as these: TEENERS RISK POP CONCERT DEAFNESS, LOUD MUSIC HURTS HEARING, DISCOS ARE HEALTH HAZARD, BANDS LOUDER THAN A CHAIN SAW and ROCK AND POP CAN CAUSE YOU PHYSICAL DAMAGE, though drawn from newspapers of the last few years, convey the tone of most newspaper accounts of the dangers of loud music.

A fundamental point overlooked in nearly all such reports is that, except at extremely high SPLs, noise level alone is no guide to the hazardousness of sound. Exposure duration must also be taken into account. For example, A-weighted energy (the product of A-weighted intensity and exposure duration) is commonly regarded as the best simple guide to the auditory dangers of noise; indeed this principle is currently built into all Australian hearing conservation regulations. Thus the regulatons permit a daily occupational noise exposure to 90 dB(A) for 8 hours but the level may be increased to 93 dB(A) if the duration is halved. Other countries have adopted different intensity/duration "trading relationships" (in the USA the level may be increased 5 dB(A) per halving of duration) but the obvious importance of exposure duration in determining the degree of hazard means that the idea that amplified music is harmful just because it is so loud is simplistic.

In any case the acid test is whether evidence of hearing damage can be found in people exposed to loud music. In the last 15 years many studies have been addressed to this question. In discussing them I will deal separately with those concerned with audiences and musicians.

2. AUDIENCES

One of the first studies attempting to link amplified music with hearing loss in young people was reported by Lipscomb (17) in 1969, just as the number of loud music events began to escalate. Because of its timing and apparently dramatic findings this study influenced opinion for a considerable time.

Lipscomb first noted that the incidence of high frequency hearing impairment (typical of noise induced hearing loss) in a sample of 3000 Tennessee schoolchildren rose from 4% at age 12 to 11% at ages 15-18. As the sample was not screened these results must have included components of inherited and disease-caused, as well as all kinds of noise induced, hearing loss. Nonetheless, Lipscomb's discussion focussed on constant exposure to "high intensity rock and roll music . . . as a possible contributing factor in the rising incidence of high frequency hearing impairment". He made only passing reference to other noise sources, even though two years previously a similar study had provided clear evidence relating high frequency impairment in 1000 Colorado schoolchildren to shooting, noisy farm machinery and other causes in that order of importance (29). Subsequent studies of American rural schoolchildren have shown that at least 25% of young males can be expected to have high frequency losses resulting from shooting (15). In passing, it is noted that a much smaller incidence (2.3%) of high frequency impairment was observed in a recent study of 14391 Swedish schoolchildren (23). About two-thirds of these impairments could be traced to noise and the authors reported that the *"most important noise causes were in the following order: motor vehicles, including tractors, firearms and crackers. In a small number, loud music could have been the cause of the 4kHz dip".*

The foregoing studies were concerned only with schoolchildren but Lipscomb (17) subsequently measured the hearing of the 1968 and 1969 freshman intakes at the University of Tennessee. Again subjects were not screened for other pathologies, though they were questioned about their noise exposures. The key result was that 29% of the 1968 intake and a startling 55% of the 1969 intake failed a 15 dB hearing level screening test at 6000 Hz. When hearing levels were related to noise exposure, however, the only significant relationship was with exposure to gunfire. Despite this, a single case study of a young rock musician with a high frequency hearing notch was presented and discussed in detail, reinforcing the impression given by the title of the article — "Ear Damage From Rock and Roll Music".

Because Lipscomb's studies were among the first in this area and were done under the auspices of a University Audiology Department — and perhaps because they produced the sorts of results people expected — they were then and subsequently widely quoted in support of claims about the auditory dangers of rock music. Interestingly, another study done at about the same time provided no support at all for such claims. Rintelmann and Smitley (20) determined the incidence of hearing impairment in two groups of students, those who listened frequently to live rock and roll music (estimated average 5 hours per week) and those who seldom did (estimated average 41 minutes per week). The subjects were screened for hereditary factors and other noise exposure. There were 30 males and 30 females in each group. The results showed that there were fewer cases of hearing impairment amongst the frequent listeners, quite contrary to the expectations aroused by Lipscomb's studies. Since they may have prompted a more critical appraisal of the available evidence it is unfortunate that the results of the Rintelmann and Smitley study were not published until 1977 (20).

In the United Kingdom a number of studies of disco attenders have been carried out by Fearn of the Department of Architectural Studies at Leeds Polytechnic. First, Fearn (9) found that, in a group of highly screened 18-25 year old students, those who attended discos had poorer hearing levels than those who did not. The differences were small, however, averaging 2.4 dB across the 0.5 to 8 kHz frequency range, and showed no sign of the high frequency notch typical of noise induced hearing losses. Nor, on further analysis, was any systematic relationship found between hearing level and frequency of attendance (10).

In more recent studies (11, 12) Fearn has looked at the 9-16 year old age group, again comparing attenders with non-attenders. The results were similar to those for the older age groups. At all frequencies the attenders had poorer mean hearing levels by an average of about 2 dB, but again there was no sign of the classical noise induced high frequency notch and no progression of the loss with age (and hence number of disco attendances). Retested about a year later, both groups showed better mean hearing levels, the non-attenders more so than the attenders, and there were 7 as against 3 subjects out of a total of 153 whose hearing declined by more than 5 dB over the year (12).

Generally, the effects reported by Fearn have been small, of an audiometric pattern unlike that generally associated with noise induced hearing loss and apparently uncorrelated with degree of exposure.

The most recent relevant study was conducted in Sydney under the direction of Carter of the National Acoustic Laboratories (5) as part of a general survey of the effects of environmental, recreational and occupational noise on the hearing of young people. It involved a sample of nearly 1000 under-21 year olds and was conducted with meticulous attention to standards of medical examination, determination of medical, hereditary and noise exposure histories, tympanometry and audiometry. Many of the subjects, of course, had attended discos, concerts and other loud music events. Nonetheless group hearing levels differed very little from internationally standardised values of normal hearing. Statistical analysis of the data revealed a weak connection between attendance at loud music events and hearing level, but only in one ear and only at 2, 6 and 8 kHz. Again, this pattern is not typical of noise induced hearing loss which, in group data, is usually more marked at 3, 4 and 6 than at 2 or 8 kHz.

3. EVIDENCE AND EXPECTATIONS

While amplified music unquestionably has the potential to cause hearing loss in susceptible individuals, the studies just described show that it has not caused the epidemic feared by earlier writers. There is thus a conflict between the survey evidence and the common belief that amplified music must be ruining the hearing of the younger generation.

How has this conflict come about? It seems most unlikely that the basic sound level measurements made by many investigators at many venues could have consistently over-estimated the levels that actually existed. It is even more unlikely that audiological investigators have consistently measured hearing levels better than those that actually existed in the exposed populations. If our expectations are incorrect, therefore, it seems that *the fault must lie in the chain of reasoning by which we proceed from noise measurements to expected hearing loss.*

I would like to illustrate some potential sources of error in such reasoning by working through a typical newspaper report about the hazards of rock music. My reason for referring to a newspaper article is simply that many more people — scientists probably included — read such articles than read the scientific literature on noise induced hearing loss. Prevailing beliefs in the community therefore tend to be based on popular accounts and it is useful to direct attention to their shortcomings, especially as these do not appear to have been discussed elsewhere.

Consider, then, an article headed ROCK BANDS ARE BLASTING AT DEAFENING LEVELS which appeared in the Sydney Sun-Herald in February, 1981 (13). This article is fairly typical of most newspaper accounts of the rock music hazard at the time; indeed it is more specific than most in that it attempts to relate actual noise measurements to official industrial hearing conservation regulations. The following statements are made in the article: "A Sun-Herald survey has found that many Sydney rock bands are playing much more loudly than danger levels recommended by the Health Commission ... The Sun-Herald took a sound level meter to measure the decibels at some popular night spots ... At Kings Cross Manzil Room a punk band ... was playing an average of 106 decibels with the needle swinging as high as 107 ... At The Rocks another punk band ranged between 100 and 112 ... A more sedate band at the Basement registered a pleasant 84 to 93 decibel reading ... A band at another hotel ranged from 90 to 104 decibels and another at Woollahra ranged between 100 and 108 with an average of 104".

The article points out that these levels are well in excess of industrial noise exposure limits but acknowledges that the latter are applicable to long term daily exposure rather than the intermittent pattern characteristic of rock music exposure. However — and this is the crucial point — the article does not attempt to quantify the difference this might make to the effective noise exposure of disco patrons and the reader is left with the strong impression that amplified music is quite dangerous. This impression is, of course, strongly reinforced by the heading of the article.

As a working figure on which to base a critical appraisal of this article, let us take a round number of 110 dB, just under the maximum level (112 dB) measured in the Sun-Herald survey, and consider the following points:

Weighting

The article does not say if the reported sound levels are weighted or unweighted decibel values. It is important to know this, however, since noise hazard is assessed on the basis of A-weighted rather than unweighted SPLs and the frequency spectrum of rock music is such that A-weighted sound levels are, on average, 2 to 6 decibels less than unweighted ones (20, 30). An unweighted measurement of 110 dB would therefore represent 104-108 dB(A). For the sake of the argument, however, let us give the Sun-Herald the benefit of the doubt and assume their measurements were made in dB(A). We are therefore considering a noise level of 110 dB(A) (though we might note that 104 dB(A) is the average live music level reported in major UK (30) and USA (20) studies).

Type of Reading

It is apparent from the article that a sound level meter with a conventional needle-and-scale meter movement was used for the measurements. From the range of values reported in the article and from the relations between the average and peak values noted by the reporter, our working value of 110 dB(A) could reasonably be said to be an "average of peaks" reading. According to Whittle and Robinson (30) the Leq value of music is typically about 3 dB less than "average of peak" meter readings, so the Leq value of our hypothetical band would therefore be 107 dB(A). Leq stands for equivalent continuous sound level and is a measure used to denote the magnitude of a sound that varies in level over time. It is equal to that steady or continuous sound level that would, in the course of the measurement period, cause the same sound energy to be received as that due to the actual, varying, sound. A-weighted Leq (Leq.A) is now the most commonly used measure of noise level for the purpose of hearing risk assessment.

Leq.A, but over what period?

Measurements of noise level alone, however, are not enough. As argued above, to evalute the hazard of a noise exposure we must also take account of its duration. In the course of an evening's performance a band usually has a few rest periods, typically it seems (3) at the rate of about one 15 minute rest period per hour. In a 4 hour session, therefore, the band actually plays for only about 3 hours. Returning to our example, if the Leq.A for the time the band is actually playing is 107 dB(A), the Leq.A for the total 4-hour session, designated Leq.A.4, will equal 107 + 10 log 3/4, which is just under 106 dB(A). This would be the equivalent continuous sound level experienced by a patron attending for a full 4-hour session.

The 40 hour week

If we are going to use industrial noise criteria to assess the hazard of rock music exposure, we have to think in terms of equivalent exposure over a 40-hour work week, because that is what industrial criteria are based on. We are assuming attendance for one 4-hour session per week (actual attendance averages 3½ to 4½ hours per week (2, 3) so this is a reasonable value); this is exactly one tenth of a 40-hour work week and so in energy terms represents a factor of 10 dB. The Leq.A.4 value of 106 dB(A) that we calculated in the preceding section therefore represents a noise dose equivalent to that received by someone working in 96 dB(A) for a 40-hour week. This is by no means a safe exposure but it is far removed from the horrendous sounding value of 110 dB we began with.

3 dB or 5 dB rule?

In the previous sections I used the equal energy or 3 dB rule to adjust Leq.A for quiet intervals in live band performances and to reduce once-weekly exposures to the common basis of a 40-hour week. This rule is built into Australian, European and ISO hearing conservation standards.

In the USA, on the other hand, a 5 dB rule is used because it is believed that the equal energy rule overestimates the hazard of intermittent noise exposures. This belief is based on evidence from laboratory studies of temporary hearing losses induced by intermittent noise exposures and field studies of permanent noise induced hearing losses in forestry workers and miners, both of whose cut-and-clear work patterns entail intermittent noise exposure. In all these cases smaller hearing losses occur than would be expected on the basis of predictions made using the equal energy rule. The general rationale of the more liberal 5 dB rule is that the rest periods sandwiched between intermittent exposures give the ears extra opportunities to recover between bursts.

If the 5 dB rule is, in fact, the more appropriate one to use for intermittent exposures the Leq.A.4 in our example would be 105-16.6 log 10, i.e. just over 88 dB(A). Given that we have been considering a louder than average live performance and that recorded music levels in public entertainment venues are up to 13 dB(A) lower than those for live music (30) it may not be so surprising that *surveys have failed to show a major epidemic of rock induced hearing loss among young people.*

4. NOISE MEASUREMENTS AND RISK ESTIMATES

This conclusion is consistent with the results of several scientific appraisals of noise exposure at loud music events. In 1973 Whittle and Robinon (30) reviewed the 38 papers published to that time that reported measurements of sound levels at such events. Combining the data from these reports they calculated that typical Leq.A.4 values received by the audience were 101 dB(A) for live music and 88 dB(A) for recorded music. Assuming once-weekly attendance these values represent Leq.A.40 exposures of 91 and 78 dB(A) respectively (84 and 71 on the 5 dB rule).

Using predictive equations derived from Burns and Robinson's (4) study of industrial noise induced hearing loss, they estimated that after 8 years of once-weekly attendance at live performances a person of average susceptibility would show a notch of 8.7 dB at 4000 Hz, still well within the "normal" range of hearing levels (up to 20 dB). A highly (5th percentile) susceptible person, however, would be expected to exhibit a 33 dB notch at 4 kHz, and such a person whose number of attendances was a standard deviation above the average would suffer a 43 dB notch.

These predictions underline a point that is worth stressing: *while most casual disco attenders probably run little risk of hearing damage a few are likely to suffer significant impairment.* As there is no way of predicting susceptibility until actual damage occurs, anyone who experiences dull or distorted hearing or ringing in the ears after exposure to disco (or any other) noise would be prudent to consider avoiding or limiting future exposures.

The same point emerges from other studies. In 1980 Cooper (7) reported a sound level survey of 37 Sydney venues where loud music was played. He observed that average Leq.A values varied, depending on the age range of the clientele, from 86 to 109 dB(A) for live music and from 82 to 100 dB(a) for recorded music. These data were subsequently converted to Leq.A.40 estimates by Macrae (18), who showed that they were equal to 40-hour per week exposures of 80 to 95 dB(A) for live music and 78 to 87 dB(A) for recorded music. Again, however, these are average values and the data imply less comforting prospects for the highly exposed or unusually vulnerable ear. For example Cooper noted Leq.A values as high as 112 dB(A) for live and 108 dB(A) for recorded music and Macrae calculated that susceptible ears could not tolerate a once-weekly Leq.A.4 of more than 88 dB(A) without damage.

Lastly, in a recent UK survey involving 4166 interviews on patrons' attendance patterns, and a sound level and dosemeter survey of 49 discos, Bickerdike and Gregory (2) reported a median audience Leq.A.4 of 97 dB(A) and thus an equivalent weekly exposure (Leq.A.40) of 87 dB(A). Using the Burns and Robinson predictive equations mentioned above they calculated that 0.025% of an estimated 6 million regular disco attenders (i.e. 1500 people) would sustain a 30 dB average hearing loss at 1, 2 and 3 kHz at the end of their attendance period. While the number of those affected is relatively small, this degree of loss entails a significant difficulty in the understanding of speech in the minority of disco attenders unfortunate enough to have susceptible ears.

Overall, these three surveys show a range of Leq.A.40 values of 80-95 dB(A) for live music and 78-87 dB(A) for recorded music and imply a small, though for the affected individuals significant, degree of hearing damage risk in rock music fans. A few provisos need to be kept in mind however. The derivation of the Leq.A.40 values and the risk estimates from the initial sound level measurements has been based on the 3 dB rule. If the 5 dB rule had been used the values would have been considerably smaller, varying from slightly below to well below currently permissible industrial noise exposure limits with corresponding reductions in risk. Evaluating such exposures by comparison with industrial criteria also presupposes regular once-weekly attendance for 10 years or more. In the only survey that has provided data on this point, Bickerdike and Gregory (2) found that the median attendance duration was about 7 years. For this reason too, therefore, the overall risk may be somewhat less than has been estimated. On the other hand the risk estimates are for loud music exposure alone and do not take account of occupational or other recreational noise exposures. Such additional exposures are cumulative in their effects and imply a greater degree of risk in individuals who combine them with loud music exposure.

As far as listeners are concerned, what is really needed now is a study of the late 20's — early 30's age group to determine the incidence of hearing impairment in people who have had many years exposure to loud music. Such a study is being planned by the National Acoustic Laboratories, again under the direction of Norman Carter.

5. MUSICIANS

If audiences show less sign of hearing damage than might have been expected, what of musicians? Several studies addressed to this question were undertaken in the USA in the late 60's and early 70's. In this area the surveys have yielded more concrete evidence.

Rintelmann and Borus (21) compared the hearing of 42 young musicians with that of 10 non-noise exposed controls. On average the musicians had been playing music at approximately 105 dB SPL for about 11 hours a week for 3 years. All 10 members of the control group and 40 of the 42 musicians had normal hearing. One of the musicians had a bilateral 4 kHz notch to 40 dB, the other had a high frequency roll-off to 40 dB at 8 kHz in one ear only.

Cohen, Anticaglua and Jones (6) measured the hearing levels of two teenage bands. The 5 members of one band had normal hearing. The average audiogram of the other, 6-member, band showed a decline in high frequency hearing sensitivity to 22 dB at 6 kHz (no individual audiograms are given).

Redell and Lebo (22) studied a slightly older group of 43 musicians (average age 22). The mean hearing levels of the group showed a 20 dB notch at 6 kHz with individual audiograms dipping to 50 dB.

Speaks, Nelson and Ward (25) examined 25 musicians and found that 6 of them had impaired hearing (HL greater than 20 dB) at at least one frequency. They pointed out that these impairments could not be attributed solely to music, however, because "in each instance, those musicians who evidenced a substantial hearing loss also had engaged repeatedly in hunting, trap shooting, or had served in the artillery of the armed services".

Jerger and Jerger (14) measured the hearing of a 5-member band who had been playing together for an average of about 14 hours a week for two years. Three of them had impaired high frequency hearing (HLs 30-70 dB at frequencies above 2 kHz). However, because they had not attempted to exclude other possible causes, Jerger and Jerger were unable to attribute these losses to music alone.

In 1977 Rintelmann and Bienvenue (20) reported a follow up of the 42 musicians originally studied by Rintelmann and Borus. Four years after the initial study 10 of the original 42 were found who were still actively playing. Their hearing was essentially unchanged, the largest individual difference measured being 10 dB. After a further 3½ years six of the musicians were still available for follow up. Their mean hearing levels were within 10 dB of those measured 7½ years before. Individual analysis, however, showed that two of them had suffered high frequency losses of 15 dB or more and one of these had a clear noise induced notch reaching 45 dB at 3 kHz.

Overall, 126 young musicians were examined in this series of American studies and at least 23 (18%) were found to have impaired hearing, though usually of mild degree and not always the result of music exposure alone.

There have also been a number of European studies of rock musicians' hearing. They were reviewed recently by Axelsson and Lindgren (1), as a prelude to an extensive study of their own. They pointed out that of a total of 118 musicians investigated in four separate studies only 6 (5%) were found to have hearing losses attributable to amplified music.

In their own study Axelsson and Lindgren examined 69 rock musicians. Their mean age was 26.5 years and on average they had played 18 hours per week for 9.3 years. Eleven (16%) of them had hearing losses attributable to music though, as found in the American studies, the degree of loss was mostly mild. Very few hearing losses exceeded 30 dB and Axelsson and Lindgren remarked that "at an average age of 31 years, after performing pop music for an average of 13 years for about 30 hr/week, these 11 pop musicians, in general, have a slight SNHL (sensorineural hearing loss) and mostly on one ear only. The incidence of SNHL and the amount of hearing loss must be regarded as surprisingly small". Axelsson and Lindgren also measured temporary threshold shift after a 2-hour pop concert and found that musicians appeared to be considerably more resistant to TTS after exposure to pop music than the audience, a finding consistent with the often made suggestion that young musicians susceptible to hearing damage may leave the profession early when they notice their hearing being affected.

As is to be expected from their greater exposures and as revealed by the comparative statistics musicians have a higher incidence of hearing damage than their audiences. Pooling the American and European data, it can be seen that 40 (13%) of 313 rock musicians have been found to have some degree of hearing impairment, usually mild. It must be acknowledged that several of the studies from which these data are drawn were poorly controlled, in that little or no attempt was made to exclude other possible causes of impairment such as medical and hereditary conditions and other noise exposures. On the other hand it is not known how representative these musicians are of rock musicians in general; a notable source of bias in fact is that there have been no studies of older rock musicians.

For what they are worth, however, the observations of musicians' hearing parallel those of audiences in one major respect: the amount of hearing loss is less than generally expected. Perhaps this is further evidence for the view that the equal energy hypothesis — the 3 dB rule — is conservative when it comes to evaluating the auditory hazard of intermittent noise exposures, a view which has received further support from recent animal experiments in which time/intensity trading relationships as large as 8 dB have been observed for intermittent exposures (19). Whatever the correct relationship turns out to be, however, the profession of rock musician clearly carries a definite risk of hearing damage for a substantial minority of its members.

6. CONCLUSION

Compared with the industrial noise toll — where the incidence of hearing impairment is over 30% in some occupations (8, 24) and over 60% in some workplaces (8), where the losses are often of severe degree, where in Victoria alone 1500 employers have notified 50,000 cases of hearing impairment to the Health Commission since compulsory hearing testing was introduced in 1978 and where the compensation payout for hearing loss in NSW and Victoria alone is running at about $20 million per year — the auditory dangers of loud music appear almost trivial.

Nonetheless there is a finite risk. Whether its magnitude is sufficient to justify political action in the form of regulations and codes of practice has been discussed in several places (2, 26, 30) and is not pursued further here. Clearly, however, at current playing levels those frequently exposed to highly amplified music either occupationally (and this includes ancillary staff as well as musicians) or recreationally who wish not to endanger their hearing must adopt self-protective strategies such as wearing some form of earplug or earmuff, limiting the duration or frequency of exposures and carefully monitoring the state of their hearing.

If people are to take a responsible interest in their own protection they need clear and accurate information. There is a need for community education about the dangers of excessive noise exposure, not only from recreational sources such as gunfire and amplified music but above all from noise exposure at work (28). As many as half a million people may work in potentially hazardous noise levels in Australia. While the larger companies have undertaken hearing conservation programs the majority of the noise-exposed workforce is employed in small enterprises, many of which have yet to take any initiatives at all in regard to hearing conservation. The auditory hazards posed by rock music are part of a very much larger problem.

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Scientific Communication

The language we use when we are writing research papers is really remarkably stilted. This first struck me forcibly when I started editing journals some years ago. I remember coming across a paper which mentioned in the body of the text that there had been a need for "instrumental readjustment". Under the references, it was noted that this change had been made as the result of "a personal communication" from a friend of mine. My friend was most surprised. He claimed that he had only met the author for half an hour over coffee, and had not been involved in any discussion of research. So I queried the reference. It transpired that what had happened was this: my friend, whilst drinking coffee, had looked down the author's microscope and remarked, **"You have the specimen in upside-down."**

There are various ways of trying to estimate how difficult a piece of prose is to read. Most of them lead to some kind of index which increases in value as the prose style becomes harder. They typically involve a count of such elements as the number of syllables per word and number of words per sentence. One that is frequently used is called (appropriately) the **FOG index**. When this is calculated for the prose found in daily newspapers, it gives a value of 9-10 for the *Sun* and the *Star*, and 12-13 for the *Times* and the *Guardian*. When the same index is calculated for physics research papers it ranges from 20 upwards.

The immediate conclusion, which has been drawn many times in recent years, is that something needs to be done about current standards of scientific writing. The commonest proposal has been that researchers should be given training in writing skills, preferably at the postgraduate stage when they are learning their trade. Another suggestion is that research workers should have linguistic mentors to whom they can turn for advice. (This already occurs in some countries where the authors are writing in English as a second language.) In the future, when an increasing number of researchers will be preparing their papers on word processors, they can be helped by programmes for assessing the author's prose style (e.g., by calculating the FOG index) and for improving the syntax automatically.

But all these proposals for improvement may be beside the point. The unreadability of modern research papers is of a special kind. It derives to a considerable extent from the stylised way in which the material is presented. An obvious example is the use of passive verbs: not "I carried out the experiment", but, "The experiment was carried out". This is bad ordinary English, but is it bad research English? The point is that **the stylised pattern of research papers allows information to be extracted from them very rapidly**.

Paradoxically, their low readability makes for greater ease of use. After all, how many research papers do you read thoroughly, as compared with skimming rapidly? Nor is this pure speculation. I have been looking recently at the reading problems of scientists who do not have English as their first language. It appears that they find it easier to extract information from our present stylised research papers than they would from the same material rewritten in "better" English.

My conclusion is that the writing of research papers should probably be left much as it is. Where training would be worthwhile is in the presentation of research to scientists working in our specialisms. Here many scientists do fall down. **The hardest lesson in communication a research student has to absorb is that the more distinguished, and therefore varied, the audience, the simpler the presentation must be**. It is all right to use stilted phrases with your immediate peers, but the world outside has other demands.

Professor A. J. Meadows
in Physics Bulletin, Jan. 1983

Digital Techniques in Acoustics
Part 3: Analysis of Stored Data (continued)

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ABSTRACT: Further common techniques used to analyse sampled and digitised data are surveyed together with some indications about future developments in signal analysis.

INTRODUCTION: The simple statistical techniques including the mean, standard deviation, kurtosis, and probability density function were described in the previous article. Also described were the standard calculational procedures used to compute the power spectral density. The discussion now continues and considers one of the newer techniques to handle short time samples. After a brief treatment of the cepstrum and digital filtering, the techniques for handling multivariate systems are described and finally a few words about nonstationary and nonlinear systems and one of the other possible functions that can be used in transform approaches.

2.6.3 MESA Approach

Two problems always present when using either of the two techniques previously described to compute the power spectral density are the difficulties associated with any discontinuities at the ends of the samples and the limitation on the frequency resolution if a long signal record is not available. Neither of the previous methods takes into account the nature of the signal in computing the power spectral density, and a method which does (often referred to as a "nonlinear" method) should produce better spectral estimates. One such approach is called the MESA (Maximum Entropy Spectral Analysis) technique, which starts by constructing a linear predictor filter allowing one to estimate the next value ($\hat{x}_n$) in a sequence from past values ($x_{n-1}, x_{n-2} \ldots$).

$$\hat{x}_n = a_1 x_{n-1} + a_2 x_{n-2} + \ldots \qquad (22)$$

The mean square error between the predicted values and actual values for M coefficients in the series will be called P_M (prediction error). The estimates of the power spectral density are given by:

$$S_{xx}(f) = P_M / \{2f_s|1 + \Sigma\, a_m \exp(-i2\lambda m f \Delta t)|^2\} \qquad (23)$$

where f_s is the sampling frequency, Δt is the time between samples, and m is summed from 1 to M.

The problem associated with the MESA method is the selection of the "optimum" filter order (value for M). If M is too small the resulting spectrum will have poor frequency resolution. If M is too large, spurious peaks (arising from numerical instabilities) can occur in the spectral estimates. The optimal order is determined by finding the value of M which gives a minimum in an expression involving P_M. If N is the number of points, then the Akaike final prediction error (FPE) criterion is

$$\text{FPE} = [(N + M + 1) / (N + M - 1)]\, P_M \qquad (24)$$

Further references on MESA techniques are given in the bibliography.

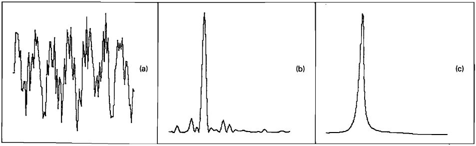
2.7 CEPSTRUM

Many signals consist of a fundamental plus many harmonics or the superposition of multiple echoes (reverberation). The resulting spectrum will have a periodic structure. The time scale of such a periodic structure can be extracted by computing the cepstrum. A spectrum is calculated and then converted to a logarithmic scale. This log spectrum is then transformed back to the time domain by an inverse Fourier transform to produce the cepstrum (see bibliography).

2.8 Digital Filtering

Filtering of signals is an important function, and one way of achieving this would be to take the Fourier transform of a signal; multiply it by the characteristic of the required filter; and then carry out the inverse Fourier transform to obtain the output. This procedure is involved, requires considerable computational effort and the output is affected by the results of any "window-carpentry". However, using the values of the digitised data already available, it is possible to achieve a filtering action without the use of Fourier transforms. A digital filter constructs the current output from current and past values of the input and past values of the output. Since

MESA Analysis of a Sine Wave Plus Noise



The advantages of the MESA technique for spectral analysis are apparent when it is compared with the usual Fourier transform technique applied to a sine wave plus noise. The figures show (a) the graphs of the 100 points of raw data; (b) the unsmoothed power spectral density using a Fourier transform; and (c) the MESA estimate (using 9 coefficients).

past values of the output are used the filter is called recursive (or Infinite Impulse Response — IIR), but if past values of the output are not used the filter is called non-recursive (or Finite Impulse Response — FIR). If y_i are the outputs and x_i are the inputs, the digital filter can be represented as

$$y_i = a_0x_i + a_1x_{i-1} + a_2x_{i-2} + \dots + b_1y_{i-1} + b_2y_{i-2} + \dots \quad (25)$$

The recursive filter requires less coefficients than the non-recursive filter, where all $b_i = 0$, but can be more prone to numerical instabilities. The determination of values for the coefficients can be achieved using available computer program packages. Some of the commercial third-octave filters now available use digital techniques to achieve the filtering action. It is possible to achieve filter characteristics using digital techniques that are not easily realisable using known analog approaches.

Consider the low-pass filter specified by

$$y_i = x_i + x_{i-1} - 0.5y_{i-1} \quad (26)$$

The frequency response of such a filter is given in Figure 3. The response is symmetrical about half the sampling frequency and since the Nyquist criterion will be satisfied when sampling the signal, no frequencies will be present in the region above half the sampling frequency.

3. PARAMETERS FOR TWO VARIABLES

3.1 Joint Probability Density Function

The pdf, f(x), for a single variable, x, was defined such that the probability that x lies between the limits x_1 and x_2 is given by

$$\text{Prob}\,(x_1 \leqslant x \leqslant x_2) = \int f(x)\,dx \quad (27)$$

where the limits of integration are x_1 and x_2.

For two variables x and y one can define a joint probability density function, f(x,y), such that the probability that x lies between x_1 and x_2 and y lies between y_1 and y_2, is given by

$$\text{Prob}\,(x_1 \leqslant x \leqslant x_2;\ y_1 \leqslant y \leqslant y_2) = \iint f(x,y)\,dx\,dy \quad (28)$$

where the limits of integration are between x_1 and x_2 and y_1 and y_2. The probability distribution function for x only, allowing y to take any value, can be determined by integrating out the dependence on y.

$$f'(x) = \int f(x,y)\,dy \quad (29)$$

where the limits of integration are from $-\infty$ to $+\infty$.

The digital formulation for the computation of the joint probability density function is an extension of the sort algorithm contained in Appendix I to two dimensions.

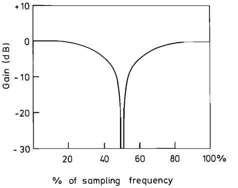


FIG. 3 Digital filter gain (dB) against percent of sampling frequency.

3.2 Cross-correlation

If two variables x_i (i = 1, 2 ... N) and y_i (i = 1, 2 ... N) are available, then the autocorrelation defined by equation (9) can be extended to calculate the cross-correlation,

$$R_{xy}(i\triangle t) = [1/(N-i)] \Sigma x_j y_{j+i} \qquad (30)$$

The cross-correlogram is an ideal means of ascertaining the delay between two signals which is illustrated in Figure 4, and can also be the starting point for the calculation of the transfer function. The significance of a peak in a cross-correlogram is better estimated by normalising the values by the geometric mean of the variances of the x_i and y_i (which are the values of the autocorrelations for zero lag). The normalised cross-correlation is given by:

$$\sigma_{xy}(\tau) = R_{xy}(\tau) / [R_{xx}(0) R_{yy}(0)]^{1/2} \qquad (31)$$

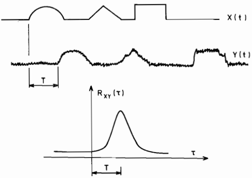


FIG. 4 Example of a signal and a distorted delayed version (delay T) together with the cross-correlogram between the two signals (showing a peak for a lag of T).

3.3 Cross-spectra and Transfer Function

As the auto-spectra can be calculated by a Fourier transform of the auto-correlation so the cross-spectra can be calculated by a Fourier transform of the cross-correlation [extension of equation (10)].

$$S_{xy}(\omega) = \int R_{xy}(\tau) \exp(-i\omega\tau)\, d\tau \qquad (32)$$

The cross-correlation is not necessarily symmetrical about $\tau = 0$ so that both the real and imaginary parts (cosine and sine) of the complex exponential in equation (32) have to be evaluated.

Alternatively, the cross-spectra could be directly calculated from the Fourier transforms of the two variables [extension of equation (14)]

$$S_{xy}(\omega) = (1/2T) X_T(i\omega) Y_T^*(i\omega) \qquad (33)$$

Four power spectral densities can be calculated from two signals, x and y. They are $S_{xx}(\omega)$, $S_{yy}(\omega)$, $S_{xy}(\omega)$ and $S_{yx}(\omega)$. The transfer function, $G(\omega)$, which tells how the two signals are related in the frequency domain (taking x as input and y as output), can then be calculated:

$$G(\omega) = S_{xy}(\omega) / S_{xx}(\omega) \qquad (34)$$

$$G(\omega) = S_{yy}(\omega) / S_{yx}(\omega) \qquad (35)$$

$$|G(\omega)|^2 = S_{yy}(\omega) / S_{xx}(\omega) \qquad (36)$$

Equation (34) is generally the preferred formula as the effects of any contaminating noise is minimised. A test of the "goodness" of the transfer function calculation, which is an assessment of the effects of extraneous noise, is to calculate the coherence function, $C_{xy}(\omega)$, which lies between 0 and 1

$$C_{xy}(\omega) = |S_{xy}(\omega)|^2 / S_{xx}(\omega) S_{yy}(\omega) \qquad (37)$$

There are many ways of representing the information obtained via a transfer function calculation. These include real and imaginary parts versus frequency; modulus (linear or log scaling) and phase versus frequency; log scaled frequency (Bode plot); imaginary part versus real part (Nyquist plot).

4. MIMO ANALYSIS

The analyses in the previous section considered that a single input to a system gave a single output. A more general case is that where there are multiple inputs and multiple outputs (MIMO). Each output could have a contribution from each of the separate inputs, so if there are N inputs, and if one considers the Mth output, then, in the frequency domain, one can write (the dependence on ω has been left out for simplicity)

$$Y_M = X_1 G_{1M} + X_2 G_{2M} + \ldots + X_N G_{NM} \qquad (38)$$

where G_{NM} is the transfer function between input N and output M. An equation similar to (38) can be constructed relating any output to all the inputs, and the most convenient way of expressing this is to use matrices

$$[Y_1, Y_2, \ldots Y_M] = [X_1, X_2, \ldots X_N] \begin{bmatrix} G_{11} & G_{12} \cdots & G_{1M} \\ G_{21} & G_{21} \cdots & G_{2M} \\ \vdots & & \\ G_{N1} & G_{N2} \cdots & G_{NM} \end{bmatrix} \quad (39)$$

Equation (39) can be written more simply as

$$\mathbf{Y} = \mathbf{XG} \quad (40)$$

where the bold type indicates a matrix. If equation (40) is premultiplied by a column vector of the complex conjugates, X_1^*, X_2^*, etc. one obtains

$$\mathbf{X^*Y} = \mathbf{X^*XG} \quad (41)$$

Using the definition of the power spectral density, equation (41) can be written as

$$\underset{N \times M}{\mathbf{S_{xy}}} = \underset{N \times N}{\mathbf{S_{xx}}} \; \underset{N \times M}{\mathbf{G}} \quad (42)$$

where N × M means a matrix of N rows and M columns. Equation (42) can be solved to find the values of the **G** matrix by inverting the $\mathbf{S_{xx}}$ matrix, so that

$$\mathbf{G} = \mathbf{S^{-1}_{xx}\, S_{xy}}. \quad (43)$$

Equation (43) has to be implemented for all the frequencies at which the values of the spectra have been calculated. Various computational algorithms are available to do the matrix manipulations of equation (43), and there are also techniques to calculate partial spectra which are the spectra relating one input to one output (the effects of the other inputs are subtracted — see bibliography).

5. FUTURE DEVELOPMENTS

5.1 Nonlinear Systems

It is usually assumed that a system is linear so that the principle of superposition applies; that is if "a" produces "c" and "b" produces "d", then "a + b" produces "c + d". Many physical systems possess some form of nonlinearity so that the principle of superposition does not strictly apply, and various approaches for the analysis of data from nonlinear systems and their identification are currently being considered. Most approaches involve relating the input and output by some form of power series. To obtain coefficients in the power series, higher order correlations are calculated, such as:

$$R_{xy}(\tau,\lambda) = (1/T) \int x(t)\, y(t+\tau)\, y(t+\lambda)\, dt \quad (44)$$

Equation (44) can be Fourier transformed to give a bi-spectrum, $S_{xy}(\omega_1,\omega_2)$, which is a complex parameter since it is a function of two variables and also there are restrictions on ω_1 and ω_2. The bi-spectrum has been used (see bibliography) but no acceptable approach for general use on nonlinear systems is yet available.

5.2 Nonstationary Systems

A basic premise in signal analysis is that the system being analysed is stationary, i.e. its statistical properties do not change with time. Often systems are non-stationary such as the transient at the start of a musical note. The simplest approach is to divide the signal into short time slices and consider that within each time slice the signal is quasi-stationary. The time slices may overlap. Since one is dealing with short time slices, there is a frequency resolution problem and a MESA approach could be used to obtain a better estimate of the power spectral density for a particular time slice. In seismic studies, where the excitation is a short duration transient, the item of interest is the maximum value for the power spectral density over any frequency range and this is termed the **peak spectrum**. Many of the commercial spectrum analysers now available have a peak spectrum option.

When the spectrum changes in some specified pattern with time, one can talk of an **evolutionary spectrum** and search for functions that can be used to better define such a changing process, but this is a difficult task.

5.3 Walsh Transforms

The Fourier transform works because the trigonometric functions are orthogonal. This means that if you multiply $\sin(\omega_1 t)$ by $\sin(\omega_2 t)$ and integrate with respect to time, the results are non-zero only if $\omega_1 = \omega_2$. Thus

$$(1/T) \int \sin \omega_1 t \, . \, \sin \omega_2 t \, . \, dt = 0 \quad \omega_1 \neq \omega_2$$
$$= 1 \quad \omega_1 = \omega_2 \quad (45)$$

where the limits of integration are from −T to +T and T tends to infinity.

The sine and cosine functions used in the Fourier transform are not the only available functions that have this orthogonal property, and also computationally they are unattractive because they have a wide range of values. A better function in a computational sense would be one which only has two values (±1) so that the multiplications that are required in the Fourier transform are replaced by simple additions and subtractions. One such function is the Walsh function, and the first eight functions are shown in Figure 5. The Walsh transform gives a "spectrum" in the "sequency" domain which has some similarities to the conventional power spectral density but also exhibits extra spectral peaks or misses spectral peaks depending on the nature of the signal when compared with the usual frequency spectrum. Walsh functions are finding uses in processing radio signals that use such techniques as PCM (pulse code modulation) and in on-line image processing.

A variation on the Walsh transform, called either the Walsh-Hadamard or BIFORE transform, can be thought of as replacing the cosine function by a square wave so that a two-valued function results.

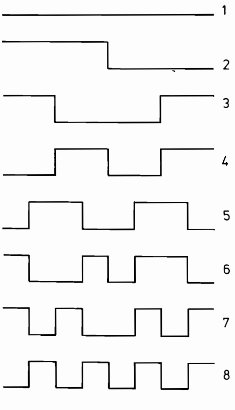


FIG. 5 First eight Walsh functions.

6. CONCLUSIONS

The availability of sampled and digitised data opens a wide horizon of possible analytical techniques that can be applied to such data. Simple statistical parameters such as the mean and standard deviation can be easily computed. The FFT algorithm allows fast calculations of the power spectral density and the analyses of transient phenomena using the MESA technique has become a possibility. Current endeavours are to develop means of analysing data from nonlinear systems and improving and extending currently available techniques.

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The SPCC's Traffic-Noise Control Programme

An Information Sheet published by the N.S.W. State Pollution Control Commission

INTRODUCTION

Excessive traffic noise is a widespread and increasing problem in most modern communities, especially for people whose homes are near busy roads and people who work or attend school in areas close to major traffic routes. As with many other forms of pollution, it is difficult to assess precisely the extent of the traffic noise problem in New South Wales or to quantify its various elements. It is clear, however, that the effects of traffic noise can range from health and psychological effects, arising from sleep disturbance and the stress imposed by continual interference with speech and listening, interruption of concentration and general noise annoyance, to effects on the value of properties on or near busy roads.

For example, a recent study of the problem in Sydney, undertaken for the State Pollution Control Commission, found that:

- 85 per cent of main-road residents responding to a questionnaire found traffic noise in their homes disagreeable to some degree.
- One-third of main-road residents claimed their sleeping patterns were affected by this noise.
- 8 per cent had sought medical help for sleeping problems caused by the noise.
- Over the period 1968 to 1980, average house prices on main roads were, on a yearly average basis, some 16 per cent lower than average house prices in parallel streets. The difference was greatest during periods when demand for houses was high. Statistical analysis showed that traffic noise contributed to these differences, although the extent of the economic impact of traffic noise varied from suburb to suburb and from time to time.

The motor-vehicle noise problems experienced in the community may be divided into several types:

- **Noise due to bulk traffic flow:** This noise is related the number of vehicles using the road and particularly to the proportion of heavy vehicles. As the study discussed above indicates, bulk traffic noise can cause severe stress and discomfort for affected residents and shopkeepers. In some cases commercial activities may be adversely affected as customers may prefer to go shopping in a quieter environment.
- **Noise due to individual vehicles:** This noise can cause annoyance, disturb rest or even frighten people in city and urban areas. In country areas, where general background noise levels are usually quite low, especially at night, the noise of individual vehicles, particularly heavy transports, can be disturbing even over long distances.
- **Noises that "shouldn't be there",** such as the constant revving of an engine by a neighbour for tune-up purposes or noise due to the illegal parking of heavy trucks in residential areas.
- **Noises that are annoying** mainly because of their repetitive, prolonged or tonal characteristics, such as noise from construction machinery or noise from the continued use of trail or moto-cross bikes.
- **Grossly disruptive noises,** such as noise from the screeching of tyres or the indiscriminate use of car horns, particularly the musical and multi-toned types.

The State Pollution Control Commission (SPCC) has embarked on a multi-pronged programme to reduce traffic noise levels at the source and to reduce the effects of noise emissions that cannot be prevented. The main elements of this programme are outlined below.

TRAFFIC NOISE AT THE SOURCE

The SPCC's activities here include the development of new control measures designed to reduce engine and exhaust noise levels from new vehicles, the introduction of improved controls and education programmes on muffler design and muffler replacement to reduce noise from in-service vehicles, the development of new controls on the use of trail bikes and multi-toned horns, surveillance and enforcement activities to improve compliance with the requirements of the Noise Control Act, and research and investigations covering areas such as truck body noise, exhaust brake noise and the development of new legal standards.

Details on these activities are provided in a separate information sheet (MV2) available from the SPCC.

PLANNING AND TRAFFIC MANAGEMENT

Proper planning, road-design and traffic-management schemes can play a major role in reducing the impact of motor traffic noise. In conjunction with other State Government authorities, the SPCC is conducting a series of case-study investigations involving noise-level measurements and traffic counts at selected home sites in the metropolitan area.

Each of these case studies is examining recent developments affecting traffic noise levels, contemporary approaches by various authorities to reducing the problem, past planning deficiencies and design and construction deficiencies. The sites are being chosen so as to best reflect traffic noise problems recently created as a result of poor planning, poor siting and/or a general lack of understanding or concern about traffic noise.

The aim of these and other related investigations is the development of assessment criteria, guidelines and strategies to assist planners and state and local government authorities to avoid, or at least reduce, traffic noise problems in the future.

NOISE REDUCTION AT THE HOME

In established residential areas traffic-management schemes may be able to effect some noise reductions, as may the installation of roadside traffic-noise barriers, but often the only means of reducing the impact of traffic noise are noise-reduction measures at the home itself. Studies of traffic noise problems have shown that noise from roadways can be excluded from homes, or at least greatly reduced, by shielding windows and doors from direct, line-of-sight noise exposure. Thoughtful rearrangement of living and sleeping areas within the home can also significantly reduce the impact of traffic noise on residents.

An information sheet with general guidelines on these noise-reduction techniques for existing houses (N2) may be obtained from the SPCC. More detailed, technical guidelines are also being prepared.

The best time to consider noise reduction in the home is, of course, at the initial stage of house design and construction. The SPCC has initiated a programme to foster awareness among architects, developers, councils and householders of the fact that traffic-noise control measures can be incorporated in new houses at a relatively low cost, without sacrificing market appeal or architectural merit, at the design stage. The techniques available include baffling, insulation, the adoption of special construction methods, careful siting of the building on its block, the arrangement of living spaces within the house, and the design and placement of perimeter walls and terraces.

The first step in this programme is the $5,000 "Quiet House" design competition, sponsored by the SPCC and Norbrik Bricks, in which competitors have been invited to design a project-type house, on a defined site, with the objective of cost-effectively minimising intrusive noise.

The SPCC is also funding research and investigations into the effectiveness of different type of building materials and facades in reducing traffic-noise levels inside buildings. The results of this research work should provide practical assistance for architects, builders, councils and householders in reducing traffic-noise impacts in the homes of the future.

For further information on any aspect of the SPCC's traffic-noise control programme, please contact the SPCC, 157 Liverpool Street, Sydney.

Marine Acoustics at the 53rd ANZAAS Congress

John Penrose
W.A. Institute of Technology

The 53rd ANZAAS CONGRESS was held in Perth in the period May 16-20, 1983. The Section (1), (Physics) programme had as its major theme "The Physics of the Earth" and within that theme a major symposium "Remote Sensing in Oceans and Atmosphere" was held. In this symposium parallel and concurrent sessions involving satellite remote sensing and marine acoustical remote sensing, convened by Dr. John Penrose of the W.A. Institute of Technology, were presented.

The keynote speaker in marine acoustics was Dr. **Earle Hays** of the Woods Hole Oceanographic Institution, Massachusetts, U.S.A. Dr. Hays, who is currently visiting R.A.N.R.L. at Sydney, provided a masterly exposition of marine acoustical sensing on the grand scale, in a description of acoustic tomography techniques carried out over 300 km path lengths in the ocean. The success so far seen in this work owes much to the development of high quality underwater technology and points to the possible emergence of a new generation of oceanographic techniques.

R. Chapman from the University of Western Australia presented a description of and results from an acoustic imaging system which allows turbulent microstructure to be revealed in selected water masses. **A. Quill** from R.A.N.R.L. described the volume reverberation data acquisition system now in use in field work around Australia. Both papers evidence interest in biological targets, either as competitors for turbulent scattering, or as the major source of field reverberation.

J. Penrose reported on the work done by a team from the Western Australian Institute of Technology to investigate the relationship between sea bottom roughness and high frequency sound scattering. A scattering model developed at WAIT is now being applied to acoustic recordings made on the North West Shelf of Western Australia by the CSIRO vessel FRV "SOELA".

M. Lawrence from R.A.N.R.L. presented a paper on ADOBE, the Acoustic Deep Ocean Bottom Experiment. This experiment will be undertaken jointly with New Zealand scientists and will employ innovative acoustical instrumentation packages in a programme to evaluate deep ocean sediment acoustic properties.

One marine acoustics paper dealt with high accuracy underwater positioning using intelligent acoustic beacons. Presented by **M. Castalanelli** of Associated Surveys (Aust.) Pty. Ltd., this dealt with the sophisticated acoustic techniques used in positioning a giant underwater plough used in association with pipeline burial for the Rankin Field platform on the North West Shelf.

Many Western Australian scientists had the opportunity to visit H.M.A.S. COOK, which came to Perth for the ANZAAS Congress. Amongst features of interest on the vessel was the Stabilised Narrow Beam Echo Sounder System (SNBESS). The availability of this system, and of output gained during the voyage from South Australia, added a valuable component to the marine acoustics activities of the 53rd ANZAAS Congress.

Machine condition monitoring at Monash University

It's possible to become comfortable about being schizophrenic according to **Dr. ROBIN ALFREDSON** of the Department of Mechanical Engineering, at **MONASH UNIVERSITY.** It came as a new experience to him to begin to perceive the possibility that noise and vibration might be used to advantage. Dr. Alfredson is in charge of a 6-man team who are now past the halfway mark in a large contract to do with Machine Condition Monitoring. It is sponsored by the **AUSTRALIAN MINERALS INDUSTRY RESEARCH ASSOCIATION.** Half of the team is concentrating on wear debris analysis of the lubricating oils while the other half is examining noise and vibration aspects. This further split is not an additional source of schizophrenia according to Dr. Alfredson as both approaches are considered necessary to provide accurate diagnosis and prognosis.

Some twenty different vibration parameters have now been assessed for usefulness for monitoring the condition of rolling element bearings. This has been carried out on an HP21MX computer which automatically samples and processes the data. It has turned out that none of the parameters is adequate to detect at an early stage all types of bearing failure. Many bearings have been tested and the work will continue to allow further experience, and to examine the effects of oils, and oil additives on bearing life.

Dr. Alfredson reports that two other test rigs are now operational. The first of these was designed for monitoring journal bearing condition while the other will enable research on the detection of gear failure to proceed. Of particular interest is the business of detecting damage where there is significant cross talk in the various vibration signatures.

A feature of the AMIRA programmes according to Dr. Alfredson is that the opportunity exists to evaluate laboratory techniques on site. This aspect of the work will be emphasised in the latter half of the programme and finally will be the most significant component of the project. His parting remarks were "Don't rely on one technique alone! Condition monitoring is difficult. There is an enormous amount of information in the vibration signals but it's not easy to perceive it. And wear particle analysis can provide a different perspective to machine condition monitoring."

Dimensions for a Melodious Room, or "Musical Box"

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It is well known that persons, especially male persons, like to sing in their baths. The usual physicists' comment on this is, that a bathroom, having little soft furnishing, is highly reverberant and gives a weak voice more volume.

A room of concert-hall size has dimensions so large compared with sound-wavelengths in the voice range that, in this range, adjacent resonant frequencies overlap — that is, the fractional difference in frequency is much less than the reciprocal of the "quality factor", 1/Q, which states the fractional width of an individual resonant response curve. Such a large room will therefore, if the various resonances all have essentially the same amplitude, not selectively respond to any particular frequencies, i.e. will be "reverberant" but not "resonant". However, a small room of the size of a typical home bathroom, has numerous but **discrete resonances** within the frequency range of the normal voice; and in such a room the voice will tend to be pulled into synchronism with one or other of these. This paper argues that a good room for singing in should be so designed that all its resonant frequencies, as nearly as possible, coincide with notes of a musical scale.

This note reports a computer study **to determine optimum dimensions** for such a room. The room is treated as being essentially a rectangular box with sides A, B and C metres. The resonant frequencies of such a box are members of 3 infinite series, viz.,

$$F = N * (343/(2*W)) \text{ Hz},$$

where W = A, B or C, and N is any integer from 1 upwards, 343 m/s being the velocity of sound in air at a normal room temperature.

It is assumed that the male voice, for instance, does not aim to sing any note above the octave of middle-C: on the standard chromatic scale with A(A4) = 440 Hz, this note, C5, = 523.2 Hz.

A **computer program** (in "BASIC") has been made

(1) to find all distinct values of W for which all resonances up to 530 Hz are within 1% of one of the semitones of this chromatic scale (except for the 7th harmonics, which are allowed to be 2% out). This is done by testing W-values successively from 1.5 to 4.0 m, in steps of 0.01 m. Of several successive W-values which match to one set of semitones, that one is chosen for which the variance of all the resonances from the respective nearest semitone is least; and a table is compiled showing, for each such W-value, the individual deviations throughout the top 2 octaves, from C-below middle-C (C3) to C-above (C5). (However, the match is checked, and the variance computed, down to 41.25 Hz, i.e., the fundamental resonance for the maximum value of W, 4m).

(2) By testing all combinations of 3 different dimensions chosen from the set of W-values (1), to find those combinations, of which one or more resonances match all of the first 12 notes of a major scale from C5 (or B4) downwards. This computation is repeated for each of the 12 possible keynotes; matching goes down to E4, or F4, or F4#. This lower limit has been chosen to set a severe, but not impossible criterion: it is perhaps also about as low as many baritone voices go. *A computer-printed listing of the program will be gladly supplied upon written request.*

TABLE I

Dimensions of rooms which have resonances that match all notes (with the exceptions indicated) of a major scale, through one octave on either side of middle-C

Case No.	Keynote of scale	A*B*C (metres)	Missing (below mid-C)	Extras (above mid-C)
1	C#	3.31 × 2.94 × 1.85	C,C#	D
2	D	3.12 × 2.78 × 1.75	C#,D	D#
3	D#	3.31 × 2.94 × 2.62	D	E,F#
4		3.31 × 2.94 × 1.75	C,D	F#,B
5		2.94 × 2.62 × 1.65	D,D#	E
6	E	3.31 × 3.12 × 2.78	C#	C,G,A (& C5)
7		3.12 × 2.78 × 2.47	D#	F,G
8		3.12 × 2.78 × 1.65	C#,D#	G (& C5)
9	F	3.12 × 2.94 × 2.62	D	C#,G#,B
10		2.94 × 2.62 × 2.34	E	F#,G#
11		2.94 × 2.62 × 1.57	D,E	G#
12	F#	2.94 × 2.78 × 2.47	D#	D,A (& C5)
13	G	2.78 × 2.62 × 2.34	E	(B3 &) D#,A#

Combinations selected as above are found only for the following keynotes: C#; D; D#; E; F; F#; and G. The specific sets of dimensions found are listed in Table I, together with listings of (a) those notes, of the 15 that comprise the two octaves from C5 or from B4 downwards, that are **"missing"** from the "spectrum" of resonances of the given chamber, with those dimensions, and (b) the **"extra"** resonances of that chamber, lying within that range, which coincide with semitones other than members of that major scale. In each of the 13 cases shown in Table I, the ratios of dimensions, A/C and B/C, have one or other of four pairs of values; i.e. the study reveals four different room-shapes which match well to major scales. Table II gives these shapes, and the ranges of keynote which they respectively cover.

TABLE II

Shape No.	A/C	B/C	Case Nos. (Table I)	Keynote Range
I	1.79	1.59	1,2,5	C# to D#
II	1.26	1.12	3,7,10	D# to F
III	1.89	1.68	4,8,11	D# to F
IV	1.19	1.12	6,9,12,13	E to G

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Victorian Environment Protection Authority's Instrumentation Section

Ian Taylor
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Environment Protection Authority of Victoria

BACKGROUND

The Environment Protection Authority was established in 1970 and in 1973 the Noise Control Branch commenced a programme to establish controls on environmental noise. In October 1976 the Environment Protection (Motor Car Noise) Regulations came into operation and this was followed by Environment Protection (Truck, Omnibus and Motor Cycles Noise) Regulation in July, 1978. In May 1981 State Environment Protection Policy No. N-1 came into operation and at the same time amendments to the Act also were effected which enabled environmental noise from industrial, trade and commercial premises to be effectively controlled. In response to these Regulations and Policy, the Authority now tests about 3,000 motor vehicles and records and analyses about 200 one hour tape recordings of industries per year.

Behind these programmes there is a need to calibrate all equipment regularly, and to make repairs when required. In addition practical research by the Authority can only be carried out with the development and introduction of circuitry and instrumentation systems not available off-the-shelf. This important service role is carried out by the Authority's Instrumentation Section, consisting of one Electronics Engineer and two Electronics Technicians.

FIELD EQUIPMENT

The Authority is currently using Bruel & Kjaer S.L.M.'s types 2209 and 2206 (the latter modified to measure down to 20 dB (A) which has been found necessary for the occasional indoor measurement and because the Policy requires a residual instrumentation noise greater than 10 dB below the measured noise) and Rion NA-60 S.L.M.'s. Tape recorders consist of Nagra, Stellavox and Sony. Cassette recorders have been considered for field recordings but the Policy requirement of 50 dB crosstalk between channels at 1 kHz has not been met by any we have looked at. (The Regulations specify performance requirements for the instrumentation and a maximum time of 12 months between calibrations.)

PLAYBACK AND ANALYSIS EQUIPMENT

For analysis of recordings, we have 3 sets of equipment comprising Otari MX 5050 recorders, B&K 2606 and 2607 amplifiers, B&K 4426 statstical analysers and B&K 2307 chart recorders. In addition, a B&K 2131 real time analyser under control of a HP 9825 calculator can be used by any set for spectral analysis. Again, these instruments must be calibrated every 12 months.

The photo shows some of the calibration equipment being used to calibrate a sound level meter. Although the Policy, and Australian Standards, call for an accuracy of measurement of better than 0.2 dB, it was decided very early that we would use a working accuracy for our calibration equipment of 0.1%, being the best that could be achieved using moderately priced calibration equipment, and not requiring special air conditioning plant. Considering that 0.1% is about 0.01 dB, we think this accuracy is sufficient!

This accuracy is achieved with standard cells, a Kelvin-Varley divider, thermal transfer unit, all used to calibrate a Fluke meter calibrator, which is then used for the calibration of all other instruments.

One interesting aspect of our calibration procedures for tape recorders involves adjustment of equalisation and bias to provide as flat a response as possible up to 8 kHz, trading-off the upper frequency response, since most environmental noise occurs well below 4 kHz. One requirement for recording is a duration of one hour, which means using tape speeds of 19 and 9.5 cm/s, and most tape recorders require a one or two dB boost around 6 kHz to give a response to 20 kHz. This is considered unsatisfactory in our application, so that bump is reduced to less than 1 dB, consistent with a response better than—3 dB at 14 kHz.

MONITORING EQUIPMENT

In addition to equipment used for tape recordings, several instrument kits have been developed for long-term monitoring at particular sites. These are general-purpose kits, not precision, comprising B&K 2225 S.L.M. and Linear Chart Recorder, plus power supply and enclosure. In use, they are left on location, providing more than 2 weeks monitoring on one set of batteries (3, 12V-60 AL car batteries) which can be changed over when the pen and paper needs to be changed on the chart recorder. A timer module provides hourly timing marks, since even a 0.1% error in paper speed would mean an error of 20 minutes after two weeks. The low cost and power consumption of this system has meant that a lot of data can be gathered for general studies without straining the budget and manpower resources of the Authority.

This equipment has been necessary to quantify background noise levels with high confidence in cases where the levels vary significantly hour-to-hour and day-to-day. It has been found particularly useful in determining the possible environmental effect of new development in some areas; has been used to monitor long-term noise levels of a refinery; and has supplied extremely useful data on the propagation of noise over very large distances. The latter cannot accurately be

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Sounds of Simon and Garfunkel — Reprise

Ian Lane
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Environment Protection Authority of Victoria

In contrast to Simon and Garfunkel's encounter with Sydney officialdom (reported in Vol. 11, No. 1) no legal constraints were placed on noise emissions from their concert at VFL Park, Waverley, on 12th February, 1983. Melbourne officialdom responded with noise level measurements plus a follow-up telephone survey of subjective reactions from the local community.

In the aftermath of the infamous "Kiss" concert tour of December 1980 the Environment Protection Authority agreed to requests by the Ministry for Planning and the City of Waverley to determine "maximum noise level parameters" for specification in the hiring contract for the use of VFL Park as a concert venue. At the time all parties agreed that, if possible, the attitudes and reactions of local residents to rock concerts should be considered. The Simon and Garfunkel concert provided the first opportunity since then to systematically gauge local community reaction to an outdoor concert.

Thus, a combined noise level/subjective reaction survey ensued with costs shared by the Authority (with money provided by an Australian Environment Council grant), the Victorian Football League and the City of Waverley. The VFL engaged Watson Moss and Growcott Pty. Ltd. to assist the council and the EPA officers with noise level measurements on the night and otherwise "keep them honest". The telephone survey was conducted by Spectrum Research Pty. Ltd. in the following week.

NOISE LEVEL SURVEY DESIGN AND PROCEDURE

Altogether 11 personnel were involved in noise level measurements in and around VFL Park. Six of these were each assigned a residential area consisting of 3 or 4 sites to be continually monitored in sequence. These areas lie generally to the north, north-west, west and east of and within 2 km of the Park.

The measurement sites were selected on the basis of Council experience with previous concerts and the anticipated weather conditions and output of Simon and Garfunkel's sound system. Alternative sites were provided for use in the event that some of the pre-designated sites would be unsuitable on the night. A stand-by officer checked the range of audibility around and beyond the general measurement area. In addition, a continuous monitoring unit was set up for operation at a fixed site (and subsequently re-located early in the proceedings).

Inside the stadium, noise levels were continuously monitored at a fixed reference position (in the Members' Stand virtually on-line to the central loudspeaker bank which faced north-west) and continually monitored around the stadium.

Each of these continuous monitoring units comprised a chart recorder plus a noise level analyser/printer set on "Fast" response. Continual monitoring was conducted generally according to AS-1055 with precision S.L.M.'s. Average maximum meter deflections attributable to the music and the range (max.-min.) of the music were noted over approximately 10 minute intervals. Where possible background measurements were taken in a similar manner.

TELEPHONE SURVEY DESIGN AND PROCEDURE

Spectrum Research was supplied with some 600 randomly selected names and addresses (culled from the Council ratepayer's roll) of people residing in or near the general measurement areas so that 500 telephone interviews could be completed.

Questions asked once it was ascertained that a respondent was at home on the night of the concert were essentially:—

1. Did you hear any noise from the concert?
   YES → 2
   NO / DON'T KNOW } → 4
2. Were you at all bothered or annoyed by the noise?
   YES → 3
   NO / DON'T KNOW } → 4
3. Rate on a scale of 0 to 10 your annoyance.
4. Anything (else) about the concert that annoyed you?
   e.g. (a) concert-goers' behaviour.
   (b) traffic congestion.
   or other (specify)?

plus demographic questions to ensure an unbiased representative sample.

DATE MANIPULATION

For the purpose of analysing the noise level data in conjunction with the telephone survey data, i.e., to obtain some form of dose-response relationship, prospective respondents were grouped into 76 regions (streets or sections of streets) over which concert noise levels were deemed to be fairly constant (at a given time). For each region an aggregate figure representing the estimated "dose" of maximum outside noise levels for the duration of the concert, L_{MAX}, was determined. An outline of the procedure is given below.

The estimated L_M values of the 5 loudest passages of the concert were selected from the annotated chart recorder traces of noise levels inside the stadium. The 5 corresponding L_M values received at each measurement site were individually estimated after comparing the original noise level readings taken at the site with those levels recorded inside the stadium for identical periods. In this way an average attenuation between the stadium and a given site was calculated. The 5 values for that site were then averaged to obtain the "dose" L_{MAX}.

The L_{MAX} values for the regions as a whole were obtained from the regression line of the L_{MAX} vs (log distance) plot for the measurement sites. Background sound levels showed little variation between neighbouring measurement sites and values for intervening regions could be readily interpolated by inspection.

SUMMARY OF RESULTS

Consecutive 15 min. L_{10} values for noise (including crowd noise) measured at the reference position in the stadium ranged from 93 to 101 dB (A) during the main performance between 8 and 10.30 p.m. Variations in noise levels around the stadium were estimated to be 10 to 15 dB (A) down at the side extremities with respect to the reference position figures and 5 to 10 dB (A) down at the uppermost level (Level F) with respect to the reference level (Level B).

It is understood that no special provisions were made to contain the noise emissions from VFL Park. Wind conditions for the period were south to south-easterly and 4-6 m/S.

The resultant L_{MAX} values ranged between 43 and 63 dB (A). Highest levels were obtained in the area to the north of VFL Park. In areas immediately to the east and west officers reported the music to be immeasurable or inaudible for most of the concert.

The excess of L_{MAX} values over respective background levels ranged from zero (or less) to 15 dB (A). The excess was greater than 10 dB (A) for 30% of the respondents.

442 people were interviewed — 165 males, 276 females and 1 "unknown". 197 (45%) of the respondents stated that they heard noise from the concert.

Of these **only 23 or 12% said they were bothered or annoyed by the noise.** None gave ratings less than 5 (moderate annoyance). The distribution of annoyance scores was 5 (9), 6 (1), 7 (3), 8 (2) and 10 (8). Most people reporting annoyance resided directly north of VFL Park. However 2 were people living in the area to the east.

21 people expressed annoyance at the behaviour of concertgoers outside their homes and 86 were annoyed by problems with extra cars in the neighbourhood. 30 people cited other causes of annoyance including helicopter noises associated with the concert, glare from lights at VFL Park, etc.

SOME COMMENTS

A relatively low incidence of reported annoyance had been anticipated for the Simon and Garfunkel concert based on prior knowledge of their style of music which contrasts markedly with that of Kiss. Noise levels measured inside the stadium by Council officers during their 1980 concert in December 1980 were of the order of 10 dB (A) higher than those measured for Simon and Garfunkel.

With only 23 data points provided for consideration of annoyance ratings any attempt to establish a close-response relationship was clearly unwarranted and in this respect the result is disappointing.

Even though the procedure for determining L_{MAX} could give only approximate values it is believed that useful information about annoyance caused by large scale music concerts would have been gained had there been statistically significant data available. It is recognised that a definitive acceptability criterion based on social survey techniques would require investigation of a number of concerts over a wide range of conditions such as noise levels, type of performance, the frequency of occurrence, duration, etc.

There is no evidence from the findings of this survey to suggest widespread opposition among residents to all rock concerts held at VFL Park irrespective of their noise emissions and frequency of occurrence.

Footnote

Lest readers imagine that the good citizens of Waverley were consumed with apathy over this issue I feel obliged to report that **23** complaints were made to the City of Waverley concerning impertinent questions from telephone interviewers about personal income. Few community noise researchers can claim responsibility for annoying as many people as the noise they were investigating.

(Vic. E.P.A. from page 76)

predicted even with extensive knowledge of the meteorological profile of the site.

At present, a precision monitoring system is being developed along similar lines, but using a printer instead of the chart recorder (since this is the least accurate instrument) and the option of a cassette recorder for a very long-term monitoring. The system will be under the control of a HP 41 CV calculator and its associated HP-IL interface loop and will provide possibly four weeks monitoring on one set of batteries, and reduce further the manpower required for data reduction.

EQUIPMENT TRENDS

Up until recently, noise measurement instrumentation changed very little, but now there is almost an explosion of new, different instruments appearing. Generally, it is becoming relatively cheaper whilst providing similar, or better, facilities. It is becoming smaller, lighter, and more power efficient. Digital electronics are replacing analogue, and providing greater resolution and accuracy. The microprocessor is taking over field equipment as it did laboratory equipment, and there are several brands of low power, portable computers available which can form the basis of computer controlled field measurement systems which can be easily reprogrammed to meet the requirements of different users.

It is possible to use a portable digital recorder for field recordings, providing an almost perfect response for a fraction of the price of a Nagra, and this could remove much of the errors introduced by the use of recordings.

Microphones, too, seem to be getting better. In the past, we have often had condensation problems with condenser microphones used at night in winer. (In Melbourne, temperatures close to 0°C at night in winter are common.) The latest electret microphones do not seem to suffer from this problem to the same degree. It is still too early to say whether the life expectancy of these microphones will be longer than the non-polarised microphone, which in our applications, averages about 5 years.

(Melodious Room from page 75)

Table II shows immediately one advantage of shape IV over the other three, viz., that in different sizes it covers a keynote range of 4, and not only 3, semintones. This is equally to say that in one size it covers a 4-semitone range of pitches for the 2-octave range to be matched (here taken arbitrarily to go up to C-above middle-C). Review of Table I shows moreover that shape IV is equal with Shape II in missing only one note of the 2-octave interval; and superior to it in providing 3 and not only 2 "extra" semitones which might match "accidentals" in a melody.

The dimensions of case 9, viz., 3.12 m (long, say) x 2.94 m (high, say) x 2.62 m wide, for example, are close to those of many suburban-home bathrooms. **Architects might with some advantage adopt these dimensions,** as they stand or perhaps scaled up or down to accommodate, say, a standard ceiling height; and offer the client home-builder a bathroom fit for a king to sing in?

However, especially if the bathtub is not sunken flush with the floor, the resonances of a real bathroom, complete with excrescences, may not match exactly enough the sets here discussed. Some direct experimentation seems called for.

HIGH-LEVEL IMPULSIVE NOISE SOURCE

Leigh C. Kenna,
National Acoustic Laboratories, Sydney.

J. Acoust. Soc. Am. **71** (2), 483, Feb. 1982.

To assist in the development of hearing protection and communication systems for use by crews of artillery weapons, a source of high-level impulsive noise has been produced which has operating characteristics allowing its use within the laboratory. Generating peak sound pressure levels in excess of 180 dB and amenable to automatic operation, the source produces no fumes or high temperatures. Its basic principle of operation is the sudden release of compressed air to the atmosphere from a pressure chamber. The physical characteristics and acoustical performance of the source are described.

Technical Notes

Solitary waves

ANU researchers believe they may have discovered the cause of some aircraft accidents at take off and landing. They attribute these accidents to previously unrecognised phenomena called solitary waves which buffet and divert aircraft from their planned flight path. They believe the risk to aircraft is world-wide.

The researchers, Mr. Doug Christie and Dr. Ken Muirhead, led by **Professor Kurt Lambeck,** of the Research School of Earth Sciences, ANU, have been studying atmospheric solitary waves for six years.

Solitary waves were first noted in 1834 on the surface of a canal in Scotland. For the next 130 years they were regarded as a curiosity of no real importance to the physical and mathematical sciences.

The first definitive observations of solitary waves in the atmosphere were made in 1976 by the ANU Earth Sciences staff. These observations were recorded on a sensitive microbaragraph array located near Tennant Creek in the Northern Territory. An extensive investigation followed and it was realised that solitary waves are a common feature of the atmosphere.

Spectacular visible examples of solitary waves can be seen near Burketown in the south-east corner of the Gulf of Carpentaria. This solitary wave, known as the Morning Glory, is an impressive roll-cloud formation.

"Pilots in northern Queensland will not attempt a landing or take-off when the Morning Glory is in the vicinity," Professor Lambeck said, "What the pilots may not recognise is that this same phenomenon also occurs without the dramatic roll-cloud.

"Of 17 large solitary waves recorded in a two-week period in September 1980, only one was visible. Invisible waves, equally intense, come from directions other than the direction favoured by the Morning Glory."

The waves travel over long distances and are not restricted to the Gulf region. In the six-year observational period, over one thousand significant solitary waves disturbances have been recorded. Some disturbances have been tracked over hundreds of kilometres.

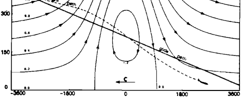


Diagram shows how the flight path of a plane is affected by a solitary wave. The aircraft is first forced upwards and then thrust downwards.

(Australian Physicist, May 1983)

The voice from space

The $400,000 U.K. amateur satellite launched into space 16 months ago is now regularly "talking" to the world. Its voice synthesiser, which allows it to report directly to schools and colleges in a normal rather than coded language, is switched on every weekend and at least 2,000 groups are receiving its bulletins worldwide.

The 48-kilogramme craft is said to be the first in space able to report back to earth in English so that amateur radio enthusiasts and students can pick up its messages and pictures with simple equipment that costs only $500-$700.

Surrey University at Guildford, near London, which built the satellite, says in a progress report that the craft—known as UOSAT or University of Surrey Satellite — is being regularly monitored from 2,000 points around the world. These are users that have been in touch with the satellite's control centre at Guildford where officials believe UOSAT's audience is much larger than this. Biggest interest is reported from Australia, followed by the Middle and Far East and the U.S.

Since the craft was launched on a Delta rocket fired from the Western Test Range in California in October 1981, the small university team has been working to stabilise the craft so that its broadcasts and camera are always beamed towards earth.

The project involved a unique method of stabilising the craft in order to cut costs. This has presented technical problems and at one stage the satellite went "deaf" for five months and would not receive commands. This was overcome by subjecting it to high power signals from the ground which were able to get through and break the silence.

Gently nudged

UOSAT is now being gently nudged into an attitude so that instead of spinning and rotating like a wobbling gyroscope it will rotate head over base. Then a 17-metre boom will be extended to act like a pendulum with its base always pointing towards earth. Success of this operation will ensure that the camera and vital microwave beacons will always be pointing towards the ground.

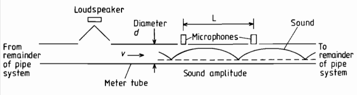
In its polar orbit, UOSAT is expected to have an operational life spanning over at least the next three years. Under the control of the satellite's main computer, the voice synthesiser gives its reports once every 96 minutes in an English voice that has a mild American accent. For instance, it gives readings of 59 gauges and 45 switches in the spacecraft which are the equivalent of an aircraft's instrument panel. It also tells the amount of solar particle radiation being experienced, the amount of current being supplied to the craft's solar cells or the temperature in the batteries or primary computer.

(John Webb in Australian Physicist, June 1983)

Flow measured acoustically

An acoustic flowmeter has been developed at the U.S. National Bureau of Standards for measuring the flow of an arbitrary fluid in a pipe. Sound waves are induced in the fluid at two frequencies whose wavelengths are much longer than the pipe diameter. The phases and amplitudes are detected by two microphones located in the wall of the pipe, one downstream from the other. The instrument then calculates in real time the volume flow rate of, and the speed of sound in, the fluid, independent of fluid composition or temperature. If the fluid is a gas, the instrument calculates the temperature, given the molecular weight and specific heat ratio.

If there is an independent measurement of the pressure in the pipe, the flowmeter also measures gas density and mass flow rate. The device is non-intrusive and bidirectional, can operate in a noisy environment and can respond to rapid changes in flow and temperature. Due to the long wavelength, measurements



are independent of flow, temperature or density profile. A patent has been applied for and a non-exclusive licence is available.

The instrument consists of a length of pipe or tube through which the fluid flows, with a loudspeaker or other sound source connected to the pipe so that it can introduce sound into its interior. Some distance from the loudspeaker, two small broad-band microphones or pressure sensors are mounted in the pipe wall with their diaphragms flush with the inner surface of the wall. One microphone is downstream of the other at a distance equal to at least six pipe diameters. The sound generated by the loudspeaker consists of two sine waves, one twice the frequency of the other, such that the distance between the microphones is half a wavelength at the lower frequency. The instrument measures sound amplitudes and uses ratios of the amplitudes to determine the sound frequencies that maintain this relationship over a broad temperature range. This gives the speed of sound and, for a gas, the temperature. The instrument then measures the time delay or phase difference between the sine waves detected by the two microphones to obtain the flow rate.

The prototype device consists of a brass meter tube 5 cm in diameter and about 1 metre long. Two wide-band quartz pressure transducers are used as microphones, located about 30 cm apart near one end of the tube, and a loudspeaker is mounted near the other end. These are connected by a cable to a control box containing a microcomputer, several other printed circuit boards, an audio amplifier and power supplies. In the experimental prototype a computer terminal is also connected to the control box. The device is easily scaled to tubes of larger or smaller diameter as long as the wavelength is at least six diameters. Comprehensive performance data are not yet available.

(James Potzick and Baldwin Robertson in Physics Bulletin, September 1982)

Leaks and cracks

The first **leak noise correlator,** a device using cross correlation techniques to determine the difference in the time taken for the noise from a leak to travel to two separate microphones and thus the exact location of the leak, was announced in July 1980. The Mk II version has done away with the need for manual determination of the time delay from chart recorder output: now the instrument is microprocessor-controlled and all the calculations are done electronically. Besides running an advisory service, the manufacturer (Palmer EAE) provides training facilities, as does the National Water Council Training Division for those in the water industry wishing to use the device.

(Physics Bulletin, January 1983)

Novel approach to sound reproduction

A four-dimensional sound image (i.e. including time) from a two-channel signal is claimed by the inventor of a novel sound recording/transmission system, and indeed the reviewer for *Professional Video* (1983 **9** (5) 10) found it very realistic. Hugo Zuccarelli, who works in North London, based his design on the theory that human hearing works in a similar way to holography and that what we hear is the *difference* between an incoming sound and a reference signal, not the presence or absence of sound.

An amazing feature of the Holophonic Sound System is that it is still possible to follow movement in both vertical and lateral planes using the signal from just one channel, though the width of the image is reduced. This is because its operation does not rely on phase differences between the two channels: indeed switching one channel 180° out of phase with the other does not affect the sound image. Moreover, high sound levels are reproduced without massive excursions by the loudspeaker cones. Zucarelli's explanation for this is in terms of human hearing being an active, rather than a passive, system and the signal being a biological stimulus to the brain, rather than a physical stimulus to the ear.

(Physics Bulletin, May 1983)

Auditory warnings in aircraft

Pilots have complained that auditory alarms, such as take-off warnings and fire bells, are too loud. In fact, an auditory alarm may be so loud that it is itself alarming; it may even distract the crew from everything else, except getting the noise shut off. There is a conservative engineering argument for very loud warnings, of course: when serious and potentially catastrophic events are occurring, the warning signal should certainly engage the attention of the flight crew. But the auditory warning area seemed to need systematic work on the setting of signal-power levels, on the composition of the alarm signals themselves, and on the learning and memory of these signals. **AT THE MRC APPLIED PSYCHOLOGY UNIT (APU),** Cambridge,U.K., **ROBERT MILROY** and **ROY PATTERSON** have been carrying out a research programme on these issues under sponsorship of the U.K. Civil Aviation Authority.

Among the first tasks of the research was to establish a suitable power level for an auditory warning signal. When a test subject is presented with two noisy sounds, one of which has a signal embedded in it, his judgment of which sound contains the signal depends on many variables, with a most important one being how high the signal dB level is, above the background or threshold level. From such data, a "psychometric function" curve shows how the fraction of correct detections goes up as signal strength is increased relative to the threshold level. The shape of this curve is generally ogival. It turns out that, for ordinary noise and signal spectra of the aircraft domain, a signal is easy to detect when it is 5 dB above threshold. And when it is 15 dB above threshold, it is "hard to miss"; after that point, more signal power brings negligible improvement in detectability. This result argues that an auditory warning should be at least 15 dB above the threshold caused by ambient noise.

Patterson and Milroy further propose that making the signal-strength differential much more than 15 dB would be ineffective, annoying, and needlessly disruptive to normal communication on the flight deck. For such reasons, they suggest that warnings should be limited to about 25 dB above threshold, and so a **good practical rule would be to provide a signal in the 15-25 dB range above threshold.**

The next logical step was to determine typical flight noise conditions under various flight regimes, and this was done on the BAC 111, McDonnell-Douglas DC 10, and Boeing 707 and 727 aircraft. Five phases of flight were used: takeoff, steady climb, level flight, descent, and approach. The 727 and BAC 111 were the worst cases, so further analysis concentrated on these aircraft. The worst noise over the 1.0-5.0 kHz range in these aircraft occurs in the level flight regime at cruise speeds, where background levels on the order of 50-55 dB were observed (in these tail-engined aircraft, most of the noise comes from turbulence in the boundary air flowing over the nose).

Patterson and his associates have formulated a model of the human auditory filter. Application of the model produced a "design band", some 10 dB wide, and from 15-25 dB over threshold, which showed acceptable power levels of warning signals at various frequencies, for each aircraft. A plot of these "desirable" power levels, with the power levels of present alarm signals superimposed, was most informative. Such a display showed, for example, that present takeoff and undercarriage warnings on the Boeing 727 were about 20 dB too loud.

There are some other design factors that have to be considered in designing auditory warnings. With many middle-aged men on the flight crews, there may be significant high-frequency hearing losses in some crew members, and so alarm signals above 5 kHz are to be avoided. And there is no doubt that spectral specifications and consideration of harmonics and "warbles" can improve discriminability. Work from the U.S. Navy Electronics Laboratory Centre in the 1960's proved, for instance, that the harmonic pattern of a sound influenced the correct identification rate; also, experiments showed that confusion of signals was less likely if the signals differed on several dimensions (wave shape, number of formats, etc.), than if the signals differed on just one dimension.

(Extract from J. Acoust. Soc. Am., June 1982)

New seismic technique

A small research team in the University of Sydney, Department of Geology and Geophysics, claims to have taken the world lead in the development of a new technique which will enable the coal mining industry to plan new mines more efficiently and more safely.

The **new "in-seam seismic" technique** will save millions of dollars in mining costs by giving an accurate picture of the layout of "fracture zones" — areas of broken-up coal rubble which pose dangers of roof collapse and are uneconomic to mine.

The culmination of three years' work by the team has been to create a world record for the distance over which sound waves from test "shots" of explosives have been recorded through a coal seam — 2.5 km compared with only 1 km in any previous experiment.

The significance of such a long distance is that coal mine developers will not only be able to "see" ahead of existing working faces in their coal mines, but will be able to plan mining procedures for entirely new coal fields well in advance: if a fracture zone (or "fault") is detected, the direction of mining can be planned to cut across it quickly instead of having to follow it for hundreds of metres, as is now often the case.

The practical implementation of the project, which involved solving many new technical and logistical problems, was largely the work of technical staff from the Department of Geology and Geophysics.

Describing the most recent project at the Invincible Colliery, north of Lithgow in N.S.W., Mr. **Phil Manning,** the Senior Technical Officer in charge, said the logistical problems had been "horrendous".

"More than 80 holes had to be drilled about two metres into the coal face to take the explosives", he said. "Just getting into a coal mine and finding your way around is difficult, and it was only the willing co-operation from mine personnel at all levels that enabled us to have the 'shot holes' surveyed and drilled and the shots fired", he said.

"At one stage, when we were putting shot holes into a part of the mine abandoned because of roof failure, we had to wade through water up to shoulder level, and one of the Mine Deputies actually found it easier to swim."

Mr. Manning said that because of safety factors and extraneous noise, firing of the explosive charges could only be carried out on weekends, and even then only by a Mine Deputy with a special licence to fire explosions underground.

In order to record the sound wave travelling along the coal seam, four holes, varying in depth from 100 to 220 metres, were drilled in an adjacent valley, at distances of up to 2.5 km away, east of the Invincible Colliery. These accommodated geophones which were designed and built in the Department.

Mr. Manning added: "We had to devise an intricate telemetry system to 'trip' a recorder on the surface near the geophones to record signals from them, which typically last for only about four hundredths of a second.

This involved having a manned detector down the mine to pick up a signal from an explosion and send it **via** telephone wires to a manned transmitter at the pit head.

The radio transmitter then sent an encoded signal via a repeater station at the top of an intervening mountain range, onto a receiver, where the signal was decoded to activate the recorder. The encoding and decoding was necessary to avoid the possibility of radio 'static' accidentally tripping the recorder."

Information from the four buried geophones, fanned out at half-kilometre intervals and picking up vibrations from the 84 separate explosions along the face of the coal mine, will enable researchers to build up a very accurate picture of faults in the proposed East Invincible extension.

An important future application of the in-seam seismic techniques will be in "longwall" mining which employs huge longwall mining machines costing more than $8 million each to scoop out upwards of $20,000 worth of coal per day. Areas of non-coal cause great damage to these machines, and fractured zones can delay them for many weeks.

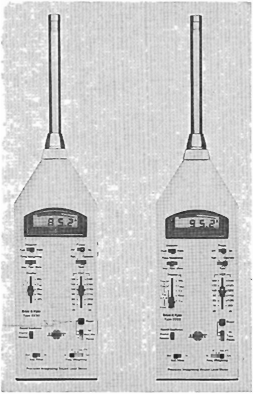
The longwall method will increasingly replace the traditional "board and pillar" method, and a longwall machine is already in operation at the Angus Place Colliery, also near Lithgow. It is expected that in-seam seismic evaluation will be carried out at the Angus Place Colliery in the near future.

(Extract from The University of Sydney News, 19 Oct. 1982)

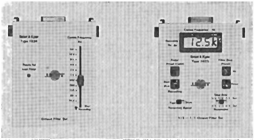
NEW BRUEL & KJAER PRECISION INTEGRATING SOUND LEVEL METERS

Two new Type 1 Impulse Precision Integrating Sound Level Meters Types 2230 and 2233, and two Filter Sets Types 1624 and 1625 have been introduced by Bruel & Kjaer. Their comprehensive facilities and high precision make them ideal for all kinds of sound level measurements, including octave and 1/3 octave frequency analysis together with the clip-on filter sets. The meters comply with IEC651 Type 1 (Impulse), ANSI S1.4.1971 Type 1, and Australian Standard 1259-1982 Type 1 (Impulse).

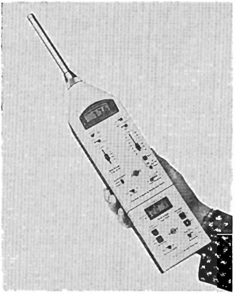
Type 2230 carries out **five independent measurements in parallel,** which enables the user to switch between the various parameters without interrupting the measurement. These are: Current, Max. and Min. SPL; L_{eq} and SEL. The Type 2233 is similar to the 2230 but measures the following parameters according to regulations applicable in the Federal Republic of Germany: L_{max}, LT (1, 3 or 5s), all appropriate L_m (according to TA-Larm and VDI2058), SEL and finally, the elapsed measuring time.



For both instruments a choice between two detector modes (RMS and Peak), three time weightings (Slow, Fast, Impulse), and four frequency weightings (A, C, Lin and Allpass) are provided. A linear free or diffuse field frequency response is obtained for the microphone by electronic frequency weighting. Measurements are displayed on a large liquid crystal display together with various warnings. The SPL is continuously monitored on a quasi-analogue 60 dB scale. AC and DC outputs allow chart or tape recordings and audio monitoring. Despite their comprehensive facilities and sturdy construction the new meters are easily held in one hand and weigh less than 1 kg.



Octave Filter Set Type 1624 and Third-Octave/Octave Filter Set Type 1625 are clip-on options for the new meters which extend their capabilities to frequency analysis. Type 1624 covers octave centre frequencies from 31.5 Hz to 16 kHz while Type 1625 covers both 1/3 octave centre frequencies from 20 Hz to 20kHz and the corresponding octave bands. Semi- or fully-automatic analysis recording is achieved with a Portable Level Recorder Type 2306 or 2309.

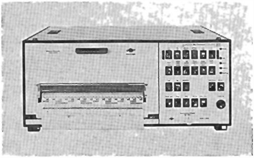


GRAPHICS RECORDER TYPE 2313

Bruel & Kjaer announce the release of Graphics Recorder Type 2313. It offers fast, fully annotated, graphic plots of measured frequency spectra and time functions as presented on the display screen of B & K Digital Frequency Analyzers, as well as documents measurement data transmitted by other equipment furnished with an IEC/IEEE interface.

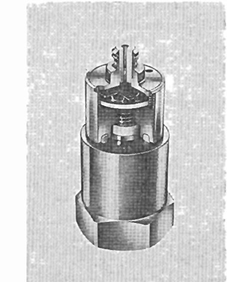
For maximum operating flexibility, a range of interchangeable Application Packages is available. These plug-in the front of the 2313 and especially format data to suit different application requirements of B & K analyzing equipment. In addition, they permit a variety of special tasks to be carried for which extra equipment would normally be required. For example, several hundred complete measurement spectra can be stored in the Recorder for future print out or transmission to other equipment. Also, new types of measurement can be made using the 2313 to reformat stored and incoming data, plus use as a system controller is possible.

Where use as a conventional alphanumeric printer/graphics recorder is concerned, the 2313 may be operated without an Application Package. High-resolution graphic plots are made using a 512-point print head and as many as 128 (ISO 646 and 2022) characters may be printed. It accepts 50 m rolls of electrosensitive paper (metallized type) and from just one roll the equivalent of 160 A4 charts can be obtained.



LINE-DRIVE AMPLIFIER TYPE 2644

A new, ultra small, unity-gain, vibration transducer preamplifier has been introduced by Bruel & Kjaer. The Type 2644 is especially designed for integral screw mounting on top of transducers and is powered by line-drive supplies, such as included with the very latest B & K Dual Channel Signal Analyzers Types 2032 and 2034. Besides permitting free choice of short or very long connection cables without sensitivity losses, it provides the convenience that only one coaxial cable is required for both power and signal transmission. Also, mechanical shock up to 50 kms^{-2} and temperature between —55 and 125°C can be tolerated, which make it ideal for use in severe environments where use of other preamplifiers is restricted.



Sectional view of Line-Drive Amplifier Type 2644 mounted directly on top of an Accelerometer. 200% actual size

Standards

ACTIVITIES OF AK COMMITTEES SINCE OCTOBER 1982

Committee AK/1—Terms Units and Symbols

The current project of this committee is the revision of AS 1633 — Glossary of Acoustic Terms. This draft will be issued for comment in July 1983.

Committee AK/2—Instrumentation and Techniques for Measurement

This committee has the most projects; the projects dealing with Audiology have been separated from AK/2 and a new Committee, AK/11, instituted. The following drafts have been sent for comment:

DR 83001 — Acoustics—Determination of Sound Power Levels of Noise Sources — Part 4: Engineering methods for special reverberation test rooms (part revision of AS 1217).

DR 82157 — Acoustics—Determination of Sound Power Levels of Noise Sources — Part 5: Engineering methods for free-field conditions over reflecting plane (part revision of AS 1217).

DR 83080 — Acoustics—Determination of Sound Power Levels of Noise Sources — Part 6: Precision methods for anechoic and semi-anechoic rooms (part revision of AS 1217).

DR 83081 — Acoustics—Determination of Sound Power Levels of Noise Sources — Part 7: Survey method (part revision of AS 1217).

The following drafts were issued for **postal ballot.**

— Requirements for tape recorders for the recording and replaying of acoustical signals in acoustical measurement systems.

— Guide for use in sound measuring equipment — Part 2: Equipment for integration of sound signals.

Other Activities

The following projects are currently on the AK/2 work programme.

— Guide for the Use of Sound Measuring Equipment — Part 3: Equipment for frequency and time analysis of sound signals. (A second committee draft has been issued under doc. AK/2/8013 and additional work is required prior to issue for public comment.)

— Pressure Calibration of Microphones by Reciprocating Technique. (One draft was prepared and issued as Doc. AK/2/81-8 and has to be reviewed prior to being issued for public comment.)

— Method of Measurement of Airborne Noise Emitted by Rotating Electrical Machinery (Revision of AS 1081). (A preliminary draft has been prepared under Doc. AK/2/81-4 and some comments have been received. These comments will be incorporated prior to submitting for comment to Committee AK/2.

Committee AK/3—Hearing Conservation

This committee has completed its present work programme with the publication of the following standards:

AS 1269-1983 — Hearing Conservation — known as the SAA Hearing Conservation Code.

AS 1270-1983 — Hearing Protection Devices.

Committee AK/4—Architectural Acoustics

This committee has published the following standard:

AS 1469-1983 — Acoustics — Methods for the Determination of Noise Rating Numbers.

The following draft was sent for postal ballot:

— Acoustics · Measurement Procedures for Ducted Silencers.

Other Activities

— Methods for Assessing and Predicting Speech Privacy and Speech Intelligibility.

— Method of Measurement of the Reduction of Airborne Sound by the Facades of Buildings. (This document is at the second committee draft stage, and is expected to be processed for public comment later this year.)

— Method of Laboratory Measurement of Airborne Sound Transmission Loss (Revision of AS 1191). (This Subcommittee chaired by Mr. E. T. Weston has prepared a draft which was issued for limited review in June 1982.)

— Ambient Sound Levels for Areas of Occupancy within Buildings (Revision of AS 2107). (A meeting was held to review the summary of public comment and the draft is now to be prepared for postal ballot.)

— Building Siting and Construction against Aircraft Noise Intrusion (Revision of AS 2021). (A second draft has been prepared and will be issued to the Subcommittee for review.)

Committee AK/5—Community Noise

The following draft will be issued for a second limited public review period:

— Acoustics — Description and Measurement of Environmental Noise (Revision of AS 1055).

The following draft has been issued for postal ballot:

— Acoustics — Method for the Measurement of Road Traffic Noise.

Other Activities

— Noise from Mechanical Equipment in Buildings. (The project approval has been received and the Scope of this project should be decided upon after discussions with the Chairman of Committee AK/5.)

Committee AK/11—Otological and Audiological Measurement

Due to the unique technical requirements of this field, Subcommittee AK/2/1, previously part of Committee AK/2, was set up as Committee AK/11, as a main committee.

The following standard was published:

AS 2586-1983 — Audiometers (Revision of AS Z43, Part 1, and AS 1591, Part 6).

Other Activities

The following projects are on the work programme of Committee AK/11:

— Audiometers for Advanced Audiological Use. (This project has been approved by SAA but has not been initiated as yet. At the last meeting of AK/11 it was decided that further investigation be carried out on the present documents published by IEC on the subject impedance meters (or immittance audiometers) prior to any work being undertaken as an Australian Standard.)

— Background Noise Levels for Audiometers Room. (This project has been approved by SAA. At the last meeting of AK/11 it was decided that investigation should be carried out to ascertain the availability of documents dealing with this subject, and that work should be started as soon as possible. Project will commence shortly.)

— Mechanical Coupler for the Calibration of Bone Vibration Used in Hearing Aids and Audiometers. (A preliminary draft has been prepared and circulated under doc. AK/2/1/80-5, but at the last meeting of AK/11 it was decided to wait for further developments to be published by ISO/TC 43 on the subject, before proceeding.)

— Instrumentation for Audiometry — Part 5: Wideband artificial ear. (Revision of AS 1591, Part 5.) (No work has been carried out on this project and the same comment as the previous project applies.)

— Electro-acoustical Characteristics of Hearing Aids — Hearing Aids with Automatic Gain Control Circuits.
(A first preliminary draft has been issued, and is awaiting finalization of IEC documents in this area, prior to moving to the next stage.)

— Methods of Measurement of Electro-acoustical Characteristics of Hearing Aids — Hearing aids not entirely worn on the listener.
(Same comments as advised for previous item.)

— Methods of Measurement of Electro-acoustical Characteristics of Hearing Aids — Magnetic field strength in audio-frequency induction loops for hearing aid purposes.
(Same comments as above.)

M. MAFFUCCI
Executive Officer
COMMITTEE AK/- ACOUSTICS STANDARDS

CHINESE ACOUSTICAL STANDARDS

A report in the Chinese Journal of Acoustics, Vol. 1, No. 1, 1982

The National Technical Committee of Acoustical Standardization, under the leadership of the State Bureau for Standardization, is a specialized organization for standardization. Its major duty is to form and to revise, as well as to conduct technical examination of the national standards of acoustics on the one hand, and to promote the spread of the technics, the exchange of experience and other activities in the field on the other. Authorized by the department responsible for the standards, the committee is to examine the standards of the imported technics and equipment and new products. It is also responsible for the technical work and contact with the Technical Committee 43 of the International Standardization Organization (ISO/TC43), and the translation and the publication of the technical materials from the ISO International Standard and other standards.

The Technical Committee consists of 32 experts in such fields as technical research, design and production of acoustical devices, who are invited from research institutes, universities and factories. The director of the committee is Ma Dayou and the deputy directors are Yu Bo, Wu Dasheng and Xu Weiyi. A secretariat under the committee is in charge of the routine work. It is located in the Institute of Acoustics, Academia Sinica.

In light of the need of the present-day work, the Technical Committee has set up four Sub-committees. They are: (SC1) **foundation of acoustics,** (SC2) **noise,** (SC3) **building acoustics** and (SC4) **ultrasonics and underwater sound.** The SC1 is in charge of the acoustical terminology, and the definition, description and measurement of the basic quantities of acoustics. The SC2 is in charge of the noise standard and measurement methods of machines, electric motors, vehicles, ships, airplanes, etc.; the environmental noise standard and measurement methods, such as the railway main line, the airport and the urban areas. The SC3 is in charge of the design standard of noise in civilian and in industrial buildings and in other environments, the control of noise and acoustical standard and measurement methods of sound insulation and acoustics and the acoustical standard and measurement methods of the architectural structure and materials. The SC4 is in charge of the acoustical standard and measurement methods of the equipment and devices of ultrasonic and underwater sound. The Sub-committees not only include those who are members of the Technical Committee, but also 28 experts invited from various units concerned. Of the 60 members, 25 are professors, associate professors or senior engineers. The director and the deputy directors of the Technical Committee are concurrently the directors of the Sub-committees. The secretariat of the four Sub-committees are individually located in the Institute of Acoustics, Academia Sinica (SC1 & SC4); the Institute of Standardization of the First Machinery Ministry (SC2); and the Institute of Physics of the Academy of Architectural Science (SC3).

Since it was set up in November 1980, the Technical Committee has organized certain departments and units to work out the preparation of the national standard. Forty three items are placed in 1981's plan. Most of these items are the basic standards urgently needed now. Nine items have been finished this year; they are: "Quantities and units of acoustics", "Acoustical levels and reference quantities", "Preferred frequencies for the acoustical measurement", "Expression of physical and subjective magnitudes of sound noise in air", "Octave and third-octave band filters used for the analysis of sound and vibration", "Standard of environmental noise of urban area", "Measurement method of community noise", "Procedures for measurement of acoustic absorption coefficient in reverberation rooms", "Free-field calibration method of underwater sound transducers".

Besides the work mentioned, the Technical Committee has also translated and published the ISO International Standards and pertinent materials. In order to push forward the work on acoustical standardization and bring it into full play in the development of production many activities will be carried out by the Technical Committee in accordance with various needs in our country.

The Technical Committee meeting will be held annually to sum up the previous year's work, examine and approve the standard, arrange the next year's work and make plans for the near future. The standardization has a close relation with industrial production, economic construction and the people's life. It is receiving more and more attention day by day and will play a more important role in the future.

(Reported by Xu Weiyi)

BOOK REVIEWS

Fundamentals of Acoustics, 3rd Edition

BY L. E. KINSLER, A. R. FREY, A. B. COPPINS, J. V. SANDERS

John Wiley & Sons, 1982, A$26.55 (soft covers) (Supplied by Jacaranda Wiley Ltd., Aust.)

"Fundamentals of Acoustics" by Kinsler and Frey has long been an accepted text book on acoustics for both undergraduate and post-graduate courses, and this 3rd Edition is indeed welcome as it is now over 20 years (2nd edition 1961) since the last major rewrite. In spite of this lengthy interval it is surprising how much of the original text has remained intact, which is an indication of its quality and presentation. The new book is of virtually the same size as the 2nd Edition although there has been some significant rearrangement and updating of its contents: the layout and type face appear more modern and there has been some change of emphasis in its treatment of subject matter, especially in the use of impedance concepts. As the book is a revision of an earlier well-established text it is probably most useful to compare its contents with that of the original.

The first four chapters cover essentially the same ground as the second edition — Vibrations, Vibrating String, Bars and Plates — but their revised treatment and greater emphasis of specific acoustic impedance allows a more instructive handling of wave motion in a string with all its side issues.

In contrast to the 2nd edition, Chapter 5 develops the wave equation in three-dimensional formalism, with full use of vector elements. This leads naturally to an introduction of velocity potentials, and to an examination of spherical waves which is dealt with much later in the 2nd edition. Also included in this chapter is an introduction to rays.

Transmission phenomena are dealt with in Chapter 6 in a revised manner, developing simple relationships for reflection and transmission coefficients in terms of specific impedances. There is an unfortunate choice of <r> as the symbol for impedance. The case of oblique angle incidence is similarly revised and more easily presented.

Chapter 7 on absorption of sound, and 10 on resonators and filters remain little changed but the two intervening chapters, "Radiation and Reception of Acoustic Waves" and "Pipes Cavities and Waveguides", contain much needed revision and additions to the material in the 2nd edition. Much greater attention has been paid to radiation of energy from a source and to waveguide and other effects in duct propagation.

Then follows three chapters of more descriptive material on environmental and architecture acoustics. The authors wisely contract to less than 100 pages this subject matter which has been exposed in infinitely greater detail in numerous other books, conference and research papers, standards and commercial literature.

Chapter 14 on Transduction is a complete revision of the three 2nd edition chapters on Loudspeakers, Microphones and Transducers, contracting them by a factor of almost 3 to 1. There is a judicious selection of the old material and more use of circuit analysis theory to explain operations and characteristics.

The final chapter on Underwater Acoustics is an improvement on the previous selection and is an acceptable introduction to this field of expertise. There is a brief but satisfactory treatment of rays and propagation in stratified layers, a useful revision of passive and active sonar concepts and finally an introduction to mode theory of underwater propagation. The authors acknowledge the introductory nature of the material by references to the authoritative texts in the field.

In summary, a text book without peer at this intermediate level of treatment and a book every acoustician should have on the shelf.

JOHN DUNLOP

Community Noise Rating, 2nd Edition

BY T. J. SCHULTZ

Applied Science Publishers, 1982, £36.00

In the Preface to this second edition, Schultz comments that soon after the publication of the first edition in 1972 there was a great increase of activity regarding environmental problems which lead to a large number of new noise rating and evaluation schemes being developed. This edition is designed to bring the story up to date.

The first three chapters have similar headings to those of the first edition, but they are enlarged in content. For example some very elementary acoustics is now included, presumably written with lay readers in mind. (The use of the logarithmic decibel scale is justified only in terms of the avoidance of handling large numbers, the added advantage of logarithmic scales relating to human sensory perceptions is not mentioned.) The problem of determining both the noise levels to which a neighbourhood is exposed and the response of people to the noise is discussed and it is pointed out that whereas some ratings have been derived from carefully conducted research programmes, others have arisen as a result of years of experience in consulting practice and these are difficult to document or to justify.

In Chapter 2 some 22 rating scales and 14 rating procedures are described and commented upon (as compared with 10 scales and 5 procedures in the first edition). The derivation of the "A"-weighting scale is discussed in some detail but surprisingly no reference is given to the work of Robinson and Whittle, published in 1964, which found that equal loudness contours for bands of noise are more nearly parallel than those for pure tones over a wide range of sound levels. (This to my mind is a satisfactory explanation for the success of the A-weighted decibel for measuring sounds of any level.) As in the previous edition, Schultz provides a salutory exposure of the derivations of the various scales and procedures that have been proposed for community noise rating. However, he tends to leave it to the gentle reader to decide on the rigour with which they have been developed and tested — the layman, who seems to have been considered earlier, is now left without guidance. For example, well researched schemes such as the Articulation Index, Statistical Centile Levels, Noise Exposure Forecast and Equivalent Energy Level are interspersed with indices which appear only to have been proposed in doctoral dissertations or in a single referenced paper. (Something called the Annoyance Index (Australia) is included, based on a 1964 N.A.L. report, but not used in this country, as far as I am aware.)

A comparison of the ratings against each other and against subjective responses follows: Three useful Tables summarise the essential factors in major rating scales, in rating procedures and in community response. Botsford's work is referred to, in which he found that A-weighted sound levels correlate with human responses as well as any of the noise ratings. Botsford also had some harsh words for researchers, consultants and noisemakers who play what he calls "The Weighting Game".

Three new chapters deal with social surveys on noise annoyance, "special matters" and some current standards on community noise. A useful summary Table of 28 social surveys on noise annoyance is provided. Since low correlations were found between noise exposure and individual response, considerable effort was put into improving questionnaire design. However, Schultz puts forward his own view that it is more fruitful to be concerned with the percentage of people who are highly annoyed, since the effects of non-acoustical variables are then reduced. He also comments on the possibility that environmental noise levels have been incorrectly measured, since "for any one observation period the dynamic range covered by the fluctuating levels never exceeds 50 dB" — the dynamic range typical of a sound level meter at any given attenuator setting! The relevance of noise levels measured at a fixed outdoor location is also questioned.

"Special matters" are those for which, in the main, there is not yet a consensus. They include the rating of low noise environments; the U.S. EPA method of formulating Environmental Impact Statements, using the Fractional Impact Method; repetitive and impulsive noise; the validity of using yearly average levels to describe community noise; corrections for pure tones and for time of day; evaluating low frequency noise and vibration. It is suggested that three models of noise annoyance may be necessary—a detectibility model for low level sounds, an equal energy model for general environmental noise and a high threshold model for infrequent high energy sources such as blast noise and sonic booms. The chapter on some current standards for community noise is very cursory and mainly relates to the United States, although the Greater London Council guidelines are also mentioned.

The concluding chapter begins by repeating the conclusions from the first edition and the comment is made that little has changed over the decade to challenge the A-weighted sound level in community noise rating, except for low frequency impulsive noises. The energy average A-weighted sound level, with or without a night-time penalty, is the most generally accepted basic measure of environmental noise world-wide, although the question of supplementary measures or corrections still needs to be explored. One contender for this, favoured by Schultz, is some measure of the noise peaks associated with individual, identifiable sources of noise. He includes some suggestions for future research including the human time constants for aversive reactions to changes in noise level and a search for an improved model of noise annoyance applicable over a wide range of community noise exposures. A total of 352 references is provided (compared to 143 in the first edition). The Index is primarily concerned with the rating scales and procedures.

To summarise: Required reading and a very useful reference for all concerned in community noise.

ANITA LAWRENCE

PRINCIPLES AND APPLICATIONS OF ROOM ACOUSTICS

By L. Cremer and H. A. Muller

Translated by T. J. Schultz
Applied Science Publishers, U.K., 1982
Vol. 1, 651 pp., £46.00
Vol. 2, 433 pp., £34.00

Volume 1

This book is a translation of the 1978 German edition and consists of three parts:

Part I. Geometrical room acoustics
Part II. Statistical room acoustics
Part III. Psychological room acoustics

Volume 1 is intended to be "of primary interest to everyone involved in building construction, architects as well as civil engineers; it will also be valuable for recording engineers and all others who are interested in room acoustics, whether as performers or listeners".

Despite its size, Vol. 1 is a very readable book. The style of Part I, devoted to **geometrical room acoustics,** is that of a discussion using very little mathematics but instead some excellent diagrams. Practical examples of the ideas abound including references to the acoustics of numerous famous buildings including the whispering gallery of St. Paul's Cathedral, a wedge-shaped cave near Syracuse in Sicily, the Capitol building in Washington, the Royal Albert Hall, etc.

The authors discuss many practical matters including the design of pulpit canopies, sound amplification, the design of orchestral shells, sound reflectors in halls, the shapes of ceilings and walls, and a useful chapter on Model Tests.

The discussion of **statistical room acoustics** in Part II starts with a detailed assessment of Sabine's trail-blazing experiments on the measurement of reverberation. Amongst subsequent chapters are those on coupled rooms, the measurement of reverberation time, the measurement of sound absorption and a discussion of various acoustic criteria relating to rooms. The treatment uses more mathematics in this part but still is basically descriptive with detailed discussions of many applications and experimental methods. An example of some of the difficulties experienced by the early workers in this field may be read in an extract from Sabine's writings quoted by the authors:

"The next experiment was on the determination of the absorption of sound by wood sheathing. It is not an easy matter to find conditions suitable for this experiment. Quite a little searching in the neighbourhood of Boston failed to discover an entirely suitable room. The best one available adjoined a night lunch room. The night lunch was bought out for a couple of nights, and the experiment was tried. The work of both nights was much disturbed. The traffic past the building did not stop until nearly two o'clock, and began again about four. The interest of those passing by on foot throughout the night, and the necessity of repeated explanations to the police, greatly interfered with the work." Sabine, W. C., "The Variation in Reverberation with Variation in Pitch"; in: *Collected Papers on Acoustics,* No. 2, Harvard University Press, Cambridge, 1927 (from *Proceedings of the American Academy of Arts and Sciences,* XLII, June (1906) No. 2).

An important chapter in Part II is a long one dealing with the physical laws that govern sound absorption. This topic is one for which Professor Cremer has become well-known and again the discussion is conducted with a minimum of mathematics. Included are the causes of sound absorption at low, medium and high frequencies and the effects produced by resonators, furniture and people.

Part III **(Psychological room acoustics)** deals with the question: "What do we mean when we say that a room has good acoustics?" The opening chapter contains some perceptive comments on the way in which opinions are formed in relation to a new concert hall. The authors point out, that for a listener in a concert hall, the ear is the final judge. "If the judge is a well-known musician or music critic, his assessment of the acoustics will usually be accepted as valid even though it may not be based upon observations that others could reproduce. No acoustical consultant would dare to challenge the auditory evaluation of a music critic or to suggest that his views be put to an objective test!"

In similar vein there is a fascinating account of the evolution of opinions. "For instance, at the first rehearsals in a new hall the artists tend to react either very cautiously or with extreme judgments ('fantastic' or 'disaster'). It is very important in such cases to take into account the hall in which they are accustomed to play. Just after the opening of a new hall, which usually entails a spectacular artistic event (or at least a social celebration), there is usually a 'happy ending' mood; this may indeed be a good time for the acoustics consultant to gather favourable acoustical opinions of the hall! During the next phase, however, one must expect increasingly critical opinions as the number of people grows who hear the hall for the first time. And as with all subjective judgments, the discontented critics get more attention than the contented ones. Whoever is critical of the hall is at least interesting; whoever praises the hall risks the accusation of insufficient listening experience or of poor acoustical judgment." The bulk of this chapter is devoted to the elements of psychoacoustics and includes treatments of loudness, pitch and localisation problems.

Then follows a long chapter devoted to the judgment of acoustical qualities of rooms including treatment of the difference limen for reverberation time, articulation tests, subjective evaluations, electroacoustic simulation, a detailed discussion of dummy heads, and a long section on factor analysis.

In the final chapter an attempt is made to relate subjective judgments to objective criteria despite the acknowledged large areas of disagreement concerning the most important factors involved. Graphs are presented showing recommended values of reverberation times for speech, concert halls, opera houses and churches. Also discussed are the effects of echoes and the achievement of acceptable background noise levels.

Volume 2

With respect to Volume 2, labelled Part IV of the complete work, the authors state that: "Because of its greater mathematical content, it is addressed more to the acoustician — who may be either a physicist or an engineer — though for him it can still be regarded as an introduction to theoretical acoustical problems, even with respect to noise abatement." Vol. 2 is in fact more like a regular textbook than is Vol. 1 although many practical applications are discussed and there is frequent reference to the historical development of ideas. As the translator remarks: "The reader may be surprised at the great amount of cross-referencing between the four parts of the (complete) work, until he recognises that he is being presented with a relatively small number of important acoustical phenomena, seen from four different viewpoints, much as musical themes appear, and reappear transformed, in the movements of a symphony".

The first three chapters cover all the necessary wave concepts including field equations, impedance definitions and reflection and transmission at walls. The next three chapters are devoted to a thorough study of the impedance tube; its properties, measurements using the tube and a study of absorption within the tube.

Chapters 8 to 10 present a comprehensive treatment of practical absorbers including porous materials, resonators and stiff plates. Then follow three long chapters that deal with the wave theory of rectangular rooms. There is an extensive treatment of undamped waves, damped eigen modes, forced vibrations of rooms and statistical aspects including high frequency level fluctuations and diffusion. In view of the thorough nature of the discussion it seems a pity that the problem of the non-rectangular room did not receive more than passing mention.

The final chapter gives an interesting account of the causes of sound dissipation in rooms. The authors' final comment is: "With good reason Knudsen has designated the problem of sound dissipation in air as 'an interesting example of the inseparability of pure and applied science'. Therefore, it is an especially suitable topic with which to conclude a book whose endeavour has been both to interest those readers immediately concerned with room-acoustical problems in the general laws of physics, and to interest physicists in the special problems of room acoustics."

HOWARD POLLARD

PUBLICATIONS by AUSTRALIANS

We are indebted to Richard Rosenberger of U.NSW for assistance in preparing the following lists of publications. Within each year the references are arranged alphabetically by first author.

1981

Acoustic Emissions Associated with Fracture Processes in Structural Steels
G. CLARK*, D. J. H. CORDEROY, N. W. RINGSHALL, J. F. KNOTT
**Materials Research Labs., Ascot Vale, Vic.*
Metal Science **15**, 481-491 (1981).

Acoustic Emission and Microstructure in Aluminium Alloys 7075 and 7050
S. M. COUSLAND, C. M. SCALA
Aeronautical Research Labs., Dept. of Defence, Melbourne.
Metal Science **15**, 609-614 (1981).

1982

Codirectional TE-TM Mode Conversion Through Codirectional and Contradirectional Acoustooptic Interactions
L. N. BINH
Dept. of Elec. Eng., Monash Univ., Clayton, Vic.
Appl. Phys. Letters **40**, 650-652 (1982).

A Computerised Approach to the Characterisation of Ultrasonic Immersion Transducers
D. S. BLOSER
Non-Destructive Testing, Aust., **19** (1/2), 9-13 (1982).

Assessment of Community Noise Exposure from Rifle Shooting
R. BULLEN, A. HEDE
NAL, Sydney, N.S.W.
J. Sound. Vib., **82** (1), 29-37 (1982).

The Effects of Multichannel Compression and Expansion Amplification on Perceived Quality of Speech
D. BYRNE, G. WALKER
NAL, Sydney, N.S.W.
Aust. J. Audiology, **4** (1), 1-8 (1982).

Alignment of Filter-assisted Vented-box Loudspeaker Systems with Enclosure Losses
R. A. R. BYWATER, H. J. WIEBELL
Prahran, Vic. 3181
J. Audio Eng. Soc. **30**, 306-317 (1982).

The Influence of Flow on the Acoustic Characteristics of a Duct Bend for Higher Order Modes
A. CABELLI
Div. of Energy Technology, CSIRO, Melbourne, Vic.
J. Sound Vib., **82** (1), 131-149 (1982).

Feedback, Sensitivity and Stability of Audio Power Amplifiers
E. M. CHERRY
Dept. of Elec. Eng., Monash Univ., Clayton, Vic.
J. Audio Eng. Soc. **30**, 282-294 (1982).

Nested Differentiating Feedback Loops in Simple Audio Power Amplifiers
E. M. CHERRY
Dept. of Elec. Eng., Monash Univ., Clayton, Vic.
J. Audio Eng. Soc. **30**, 295-305 (1982).

Acoustically Evoked Activity of Single Efferent Neurons in the Guinea Pig Cochlea
A. R. CODY, B. M. JOHNSTONE
Dept. of Physiology, Univ. of W.A.
J. Acoust. Soc. Am., **72** (1), 280-282 (1982).

Impulse Duration: A New Instrument for its Measurement
R. COOK
Advanced Measurement Technology Section, NAL, Sydney, N.S.W.
Appl. Acoust. **15** (3), 205-222 (1982).

Normal Mode Theory: The Role of the Branch-line Integral in Pedersen-Gordon Type Models
M. HALL
RANRL, P.O. Box 706, Darlinghurst, N.S.W. 2010
J. Acoust. Soc. Am. **72**, 1978 (1982).

The Detection, Transmission and Interpretation of Acoustic Emission Signals
R. W. HARRIS, B. R. A. WOOD
CSIRO Division of Mineral Physics, Lucas Heights Research Labs., Sutherland, N.S.W. 2232
Metals Forum **5**, 210-216 (1982).

Community Reaction to Noise from a Suburban Rifle Range
A. HEDE, R. BULLEN
NAL, Sydney, N.S.W.
J. Sound. Vib., **82** (1), 39-49 (1982).

The Prediction of Sound Fields in Nondiffuse Spaces by a "Random Walk" Approach
G. KRUZINS, F. FRICKE
Dept. of Architectural Science, Univ. of Sydney, Sydney, N.S.W.
J. Sound. Vib., **81** (4), 549-564 (1982).

The Relationship between Hearing Loss and Incapacity
J. MACRAE
Audiology Research Section, NAL, Sydney, N.S.W.
Aust. J. Audiology, **4** (1), 10-13 (1982).

A Damped High-Cut Cavity Vent for Profound Hearing Loss
J. MACRAE
NAL, Sydney, N.S.W.
Aust. J. Audiology, **4** (1), 22-25 (1982).

A High-Cut Sound Channel Cavity
J. MACRAE
NAL, Sydney, N.S.W.
Aust. J. Audiology, **4** (1), 16-17 (1982).

Techniques for Evaluating the Effectiveness of Earmould Vents
J. MACRAE
NAL, Sydney, N.S.W.
Aust. J. Audiology, **4** (1), 18-20 (1982).

Ultrasonic Characteristics of a Rock Mass
C. K. McKENZIE*, G. P. STACEY, M. T. GLADWIN
**Julius Kruttschmitt Mineral Research Centre, Univ. of Queensland, St. Lucia 4067*
International J. Rock Mech. & Mining Sci. **19**, 25-30 (1982).

Elastic Wave Propagation in Solids in Relation to Acoustic Emission
H. F. POLLARD
School of Physics, Univ. of N.S.W., Kensington, N.S.W. 2033
Metals Forum **5**, 158-166 (1982).

Analysis and Assessment of Musical Starting Transients
H. F. POLLARD and E. V. JANSSON*
School of Physics, U.N.S.W., Kensington, N.S.W. 2033
**Royal Institute of Technology, Stockholm*
Acustica **51**, 249 (1982).

Measurement of Basilar Membrane Motion in the Guinea Pig Using the Mossbauer Technique
P. M. SELLICK, R. PATUZZI, B. M. JOHNSTONE
Dept. of Physiology, Univ. of W.A.
J. Acoust. Soc. Am., **72** (1), 131-141 (1982).

Bioacoustics of the Ear of the Bushcricket Hemisaga (Saganae)
(1) R. O. STEPHEN, (2) W. J. BAILEY
(1) Dept. of Physiology, Univ. of W.A., Nedlands 6009, W.A.
(2) Dept. of Zoology, Univ. of W.A., Nedlands 6009, W.A.
J. Acoust. Soc. Am., **72** (1), 13-25 (1982).

The Perception and Appreciation of Richness and Timbre in Rooms for Music
D. VAUGHAN
G.P.O. Box 1515, Adelaide, S.A.
Appl. Acoustics, **15** (4), 289-306 (1982).

Learning Effects with a Closed Response Set Nonsense Syllable Test
G. WALKER, D. BYRNE, H. DILLON
NAL, Sydney, N.S.W.
Aust. J. Audiology, **4** (1), 27-31 (1982).

1983

Wind-generated Surface Noise Source Levels in Deep Water East of Australia
A. S. BURGESS, D. J. KEWLEY
Defence Research Centre, Salisbury, S.A.
J. Acoust. Soc. Am. **73**, 201-220 (1983).

The Effect of Test Difficulty on the Sensitivity of Speech Discrimination Tests
H. DILLON
National Acoustic Labs., Millers Point, Sydney
J. Acoust. Soc. Am. **73**, 336-344 (1983).

The Physics of Organ Pipes
N. H. FLETCHER, S. THWAITES
Dept. of Physics, Univ. of New England, Armidale, N.S.W. 2351
Sci. Amer. **248**, 94-103 (1983).

Improved Methods for Determining Eigenfunctions in Multi-layered Normal-mode Problems
M. HALL*, D. F. GORDON, D. WHITE
**RAN Research Lab., Rushcutters Bay, Sydney*
J. Acoust. Soc. Am. **73**, 153-162 (1983).

Nonlinear Vibrations in Plates and Gongs
T. D. ROSSING*, N. H. FLETCHER
Dept. of Physics, Univ. of New England, Armidale, N.S.W. 2351
**On leave from Northern Illinois University*
J. Acoust. Soc. Am. **73**, 345-351 (1983).

ACOUSTICAL SOCIETY OF CHINA

Received from the Acoustical Society of China recently have been exchange copies of Acta Acustica published bimonthly in Chinese with an English contents list and English captions on all diagrams; and a copy of Applied Acoustics published quarterly, again with an English contents list. Our acoustical friends in China very thoughtfully included in the parcel an English-Chinese Dictionary of Acoustical Terms. It is quite an education to look up the Chinese characters for some well-known acoustical terms. Reproduced here are two extracts from the dictionary.

STOP PRESS

We have just received Vol. 1, No. 1 of the new Chinese Journal of Acoustics published in English. The contents of this issue are given in the International News section.

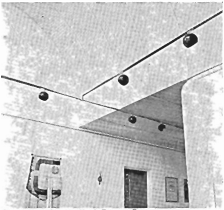
noise reduction 减噪，噪声降低
noise-reduction coefficient 降〔低〕噪〔声〕系数
noise-reduction slit 降噪缝隙
noise reduction system 降噪装置
noise-rejected tube 噪声抑制管
noise remover 干扰抑制器
noise selection 噪声选择
noise sensitivity 噪声灵敏度
noise shield 防噪罩，隔噪罩
noise signal 噪声信号
noise silencer 静噪器，消声器，噪声抑制器
noise source 噪声源
noise speckle 噪声斑点
noise spectrum 噪声谱
noise spot 噪声〔引起的〕斑点
noise squelch 噪声消除器
noise-stop 抗噪声的，静噪的，减噪声的
noise stop device 防噪装置
noise stopping 噪声抑制，静噪
noise strength strandard 噪声强度标准
noise stretching 噪声扩展
noise suicide circuit 抗噪声电路，噪声抑制电路
noise-suppressing system 噪声遏抑系统
noise suppression 噪声遏抑

impact 碰撞
impact elasticity 撞击弹性
impact force 撞击力
impact loss 碰撞损失
impact microphone 撞击传声器
impact noise 撞击噪声
impact-noise analyser 撞击噪声分析器
impact noise signature 撞击特征噪声
impact sound 撞击声
impact sound insulation 撞击声隔绝
impact sound level 撞击声级
impact-sound transmission level 撞击声透射级
impact strength 撞击强度，抗撞强度
impact velocity 碰撞速度
impact vibration damper 撞击振动减振器
impair 损害，损伤，削弱
impairment of hearing 听力损伤，耳聋
impairment of hearing for conversational speech 语言听力损伤
impedance 阻抗
impedance analogy 阻抗型类比
impedance angle 阻抗角

LUTHER COLLEGE'S ART DEPARTMENT is quieter than most, thanks to a RIPPLE SOUND CEILING SYSTEM!

Entrance to the Art Department

A main class room with Ripple Sound ceiling



Curved Ripple Sound ceiling in Entrance Foyer

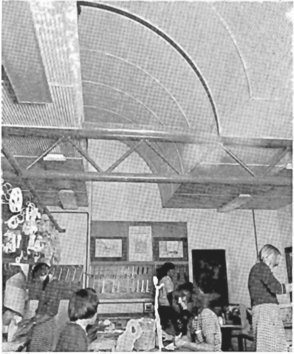
The Architects, Loftus-Hills Harkin & Ziersch, who designed the Art Department at Luther College, Croydon, Victoria, looked for a ceiling that would reduce noise levels, as well as providing efficient thermal insulation and maximum reflection of natural light. The material to be used should also have the flexibility to follow their structural design. They found the answer in Renhurst's RIPPLE SOUND CEILING SYSTEM.

A RIPPLE SOUND Ceiling System provides –

- **Excellent sound absorption**
- **Effective thermal insulation**
- **A decorative maintenance-free surface**
- **A dramatic increase in light reflection**

The RIPPLE SOUND System comprises corrugated, perforated aluminium with polyethylene and bulk insulation above. It is designed as a lightweight ceiling lining, easily suspended from new or existing roof structures.

Sound Absorption tests by recognised independent authorities prove that RIPPLE SOUND is a most effective system for controlling noise, and its low cost is also an attractive feature. We'll send you comparative test results. Just indicate on the coupon.



Ripple Sound follows curves of light recess

RIPPLE SOUND

manufactured and installed by

RENHURST INDUSTRIES

A unit of James Hardie Industries Limited
Incorporated in N.S.W.

Renhurst Industries
Faigh St., Mulgrave, Vic. 3170
Please send me Test details ☐ & literature ☐
about RIPPLE SOUND

Name..

Company..

Address..

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Bris.	376 3222
Adel.	255 7666
Perth.	451 5666

RH170