Acoustics Australia

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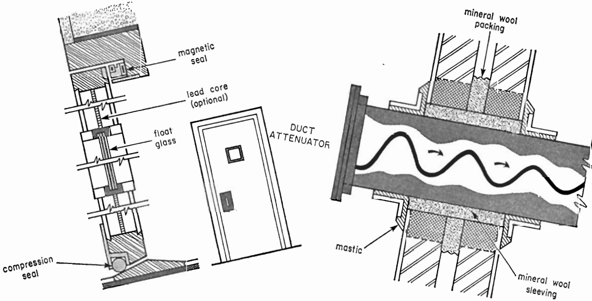
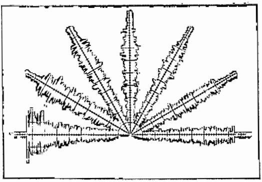
AUSTRALIAN ACOUSTICAL SOCIETY



- **Architectural Acoustics**



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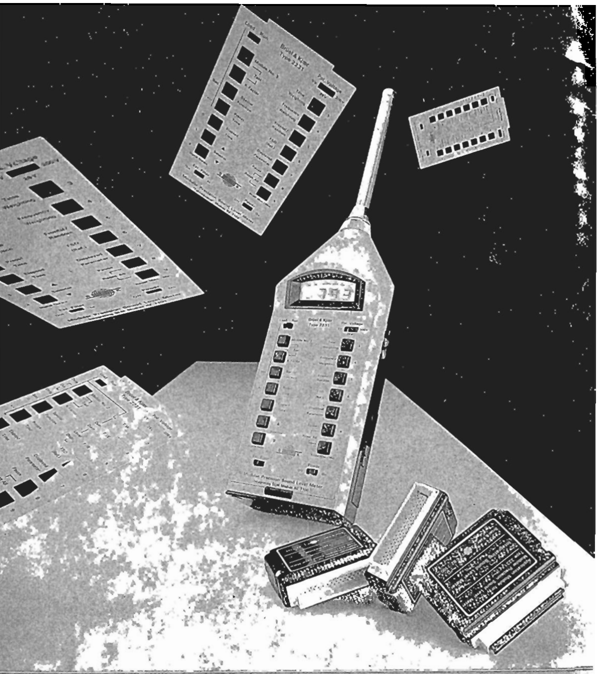

Acoustics Australia

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NEWS

From the President

Welcome — Fellows

It was a particular pleasure, and a unique one for any President to date, that one of my first duties as President of the Society was to advise Howard Pollard and Paul Dubout that Council had been pleased to ratify proposals that they be elevated to the grade of Fellow of the Society.

The citations which accompany these honours appear within the body of this publication.

The Society's Articles of Association have always provided for the grade of Fellow but until now we have had only one Fellow, the late Vivian Taylor. Originally there was a limit on the total number of possible Fellows of the Society in order, presumably, to ensure that this grade was truly an honour to which only a few could aspire.

Over the years it became evident that this restriction was acting as a deterrent to the sponsorship of Fellows and it was removed by resolution at the 1981 AGM of the Society. Nevertheless no sponsorships for Fellows were forthcoming and Council sought to rectify this by establishing a set of guidelines relating to the procedures for sponsoring Fellows. These were published in the April 1983 issue of Acoustics Australia.

Council's desire to stimulate the sponsorship of members to the grade of Fellow is apparent at the beginning of the guidelines, viz.,

> "Each Division's Membership Grading Committee will examine the members in its division every two years to see if any member's work, ability, or service to the Society, warrants elevation of that member to Fellowship, and shall seek a sponsor for such member. Alternatively, any member or Fellow may sponsor a member for elevation".

To avoid any possibility that Council could appear to be favouring members of Council, it resolved that serving members of Council or of the Council Standing Committee on Membership were ineligible to be sponsored as Fellows. The 39th meeting of Council in 1987 decided that this was an unnecessary restriction and resolved that such members would be eligible for sponsorship but that they could not be sponsors and in the event of being proposed themselves, could take no part in any deliberations regarding that sponsorship.

So it remains that the sponsorship of Fellows lies in the hands of members. Over the past few years a number of members have expressed concern about the lack of Fellows of the Society, yet remained reluctant to rectify the situation until 1987.

In welcoming and congratulating Howard and Paul, I hope that they are but the forerunners of many of our members who undoubtedly merit the honour of becoming Fellows of the Society.

Bob Boyce,
President.

ACT

February Technical Meeting

Twenty people attended a discussion and demonstration of the Environmental Noise Model (ENM) on February 16, 1988. This model is a package of computer programmes developed especially for government atuhorities, acoustic and environmental consultants, industrial companies and any group involved with the prediction of noise in the environment. The programme allows the user to input data from up to 100 noise sources. For the predicted noise level, the effects of attenuation due to distance, barriers, ground, wind and temperature can be included. The package has been endorsed by the Australian Environment Council.

David Southgate, Secretary of the Environment Noise Control Committee of the Australian Environment Council, explained the background to the development of the Environmental Noise Model. The package has been produced by RTA Software Pty. Ltd., and **Renzo Tonin** described the components of the package and gave a demonstration using the equipment provided for the evening by the ACT Administration. **George Knight** from the Environment Group of the ACT Administration provided comments from the viewpoint of a user.

The discussions on the model continued during an enjoyable meal at the Canberra Club which was attended by most of those who came to the meeting.

Marion Burgess

NSW

August Technical Meeting

A seminar on "Community Response to Aircraft Noise" was held on August 20, 1987. The speakers and their topics were:

- **Dr. Ian Diamond,** from the Department of Social Statistics, University of Southampton, England. "Community Response to Noise from General Aviation in the UK".
- **Mr. Leigh Kenna,** Director of Environmental Engineering, Airways Division of Transport. "Airship Noise Measurements".
- **Mr. Gareth Morgan,** NSW Regional Superintendent of Environment and Security, Airways Division, Commonwealth Department of Transport. "Complaints Concerning Aircraft Noise in the NSW Region".

AGM and September Meeting

The AGM of the Division was held on September 15, 1987 at the Hyatt Kingsgate Hotel.

The AGM was followed by an address and demonstration by **Renzo Tonin** of the Environmental Noise Model. This is a computer programme developed by RTA Software and is endorsed by the Australian Environment Council.

October Technical Meeting

Dr. Ulf Sandberg, of the Swedish Road and Traffic Research Institute, is a world authority on tyre/road noise. He kindly agreed to give a talk at a technical meeting of the NSW branch of AAS on "Tyre/road Noise — a major component of traffic noise: reflections on the past and projections for the future". This meeting was held on October 26, 1987.

VIC

February Technical Meeting

The first meeting for 1988 was held at the Environment Protection Authority's new offices on February 11.

The guest speaker was **Renzo Tonin** of RTA Software Pty. Ltd., the topic of the discussion being of course RTA's newly developed Environmental Noise Model. Renzo led the meeting of approximately 35 members through the various algorithms on which the model is based. Of particular interest was the method of predicting the effects of wind on barrier performance. A practical demonstration of the programme was then provided at the meeting using the recently installed EPA equipment.

The presentation by Renzo was well received, with a series of penetrating questions following the demonstration. The provision by the EPA of the venue, equipment and refreshments were greatly appreciated by the members.

Robert Burton

WA

August Technical Meeting

In August the WA branch was briefed on the **M.T.T. Quiet Bus Programme.** A site visit was held at J. W. Boltons who do most of the bodywork for the Metropolitan Transport Trust. The latest "PR100 Renault" buses were inspected at different stages of assembly. A full array of acoustical material has been implemented, ranging from pre-cut absorbing foam panels for the bodywork, all numbered and interchangeable if required, to extensive noise barrier treatment of the engine incorporating loaded vinyl and marine grade plywood.

The comfortable ride which followed convinced the division members on the vibration isolation efficiency and super-quiet exhaust system.

End of Year Function

The Christmas visit took us to the **OMNIMAX theatre.** This theatre, (the only one of its kind in Australia so far) projects total vision films. The film we viewed was on the US space programme and we were able to experience space travel (well, almost). To go with it, a superb sound system creates a true concept of "perfect" acoustics. Hence a rocket blast-off sounds like the real thing and a trip in a helicopter cockpit makes you feel at the "command". To create this atmosphere, substantial quantities of rockwool have been laid over the whole internal surfaces, as have been many layers of plasterboard to isolate the building from the nearby freeway. A first class acoustics design.

Michael Pons

INCE President

William Lang, from USA, has been elected President of INCE and succeeds **Fritz Ingerslev** from Denmark. Lang is currently an adjunct professor of physics at Vassar College and a programme manager for the IBM Corporation in Poughkeepsie, New York, USA. He has served continuously as a director of International INCE since the institute was founded in 1974.

The Australian Acoustical Society is one of the 27 member societies in International INCE which represent professionals working in acoustics and noise control on all continents of the world. A primary purpose of the institute is to sponsor the INTER-NOISE series of annual conferences in the countries of the member societies. The seventeenth International Conference on Noise Control Engineering (INTER-NOISE 88) will be organised by the French Acoustical Society and held in Avignon, France next August.

Standards

DR87268 — Acoustics and Mechanical Vibration — Definitions of Fundamental Quantities and their Expression as Levels —

For several kinds of levels, different reference quantities have been used from time to time and as it is most important that for general measurements and engineering specifications reproducible results are obtained, this draft standard proposes the most used quantities. Also for airborne sound, a special reference sound pressure is preferred according to widespread use and legal implication.

The draft provides formulae to express these quantities as levels and establishes references quantities for these levels. Single copies of DR 87268 can be obtained free of charge from any SAA office and comment should be received by SAA November 15, 1988.

AS 1948 — Acoustics — Measurement of Airborne Noise on Board Vessels and Offshore Platforms.

This supersedes AS 1948-1976 and deals with the method of measurement noise on board vessels and platforms where such noise is likely to cause disturbance or annoyance.

The standard sets out the methods and conditions for obtaining objective measurement of the noise levels and noise spectrum of airborne noise on board vessels and fixed and mobile off-shore platforms, where the surface of the noise is on or in the vessels and platforms.

Members

At the 39th Meeting of the Council of the Australian Acoustical Society in 1987, Paul Dubout and Howard Pollard were elevated to the grade of Fellow of the Society with the following citations:

Howard Pollard

Paul Dubout

"The grade of Fellow of the Australian Acoustical Society is conferred on Howard Frank Pollard for his notable research in the fields of physical and musical acoustics, his significant contributions to the teaching of acoustics while Head of the Acoustics Group of the School of Physics, University of New South Wales, for a period of 20 years, and his meritorious service to the Australian acoustic community as Editor-in-Chief of the Society's journal 'Acoustics Australia'."

"The grade of Fellow of the Australian Acoustical Society is conferred on Paul Dubout for his notable work over many years in research on building acoustics, his contribution to Acoustical Committees of the Standards Association of Australia, and for his dedicated service to the Society".

New Members

Admissions

We have pleasure in welcoming the following who have been admitted to the grade of subscriber while application for member grade is being processed.

Queensland
Mr. R. Rumble.

New South Wales
Mr. J. C. Fryer.

Graded

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

Member

New South Wales
Mr. R. H. Withnell.

Queensland
Mr. D. R. Cardnell, Mr. R. H. Rumble.

Western Australia
Mr. A. Duncan.

Australian Acoustical Society
NSW Division

EXCELLENCE IN ACOUSTICS AWARDS 1988

The NSW Division of the Australian Acoustical Society invites entries for its Excellence Award Scheme. The awards, which are being made to encourage excellence and develop community awareness of achievements in the field of acoustics will be presented for research, design or execution of projects of an acoustical nature.

A brochure outlining the scheme and including details of conditions of entry can be obtained by telephoning **Peter Griffith** at (02) 437 4611 or by writing to the Secretary, Australian Acoustical Society, NSW Division, 35-43 Clarence Street, Sydney NSW 2000.

The Society requires to be advised of intended entries by April 30, 1988.

P Knowland
Excellence Award Sub-Committee
(02) 922 4199

Letter

Conference in Hawaii

Members of the Australian Acoustical Society, and other readers of this journal may not have realised that the Acoustical Society of America and the Acoustical Society of Japan are to hold a second joint meeting at **Honolulu** from **14th-18th November 1988.** Hawaii is geographically as close to Australia that meetings of these societies are ever likely to be held, and thus it is a great opportunity for us to attend. The ASA holds two major meetings each year — the programmes and abstracts for which are circulated to subscribers to JASA. Those of you who have not yet had the opportunity to attend an ASA meeting may be interested to know that a very wide range of topics is covered, similar to those of an ICA meeting. For example, the recent ASA meeting held in Miami covered Engineering Acoustics, Psychological and Physiological Acoustics, Underwater Acoustics, Architectural Acoustics, Noise, Physical Acoustics, Structural Acoustics and Vibration, Speech Communication and Education in Acoustics, in a number of parallel sessions. In addition to the invited papers which usually commence each session, contributed papers are allotted 12 or 15 minutes presentation time, including discussion. There are usually a number of papers from non-North Americans, and, of course, in the joint meeting with the ASJ one would expect there to be a significant contribution from Japan.

Abstracts of contributed papers should be forwarded to John C. Burgess, Department of Mechanical Engineering, University of Hawaii, 2540 Dole Street, Honolulu, HI, 96822, USA **before July 8th, 1988.** (Instructions for the preparation of abstracts, which, as mentioned above are published in the JASA Meeting Supplement, are given in JASA 82, 1987, p. 389. (It is not necessary to prepare a full paper for publication.)

The meeting will be held at the Sheraton Waikiki, and special room rates will be available for delegates from Saturday, November 12th to Saturday, November 19th inclusive. Rooms for delegates will also be available at the Princess Kaiulani. However, intending participants from Australia may do well to investigate air/accommodation packages locally.

If anyone would like further information, please contact me on (02) 697 4850 (work) or (02) 487 3250 (home).

Anita Lawrence
GSBE, Univ. of NSW

Ron Carr Associates Pty. Ltd. has been formed to continue and expand the acoustical consulting practice of Ron Carr and Company Pty. Ltd. The new company is a partnership between **Peter Fearnside** and **Prof. Harold Marshall** and **Christopher Day** of Marshall Day Associates in New Zealand.

Martin Beech-Jones, who worked for Ron Carr for three years, has joined the new practice, which is located at 22 Trafalgar Road, Camberwell, Victoria 3124 — Telephone 882 9022, Fax 882 9298.

Noise-Con 88

It is expected that more than 100 papers will be presented at **Noise-Con 88,** the 1988 National Conference on Noise Control Engineering, to be held June 20-22, 1988 at Purdue University in West Lafayette, Indiana. The theme of the conference is **"Noise Control Design: Methods and Practice".** The conference is jointly sponsored by Purdue University and the Institute of Noise Control Engineering.

The conference will feature plenary sessions to open the technical programme each day. On Monday, June 20, the speaker will be Emeritus Professor P. E. Doak, of the Institute of Sound and Vibration, University of Southampton, Southampton, England and editor of the **Journal of Sound and Vibration** who will speak on the subject "Is There a 'Zero Option' in Noise Control Design?" On Tuesday, June 21, the plenary speaker will be Professor Dr.-Ing. E. Zwicker of the Lehrstuhl fur Elektroakustik, of the Technischen Universitat Munchen, West Germany who will discuss "Loudness Patterns (ISO 532 B), An Excellent Guide to Noise-Reduced Design and to Expected Public Reactions". On Wednesday, June 22, the plenary speaker will be Professor Dr.rer.nat M. Heckl of the Institut fur Technische Acustik at the Technische Universitat Berlin, West Germany, who will speak on "The Use of Mathematical Models in Noise Control Design".

The technical programme will feature special sessions on noise control of marine structures, noise control in aircraft, structure-borne noise, hydrodynamic sources of noise, non-linear acoustic imaging and rotorcraft noise control. The technical programme will include discussion of all aspects of noise control engineering.

An exhibit of instrumentation and materials for noise control will be open on all three days of the conference. In addition, tours of the Ray W. Herrick Laboratories and the facilities of the School of Mechanical Engineering will be available. Social events are planned for Monday and Tuesday evenings.

Further information: Vicki Delaney, Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907.

Noise Control Seminar

Computational methods for the solution of a wide variety of environmental noise control problems will be the theme of a newly-developed seminar by the Institute of Noise Control Engineering. The seminar will be offered on June 18-19 in West Lafayette, Indiana, and will immediately precede NOISE-CON 88.

The seminar will be of interest to all individuals with a need to understand the latest computational methods for the solution of environmental noise problems. The seminar will include informatian valuable in the solution of problems related to environmental noise control, product noise, noise source localisation, noise and vibration from structures, vehicle noise emission and aircraft noise. Computational methods and models used in popular computer programmes such as FAA's "Integrated Noise Model" and FHWA's "Stamina" will be discussed. Computer algorithms to be covered include signal processing, sound intensity, finite element analysis, statistical energy analysis, and modelling for aircraft, airport, traffic and industrial noise.

Further information: INCE, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603, USA.

Catgut Acoustical Society

A conference is being organised by Helmut Muller and Jurgen Meyer to be held in Mittenwald in conjunction with the 13th ICA, Belgrade, Yugoslavia, 24-31 August, 1989. Anyone interested in this conference is invited to write to the Catgut Acoustical Society, 112 Essex Avenue, Montclair, New Jersey 07042, USA.

Australian Bicentennary Congress of Physics

This large Congress was held at the University of New South Wales, Kensington on the 25th and 27th-29th January, 1988; Tuesday, 26th January being left free for the (approximately) 1000 delegates to attend the Australian Bicentenary celebrations being held in Sydney. The Congress included many sub-conferences organised by different professorial organisations involved in physical science. The Australian Acoustical Society organised one such sub-conference on 28th January — a one day conference on "Seismo-Acoustics and the Sea Floor Interaction" which was attended by about thirty acousticians of whom ten were from overseas. The invited speaker for this conference was Professor Alec Kibblewhite from the University of Auckland who presented a review of low frequency acoustic propagation in marine sediments. This was followed by seven papers on different aspects of sea floor acoustic and seismic characteristics. The conference was supported by an associated symposium and workshop on Sea Noise held at DSTO (Sydney) on 27th and 29th January.

J. I. Dunlop

Ultrasound Award

The American Institute of Ultrasound in Medicine (AIUM) announces the establishment of the **Terrance Matzuk Memorial Award** for innovative research in the development of ultrasonic instrumentation or technology. The awardee will be selected from abstracts submitted for presentation at the AIUM Annual Conventions. The awardee will be recognised at the Annual Awards Banquet and will receive a $1000 monetary award donated by Dymax Corporation and Philips Ultrasound and a commemorative plaque. All abstract submissions will be considered and an initial screening will be made by the AIUM Instrumentation Review Committee.

☆ ☆ ☆

The Memorial Award honours Terrance Matzuk, who died in 1985, and was an engineer, physicist, chemist, physiologist and founder of Dymax Corporation. The first Terrance Matzuk Memorial Award will be presented at the 1988 WFUMB/AIUM Meeting and Second World Congress of Sonographers, co-hosted by SDMS, to be held October 17-21 in Washington, DC. *Further details: AIUM, Conventions and Education Department, 4405 East-West Highway, Suite 504, Bethesda, MD 20814, USA.*

Guest Editorial

Special Articles:

New Directions in Architectural Acoustics

Three invited papers by prominent overseas acousticians have now been received which deal with quite diverse aspects of architectural acoustics. The paper of **D. J. Meares**, who is Head of the Sound Section in the British Broadcasting Corporation, is of special interest to all who are attempting to provide very high sound isolation at reasonable cost. A number of different forms of construction, developed by the BBC's acousticians over many years, is presented, together with measured performance data. Unfortunately, it is only too rare that such information is available outside individual consultants' files. (If this comment should inspire some of the latter to dig into their files for the benefit of all of us, I would be happy!)

Dr. Jaffe's paper is concerned with the impact of the electronic age on auditoria. Since Peter Parkin's brave introduction of assisted resonance, as a fix-it solution for the Royal Festival Hall, the use of sound systems in concert halls and other auditoria is gradually achieving respectibility. Some purists will still not accept electronic assistance for live performances of classical music, and, certainly, there are far too many dreadful installations in auditoria that cannot even cope with speech reinforcement adequately. However, with the increasing knowledge of the musical listener's binaural perception of sound and of the detailed reflection sequence requirements on the one hand, and with the increasing sophistication of sound systems on the other, concert halls and other auditoria may be designed from the outset to provide "good" acoustics to all parts of the audience. In addition, for multipurpose auditoria, it is necessary either to choose a compromise solution, or to provide for major modifications to the room volume, shape and absorption to suit different types of performance. A well-designed sound system, with inbuilt flexibility may well be a more economical solution to this common problem.

A paper by **Drs. Cops** and **Winjants** of the Acoustic Laboratory, Catholic University, Leuven, Belgium, is being held over until next issue. Their paper on the use of sound intensity measurement techniques to measure sound transmission loss is a contribution to a topic that promises to have far-reaching effects in the near future. The conventional methods of measuring sound transmission loss are time-consuming and expensive, and it is difficult to achieve similar results in different laboratories, even when in compliance with the appropriate Standards. When laboratory data are then used to predict the performance of components in real buildings there are even larger discrepancies, furthermore, if compliance measurements are made in situ, it is difficult, if not impossible to determine the most important sound paths if the overall performance is inadequate. However, sound intensity measurements should allow the energy travelling via the various paths to be quantified, and thus remedial solutions may hopefully be applied. When this is possible, there will be a great opportunity to demand proper legislative control of minimum sound isolation standards, at least in residential buildings. (It must be admitted that in Australia we are far behind many other countries in this field.) This paper will be published, together with other papers on acoustic intensity measurements, in our August issue.

These are only a few of the many areas of architectural acoustics in which developments are, or should be taking place. Owing to the paucity of regulatory requirements, and to the rarity of even carrying out specification compliance measurements in completed buildings, very little research is being carried out in many important areas, these include: airborne sound attenuation of local building materials and components, particularly of the non-propriety kind; control of impact noise transmission through floors and walls and of rain noise through roofs; the actual acceptability of ambient sound levels and reverberation times in buildings of various types; vibration isolation in buildings — particularly from ground-borne sources; propagation of sound from buildings; plumbing and drainage noise control; appliance noise; etc. etc.

Although some of the topics mentioned must necessarily be studied in field situations, several of them are best carried out in acoustical laboratories. The means for carrying out this essential, community-benefit research must be found quickly. With the completion of the new building for the National Acoustic Laboratories we have now one of the best acoustical facilities in the world — and also one of the emptiest, this potential waste of resources cannot be allowed to continue!

Anita Lawrence

(Our sincere thanks go to Anita Lawrence, who is one of our panel of Consulting Editors, for organising the papers on this special topic.—HFP.)

International Conference

Nanyang Technological Institute in Singapore is organising a conference "Noise and Vibration '89" in August 1989. The aims of the conference are to promote interaction amongst institutions and to encourage exchange of knowledge related to noise and vibration. Details from: Dr. Lim Mong King, Chairman, Conference Organising Committee, Nanyang Technological Institute, School of Mechanical and Production Engineering, Nanyang Avenue, Singapore 2263.

Inter-Noise 88

Inter-Noise 88, the seventeenth International Conference on Noise Control Engineering, will be held in Avignon, France from August 30 to September 1, 1988. This conference is sponsored by the International Institute of Noise Control Engineering and organised by the Industrial and Environmental Group of the French Acoustical Society, on the theme "Sources of Noise".

Over 350 Invited and Contributed papers will be presented at the Conference. A large technical exhibition will be open during the Conference.

Further information: Internoise Secretariat, B.P.23. 60302 Senlis Cedex, France; tel: (33) 44 58 3415, telex: 140 006 F; telecopy: (33) 44 58 3400.

Residents of Rose Bay who rang the local police to complain about the level of amplification used by Johnny Farnham at THAT party got short shrift. One woman who rang at 2 a.m. was told by an apologetic officer: "Madam, there is nothing we can do. The Prime Minister is still there."

From The Australian, 5 September 1987

Sound Insulation in Broadcasting Studio Centres

D.J. Meares
BBC Research Department
Kingswood Warren
Tadworth, Surrey
England KT20 6NP

ABSTRACT: In order to ensure that the use of studios is not unduly restricted it is essential to provide them with adequate sound insulation. Whilst many studies present the results of laboratory and field measurements of the sound insulation of constructions used in domestic buildings, virtually none give results for the more substantial walls needed in the case of studios.

This paper gives an overview of some of the field measurement results obtained by the BBC in its routine testing of studios. It particularly aims to highlight, with quantitative examples, the importance of the components which make up a composite wall, for example windows, doors, foundations etc. Though based in part on timber-framed forms of construction, other examples are for masonry walls and outside broadcast vehicle walls.

1. INTRODUCTION

In any broadcasting studio centre, the provision of adequate sound insulation is vital if the studios are to work satisfactorily. Not only does this mean excluding from studios the noise of passing traffic, vehicular, rail or aircraft, but in residential areas from, for example, pop music studios. Within the studio centre itself, sufficient sound insulation is needed to prevent one area interfering with the work of another. Even in the case of a studio and its own control room, one has to prevent howlround (acoustic feedback) between monitoring loudspeakers and recording microphones, or even tonal distortions due to low frequency sounds breaking through from the studio into the control room at a higher level than those being reproduced by the loudspeakers.

Over the years, the BBC has needed to develop a working practice in all of its studio centres such that sound insulation problems can be eliminated or at least minimised. Wherever possible this is done by a careful layout of the inter-related areas but on occasions such flexibility on site is not possible and then complex forms of construction are inevitable. In all, the BBC has many hundreds of studios for Radio, Television and External Broadcasting. Each of these has been designed to specific sound insulation criteria and has been acoustically tested to check that the partition conforms to criteria. Any departure is investigated and attempts are made to put right any major problems.

This paper is not intended to be a detailed exposition of how a studio centre should be designed. Such information can be found elsewhere (for instance, references [1-6]). It is, however, intended to highlight some examples of the ways problems can be avoided, these examples being supported by test results. For completeness, it also includes some test results on relatively complex partitions.

2. FACTORS AFFECTING AIRBORNE SOUND INSULATION

The most obvious factor in the design of the studio centre is its location, not only in the sense of whether it is adjacent to a significant source of noise but also whether there is sufficient area available on the site to space the noise generating and noise sensitive areas well apart from one another. The majority of the BBC's studio centres are, for operational reasons, located near to the centre of cities. Under such circumstances, space is at a premium and thus studios and other areas tend to be very close to one another. Only on one site at Birmingham is there sufficient space for the studios to be built in isolation of the rest of the premises, in this case, on either side of an isolated spine corridor with all the heavy plant and other machinery located at a far point on the site.

The type of wall will obviously affect sound insulation, but this choice itself can to some extent be dictated by the circumstances pertaining in the building under development. For instance if floor loading is severely limited, as it can often be when converting existing premises, then only lightweight partitions can be used. These inevitably impose an upper limit to the amount of sound insulation at low frequencies. Even if masonry walls can be used, the choice between brick, block, or concrete can affect the overall performance. Certain lightweight block work has been found to resonate and this inflicts a weakness in the achieved sound insulation characteristic. In the case of cavity walls, building regulations normally require the use of wall ties for structural reasons. Though these are relatively small elements in the wall they effectively bypass the cavity acoustically and can severely limit the overall performance. It is BBC's practice for acoustically sensitive cavity walls to use flexible wall ties (see Figure 1).

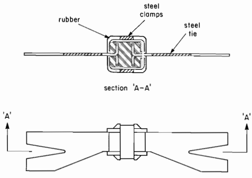

Figure 1: Flexible wall tie

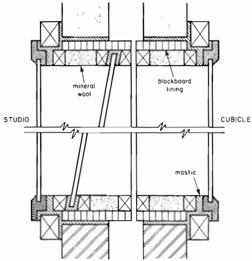

Figure 2: Triple glazed window

It is an unfortunate fact of life in any working area that one has to provide doors for personnel to pass through and windows for them to see through. These features can dramatically reduce the acoustic insulation of an otherwise effective cavity wall. A great deal of attention has to be paid to the details around these features such that the overall insulation is not too drastically reduced. Figure 2 shows a typical detail for a triple glazed acoustic window. The important details are that there is no unobstructed airborne path through which sound can be conveyed from one side of the window to the other (thus a number of sealing strips can be seen), the lining of the reveal has to be broken where it crosses the cavity, the exposed face of the reveal has to include acoustic absorption and finally the panes of glass need to be of different thicknesses such that their own resonances do not coincide at the same frequency. In the case of doors (see Figure 3) it is equally important to ensure that no gap exists between the door frame and the wall, and between the door frame and the door itself. In the former case, non-setting mastic is used to ensure a permanent seal even if the woodwork warps slightly, whilst in the latter case a combination of compression seals at the threshold and magnetic seals elsewhere are necessary. Even then the single door, unless lead loaded, is unlikely to give much more than 35 dB average attenuation. Thus the normal detail for a studio door would be two doors in series with an acoustically treated sound lobby between them. In the case of the larger scenery doors necessary for television studios, much the same approach has to be taken. Even a single massive metal door is unlikely to achieve much more than 40-45 dB attenuation and thus double doors are a preferred, though rare, choice. In this particular case, hydraulically or mechanically driven compression seals can be used at the edges of the scenery doors, but these are extremely prone to damage and have to be maintained regularly in order to protect the studio against the ingress of noise.

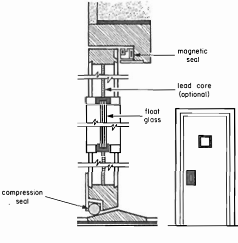

Figure 3: Studio door

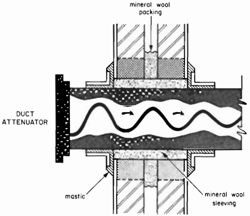

Figure 4: Duct passing through a cavity wall

Ventilation and cable ducts are other routes by which noise can enter a studio. Figure 4 shows a detail for a duct passing through the cavity wall into a studio. Once again, elements are buried in mastic to provide a semi-permanent seal whilst the duct itself is sleeved with mineral wool where it passes through the wall such that it does not acoustically bridge the cavity.

In addition, because of the possibility of sound breaking into the duct on one side of the wall and out of the duct on the other, it is necessary that this section of duct work should actually be an attenuator. For many years, the BBC has recommended that this duct attenuator should have a performance equivalent to the weakest part of the rest of the partition through which it is passing. This, however, is now proving to be something of an over-design as it does not take into account the additional loss where the sound breaks into or out of the duct. Thus some economies can now be seen and are currently being examined. In the case of cable ducts, it is similarly necessary to make sure that they do not bridge a cavity and that they do not allow airborne sound to pass through them. It is recommended that indirect routes are taken wherever possible. Thus a cable run between a studio and its control room would generally pass through the sound lobby such that the direct route is avoided. Finally, after the installation of the cables, the cable ducts should be pugged with sandbags as tightly as possible thus avoiding the airborne conveyance of sound.

Even if the acoustic designer has managed to avoid weaknesses in the partition directly linking two areas, he is still not able to relax. If the required insulation is in excess of, say, 65-70 dB, indirect flanking paths have also to be examined. One of the most common is flanking via the supporting structure, namely the floor. On many occasions, it is necessary to float the adjacent areas such that this route is also avoided. Figure 5 shows a detail for a fully floated box within a box studio. In this case, the studio floor is laid on a grid of rubber pads and the walls and ceiling are then built off this floated floor. A great deal of care is needed in specifying the loading on the pads such that the whole room does not resonate at too high a frequency which could make the floated studio worse than a non-floated studio. It is obviously essential to make sure that there are no rigid links across the cavities of both the walls and the floor. In this context, it should be noted that even the air in the cavity is to some extent a link across the cavity. Air is not totally compressible and thus it will convey sound from one wall to another or even from the structural floor to the floated floor. Recent tests [7, 8 & 9] have indicated that an upper limit for airborne flanking of anti-vibration mounts of about 30-35 dB should be anticipated.

3. MEASUREMENT METHODS

In the BBC, the most useful parameter for the assessment of sound insulation is the airborne sound level reduction. Transmission Suite measurements commonly use sound reduction index and though this could be computed from the field measurements, it is not immediately related to the subjective assessment of insulation; thus it is little used as a final parameter in the BBC. The measurement technique is illustrated in Figure 6 where a warble tone generator (frequency modulated tone) drives a loudspeaker in the source room and measurements of sound pressure level at one-third octave band centre frequency are made at a number of points in both the source room and the receive room. These two sets of sound pressure levels are averaged and the difference between them is the sound level difference.

The results are presented normally as a plot of sound level difference against frequency although for shorthand reference and comparison, it is beneficial to have a single number average for the performance of a partition. Many such averages have been proposed in the literature, but one that the BBC has found most useful for many decades is the average sound level difference centred on 500 Hz. This is normally taken over the frequency range 100 Hz — 2500 Hz. In the examples that follow, it is this 500 Hz average that is quoted together with a standard deviation of those averages, where a sufficient number of samples are available.

There are occasions where the above test method cannot be used, specifically those areas which have extremely high levels of sound insulation. Under these circumstances, a twin-channel fast fourier transform analyser is used together with a repetitive pseudo-random noise source. By synchronously averaging the source and receive signals, it is possible to improve the signals to noise ratio by up to 30 dB without imposing too great a time penalty on the duration of the test sequence.

4. ILLUSTRATIVE EXAMPLES

In order to illustrate the importance of some of the above factors, it is useful to look at the large number of lightweight partitions that the BBC has constructed over the last 20 years.

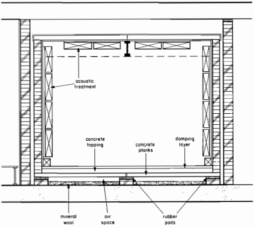

Figure 5: Box within a box floated structure

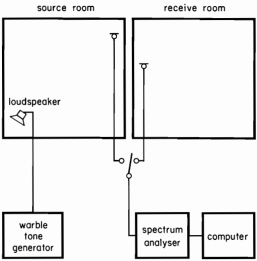

Figure 6: Conventional technique for measuring sound insulation

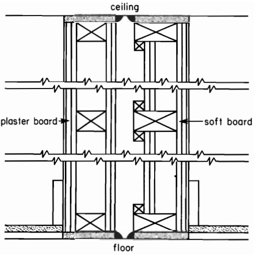

Figure 7: Double Camden partition

A particular form of construction used widely is the Camden partition shown in Figure 7. (It is so called because its first use was at the BBC's Camden Theatre). The diagram shows the Camden partition in its double skin version, but essentially each skin comprises a framework of soft wood studding on to each face of which a layer of softboard and then a layer of plasterboard are pinned. Each of these layers is approximately 12 mm thick. This form of construction has the advantage of being relatively easy to assemble on site, of being relatively lightweight, and of combining the mass of the plasterboard with the damping properties of the softboard.

Figure 8 shows the results for a number of forms of such a partition. In the first curve, the double Camden partition is equipped with a double glazed observation window and personnel doors via a lobby or corridor. The results show an average performance of 51 $\pm$ 5 dB. If the double glazed window is changed for a triple glazed window, the overall performance improves to 55 $\pm$ 6 dB. Eliminating both doors and windows increases the performance marginally to 56 $\pm$ 6 dB. Obviously in the first case the double glazed window is providing the weakest element in the partition, but once this has been replaced by a triple glazed window, it is the partition itself which becomes the limiting factor, though there is some evidence in the shape of the curves of high frequency leakage of sound.

Figure 9 shows comparative results for a triple Camden partition. In the first curve the triple Camden partition has a triple glazed window and double personnel doors with a sound lobby. The insulation provided by this is 59 $\pm$ 5 dB. In this case, the two adjacent areas share a common floor structure and it is this that is the limiting factor. In the second curve in Figure 9, this common floor has been eliminated and both of the adjacent areas are built on floated floors. The achieved performance then increases to 68 $\pm$ 4 dB. Finally, if the doors and windows are again eliminated, still with the areas built on isolated floors, the overall performance improves to 87 $\pm$ 4 dB.

As can be seen from the above examples, it is necessary to pay attention to all elements of the partition and all likely flanking paths before a net improvement in performance can

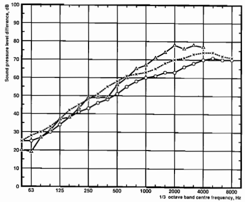

Figure 8: Insulation of double Camden partitions

With double glazed windows and double doors. 51 +/- 5dB
With triple glazed windows and double doors. 55 +/- 6dB
With no windows or doors. 56 +/- 6dB

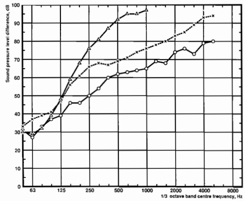

Figure 9: Insulation of triple Camden partitions

With triple glazed windows and double doors; with common floor. 59 +/- 5dB
With triple glazed windows and double doors; with isolated floors. 68 +/- 4dB
With no windows or doors; with isolated floors. 87 +/- 4dB

be achieved. Though these results relate specifically to lightweight partitions, the trends are equally applicable in the case of other forms of construction. It is not possible to include all examples in this paper, but the interested reader is referred to reference [3] for the full bank of data published by the BBC.

5. COMPLEX PARTITIONS

To give a further example of the range of partitions included in reference [3], some of the more complex forms of structure are worth further comment here. The BBC currently has a large fleet of outside broadcast vehicles and, both for monitoring sound on location as well as recording original sound in mobile studios, it is necessary to achieve reasonable sound insulation in spite of the restrictions imposed by the Road Traffic Acts.

The original form of construction, now superseded, used in outside broadcast vehicle walls is illustrated in Figure 10(i). This is based on two structural skins with thermal insulation between them. It is a very simple and cheap form of construction and does not achieve significant sound insulation. Figure 11, curve 1 illustrates the performance typical of this type of partition, giving a mere 28 ± 3 dB. If that partition is made into a triple skin, by the addition of a lossy sound barrier mat, Figure 10(ii), results can be significantly improved to 40 ± 3 dB (Figure 11, curve 2). It should be noted in both cases that personnel doors and access hatches for equipment are included in the partition under test and the performance quoted is only achieved if adequate arrangements are made for sealing these. Finally, in the context of outside broadcast vehicles it is worth noting the one example the BBC has of constructing two cabins on the same chassis. The construction of this is shown in Figure 10(iii) and the results are presented in Figure 11, curve 3. The performance in this case, though still limited at low frequencies, rises rapidly to give an average insulation of 61 dB.

Where low frequency insulation is important, there is seldom an option other than to use masonry forms of construction. Some examples of this are shown in Figure 12. Curve 1 is for double 112 mm cavity brick wall with flexible wall ties. In this case, no doors or windows pierce the partition and the achieved performance is 59 ± 8 dB. A triple 150 mm brick wall again with no doors and windows but this time with both areas built as box-in-box construction achieves a much improved average of 84 ± 3 dB (curve 2).

On those occasions where even better results are required, very much more work has to be done to achieve the requirement. There is one example in the BBC where it proved necessary to site a drama studio adjacent to a pop music studio and for this the sound insulation requirement was 77 dB at 63 Hz rising to 107 dB at 1 kHz. The final curve in Figure 12 shows the achieved results being an average of 102 dB, nearly meeting the actual requirement even at low frequencies. Even so a massive form of construction was required. The partition comprised four layers of masonry, two being 228 mm brick and 2 of 325 mm brick with 228 mm cavities. Each of the adjacent areas was built as a box within a box; the drama studio being built on helical steel springs and with the pop music studio being built on rubber pads. The roof of the drama studio comprised 300 mm concrete, 200 mm airspace and 200 mm concrete, whilst that for the pop studio was 200 mm concrete, 650 mm airspace and 200 mm concrete. Such a construction is far from being cheap, but other than spacing such areas further apart, it is the only way of providing such enormous levels of sound insulation.

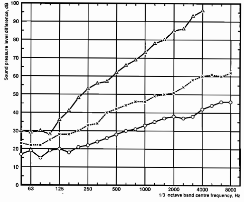

Figure 11: Insulation of OB vehicle walls

o——o Simple partitions. 28 +/- 3dB
x-------x Complex partitions. 40 +/- 3dB
Δ——Δ Double cabin on same chassis. 61dB

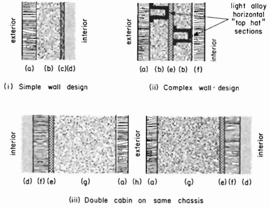

Figure 10: Typical OB vehicle wall designs — (i) Simple wall design; (ii) Complex wall design; (iii) Double cabin on same chassis

(a) 15 mm GRP faced plywood
(b) 25 mm high density mineral wool
(c) 18 swg aluminium
(d) carpet
(e) 4 mm sound barrier mat
(f) 19 mm plywood
(g) 76 mm high density mineral wool
(h) 50 mm air space

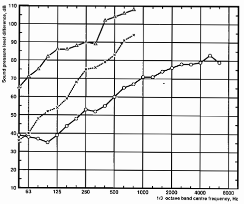

Figure 12: Insulation of masonry partitions

o——o Double brick; see text. 59 +/- 8dB
x-------x Triple brick; see text. 84 +/- 3dB
Δ——Δ Quadruple brick; see text. 102dB

6. CONCLUSIONS

This paper has attempted to give an over-view of the importance of attention to detail when prescribing sound insulation between noise generating and noise sensitive areas. In the first instance, it has been shown that there is much to be gained by a sensible choice and layout of the site. Thereafter, the details relating to elements passing through the partition and the construction of the partition itself become very important. If there are no ways of avoiding it, it is possible to achieve high levels of sound insulation even at low frequencies, but it has to be borne in mind that this is at the expense of very complex and massive forms of construction requiring very close supervision on site during construction.

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Application of Advanced Electronic Systems to Concert Halls and Auditoriums

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ABSTRACT: Electronic architecture is a means of simulating sound reflection patterns that appear in the world's most highly regarded concert halls. This paper discusses the raison d'etre, technical approach and application for these systems. The response of the musical community to the results of the work validate the application of the methodology in the most sophisticated venues and support the accuracy of a translation system refined by the author that correlates subjective response to physical acoustic phenomena.

INTRODUCTION

The most important new development in concert hall acoustics is the rapidly widening recognition by acousticians of the importance of reflected sound energy as related to the subjective expectations of the musical community.

There is a direct relationship between qualitative judgments and sound reflection characteristics *throughout* the entire period of room decay.

Early work by Dr Leo Beranek suggested the existence of a translation system between psychoacoustic response and physical acoustic phenomenon. Subsequent research by Barron, Blauert, Jaffe, Marshall, Schroeder and Schultz verified many aspects of Beranek's work and uncovered new correlations. Figure 1 describes a basic translation system currently in use at Jaffe Acoustics.

As many translators can attest, the art of translation is more complex than matching words in language B to words expressed in language A. The art lies in matching subtleties, the nuance of each phrase or sentence.

Acousticians must take the language of the musical world — *warmth, brilliance* — and translate it into physical acoustic terms — *sound reflections, reverberation time*. Then they must translate acoustical language into an architectural vocabulary — *geometry, volume, surface contours and materials.*

The first translation, from musical to acoustic terminology, is a continually absorbing study. Such musical terms as *transparency* and *warmth* are subjective descriptions that comprise complex acoustical phenomena. It is these phenomena the acoustician must sort out and define as criteria for concert hall design.

In the second half of this century, university researchers and practising acousticians have made remarkable strides in correlating the psychological and physiological responses of human beings to a variety of reflecting patterns of sound energy. They have a clear grasp of what the musical community means by such terms as *warmth* and *transparency*.

Figure 1: The Architectural Acoustic Translation System

A musician, an acoustician and an architect each have seperate vocabularies to describe acoustic criteria. The language of each is correlated below:

MUSICAL VOCABULARY	*SCIENTIFIC VOCABULARY*	*ARCHITECTURAL VOCABULARY*
Running liveness, wetness, fullness, persistence of sound	Reverberation time throughout the frequency spectrum	Geometry of the hall Containment of volume Absorption in the hall Distribution of volume Stiffness of boundary surfaces
Presence, brilliance, transparency, definition, articulation	Arrival time of mid- and high-frequency reflections	Geometry of the hall Audience to performer relationship Relationship of audience to reflective surfaces Design of inner reflector systems
Warmth, low string balance	Arrival time of low-frequency reflections	Geometry of the hall Volume to seating area ratio Absorption in the hall Containment of volume Stiffness of boundary surfaces Coupled volumes near the sound source
Orchestral balance	Minimum masking of low power instruments	End of the hall or concert enclosure geometry Musicians risers Audience seating rake Tunable inner reflector systems
On-stage hearing	Minimum masking of low power instruments Arrival time of mid- and high-frequency reflections	End of hall or concert enclosure geometry Musicians risers Coupled stage volumes

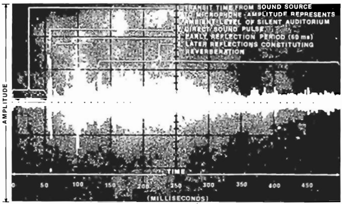


Figure 2: Sample oscillogram of a reflected energy field.

Utilising this new information, contemporary acousticians have opened up opportunities to redefine performer-to-audience relationships. Techniques include the design of shallow and vertical surround halls, the placement of orchestral platforms forward of the proscenium arch in multi-event facilities and the utilisation of electronic reflections when practical constraints of architecture and performance rule out purely physical solutions.

Looking at the Translation Table (Figure 1) which correlates the vocabularies of the various disciplines, one can begin to understand how a professional practitioner sets his initial physical criteria for a concert hall.

For example, if an acoustician is interested in achieving intimacy, presence and definition of sound, he or she must instruct the architect to develop a narrow rectangular configuration or else provide inner walls, terraces and canopies in a fan-shaped or circular design. These architectural forms will result in the listener receiving first reflections within the required 20 ms time domain, thus achieving desired subjective acoustic goals related to presence and intimacy.

One uses a similar approach in terms of applying techniques of "electronic architecture". However, instead of utilising the boundary surface of a room or inner reflective wall and canopy systems, the designer locates loudspeakers at proper distances or signal delay to simulate the reflections needed to provide required subjective response.

SYSTEM DESCRIPTION

Electronic Architecture systems are composed of microphones, pre-amplifiers, amplifiers, equalisers, digital signal delays and loudspeakers. The microphones are placed in the far field so that signal pick-up is equivalent from all locations on a performance platform.

The signal is then amplified, equalised and delayed in time to represent sound waves emanating from architectural surfaces of different absorption coefficients located at various distances from and azimuths to individual listeners. From an acoustic standpoint, this enables one to electronically raise and lower ceilings, move walls in or out, increase room volume and float non-existent clouds and panels in space.

The results to date have been extremely successful and it is already possible to utilise these systems to provide outstanding environments for classical music in concert halls, churches and arenas. Mini-computers allow us, at the flick of a switch, to adjust acoustics from Mozart to Tchaikovsky — from Boston Symphony Hall to those of Carnegie Hall.

Reflected sound energy is comprised of four components. Each reflection reaches the listener from a given direction, at a certain amplitude or intensity, with a particular frequency spectrum and at a set time after the source signal has arrived.

Figure 2 describes an oscillogram of a typical reflected energy field with a sound source pulse on stage and a microphone located in the audience area. It is the frequency composition, strength, directivity and time arrival of these reflections in relation to the direct sound field that affect qualitative subjective judgments.

Figure 3 is a basic channel for a reflected energy system. It is comprised of a microphone, pre-amplifier, signal delay, filters, gain control, power amplifier and speaker. The basic system is expanded by appending more circuits on the output side (Figure 4). In the most sophisticated Electronic Reflected Energy Systems (ERES), only one microphone is usually required as a pick-up for the signal processors.

The key to the success of these installations is based on providing reflected energy at a level comparable to that of the natural reflections and reverberation field in the concert hall of your choice. Normally one would attempt to keep the intensity of the reflections below that of the source sound and deliver it after the arrival of the source signal (Figure 5).

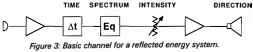


Figure 3: Basic channel for a reflected energy system.

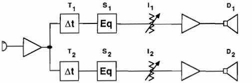


Figure 4: Expansion of the reflected energy system.

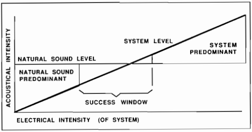


Figure 5: The impact of intensity adjustment of the system.

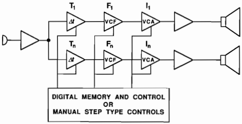


Figure 6: An idealised reflected energy system.

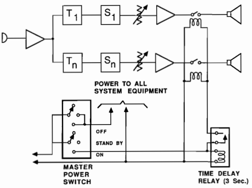


Figure 7: Power control schematic.

However, under certain circumstances, such as deep underbalcony seating areas in old movie palaces, it is possible to take advantage of the Haas effect and deliver a signal equal or slightly higher in intensity than the source sound. Such a design decision would allow an increase in the dynamic range of the orchestra in a listener location that could not be improved by any known physical means. Here again, the signals are filtered accordingly and the sound energy received by the listener is *not a reproduction* of the entire spectrum.

An idealised system (Figure 6) would utilise voltage controlled filters and amplifiers and could be operated by a computer program to recreate an infinite number of different reflecting patterns in the hall. This device could be controlled by the conductor at the podium to vary the acoustic response of the hall from one movement to another, as well as for composers of different eras. A contemporary composer could actually write a part for the room itself in his score.

Although it is permissible for Itzhak Perlman to break a violin string in the middle of a performance, ERES systems are never permitted to emit thumps under any circumstances, even during a main power failure. For this reason, a master power switch (Figure 7) with a signal delay relay enables one to turn the system on or off at any time without disturbing audience or performer.

A typical ERES system is shown in its entirety in Figure 8. Signal processing would include a notch filter for each signal, high and low pass filters and a reverberation device for those channels used to increase liveness and warmth. In systems designed for smaller spaces (under 1,000 seats), Sound Control Technologies' ERX-1 has proven to be a suitable and economical signal processor.

Currently designers are implanting a Knowles microphone #BT-1759 in shell panels, forestage canopies, proscenium arches or discs in order to provide signal to the electronic processors. This microphone has an exceptionally flat response from below 100 Hz to 6 KHz, the typical frequency spectrum used for these designs. In addition the miniature diaphragm implanted in an architectural element is totally invisible to the audience. When such placement is not feasible, a modified Countryman ISOMAX-IV can be substituted for the implant.

Electronic architecture cannot assist the conductor in creating orchestral balance or compensate for undermanned sections in regional symphonies. This direct sound and those reflections emanating from the physical surfaces surrounding the musicians reaches the listener in the purest form. The microphone is used only as a pick up for this same signal which is then processed and reintroduced as reflected energy.

Typical applications for ERES systems can be found in new multi-event performances spaces where the acoustic environment must vary within hours to meet the requirements of a diverse constituency.

Traditionally, acousticians have attempted to solve this problem by providing sufficient volume in a hall to develop the longer reverberation times required for symphonic performances and then physically moving ceilings, reflectors and/or draperies to reduce the reverberation for other events requiring shorter room decay slopes.

An acoustician utilising ERES as an architectural tool would design rooms with a low reverberation time and add reflected energy as needed for those events requiring longer reverberation times, shorter initial time delay gaps and more low frequency energy within the early decay field. Such an approach gives the acousticians an unusual opportunity to fine tune reflected energy patterns, reduces construction costs and allows the architect to design a focused interior space that is devoid of suspended clouds, transparent walls and ceilings and yards yards of draperies or banners. The room remains a *fixed* architectural entity for *all* performances.

ERES systems also have wide application in the renovation of historic structures where the design team is limited as to the physical modification of the interior.

Although it is prudent for an acoustician to say that these systems are superfluous in a single event space such as a concert hall, the truth of the matter is that they have a role in these halls as well. No concert hall in the world has an environment suited for every period of musical composition or a wide range of performing forces. ERES can provide the proper salon environment for a Bach Brandenburg Concerto and, at the touch of a button, the required acoustic for the Verdi Requiem.

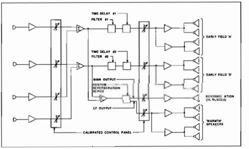


Figure 8: A typical complete Electronic Reflected Energy System.

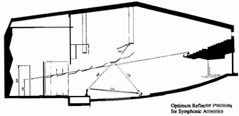


Figure 9: Listener receives first reflection 21 milliseconds after the arrival of the direct sound, but the reflectors effectively block sightlines in the balcony as well as lighting positions on the catwalk.

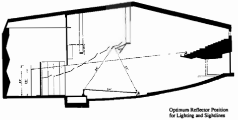


Figure 10: With reflectors repositioned for lighting and sightlines, the listener receives the first reflection 48 milliseconds after the arrival of the direct sound, far too late for a good listening experience.

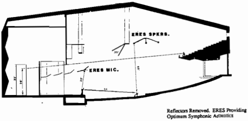


Figure 11: Using an electronic canopy, it is possible to provide first reflections at the proper time arrival and maintain good sightlines and access to lighting positions on the catwalk.

In the last few years, Jaffe Acoustics encountered a number of situations where the implementation of electronic architectural systems in conjunction with traditional physical acoustic solutions were able to provide clients with outstanding symphonic acoustic environments.

Figures 9, 10 and 11 illustrate a condition where an acoustician might employ "electronic architecture" and design an electronic forestage canopy instead of a physical one. The sketches describe a fan shaped, single balcony, multi-event symphonic music pavilion with no side or rear walls. As shown in Figure 9, it is impossible to position a physical canopy so as to enable listeners to receive reflections within 20 ms without restricting sightlines and cutting off front lighting positions for the soloists and the orchestra.

Figure 10 locates the canopy in an optimum position for sightlines and lighting, but delivers the first reflection to a listener in over 48 ms.

One could design a movable canopy system with its own integrated lighting system and select a *compromise* position between adequate sightlines, proper front lighting and good acoustics. This would be an expensive solution for a building that is only open three months of the year and during this period schedules three to five weeks of symphonic concerts.

The most practical, least expensive and optimum acoustical solution would be to design an electronic canopy. Figure 11 illustrates that it is feasible to locate speakers at heights which will supply the requisite reflections without interfering with front lighting or sightlines.

APPLICATION

Figures 12, 13 and 14 describe four reflectograms taken in the Ravinia Pavilion, summer home of the Chicago Symphony, with the ERES system on and off and a graph of reverberation times taken in the Circle Theatre, home of the Indianapolis Symphony, with the ERES system on and off.

In terms of the Ravinia Pavilion reflectograms, note the increase in lateral energy at the 2,000 Hz octave band and the increase in energy at the 125 Hz octave band through the E.D.T. period. As listed in the translation table (Figure 1), increased mid and high frequency energy provides improved presence, transparency and definition while increased low frequency energy provides improved warmth and low string orchestral balance.

The true test of the success of ERES designs is whether or not a listener's subjective response is similar to one experienced in a room of different proportions and finishes. Measurements notwithstanding, the resultant sound must not change an individual's perceptions of source origination, has to be free of any unnatural coloration and should result in an increased sense of warmth, presence and liveness.

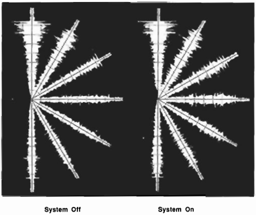
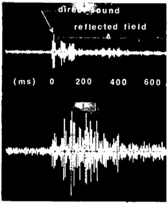


Figure 12: Comparative reflectograms for the 2,000 Hz octave band at Ravinia Park Pavilion, Chicago, Illinois.



125 Hz Octave Band
(source: 2 millisecond pulse)

Figure 13: Comparative reflectograms for the 125 Hz octave band at Ravinia Park Pavilion, Chicago, Illinois.

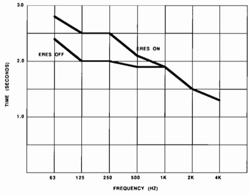


Figure 14: Circle Theatre reverberation times — system on and off.

REACTIONS

Comments from critics, audiences and performers in completed facilities have been extremely encouraging, as illustrated below:

Laurie Auditorium — San Antonio Symphony: *"...the Laurie Auditorium long known for its terrible symphonic acoustics has had a 'sound lift' and the difference is monumental"* — Don Huff, San Antonio Herald, 13 October 1977.

Hult Center — Eugene Symphony: *"I've sung in every great theatre in the world and here in Eugene you have the very top of the earth"* Marilyn Horne, Musical America, 21 February 1983.

Circle Theatre — Indianapolis Symphony: *"The acoustics were clear, well defined with a good deal of presence, solid bass and excellent definition"* — Harold Schonberg, New York Times, 5 November 1984.

If major orchestras now appreciate and accept the application of electronic architecture as a means of achieving outstanding aural perception in their major performing venues, then it is safe to assume that electronic architecture may indeed become one of the most useful tools in the acoustician's work box.

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DAT computer cassette

Hewlett-Packard and Sony have struck a deal which will put the power of 1,000 floppy discs in a desk-top personal computer. HP and Sony hope to set an industry standard for DAT (Digital Audio Tape) as an even higher density erasable store at a tenth of the price of optical discs.

The DAT cassette is the size of a credit card and contains tape that is only 3.9 mm wide. This runs at 0.8cm/s past a head-drum, similar to those used in video recorders, which rotates at 2,000 r.p.m. For hi-fi, the stereo sound is converted into 16 bit digital code. For data storage, blocks of 8 bit bytes are recorded instead. This data streams on, and off, the tape at the very high rate of 170 kilobytes/s which is around 600 Mbytes/hour. So a two-hour DAT cassette can store 1.2 gigabytes of data. This makes the tiny cassette equivalent to more than 1,000 conventional floppy discs.

The DAT data storage deck will be made the same size as a conventional floppy disc drive, so that it can be built into the body of an IBM PC or clone. The cassette can either be used as a back up store or for loading large chunks of data into the computer's memory for rapid access.

A two-hour DAT cassette, storing 1.2 gigabytes of data, can be fully re-wound in 41 seconds. The average search time between sections of data along the tape is less than 20 seconds. HP and Sony plan to start volume production of DAT data drives by the end of 1988.

From Electronics Today International, December 1987

Digital Techniques in Audio Equipment

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CDD CLAIMS

Numbers are all important today and numbers sell audio equipment. So let us start with some numbers. Proponents of compact digital disks (CCD's) claim a signal to noise ratio of 96 dB, a distortion of 0.0015%, 90 dB separation between left and right hand channels. They conveniently forget that distortion increases as signal level decreases. At 60 dB below maximum recorded level the distortion rises to 1.5%. The disk is claimed to be free from noise in replay for all but the grossest of surface damage. Disks can be played forever without wearing out or being damaged because they are scanned with a laser beam, not a stylus.

As for LP disks, the signal to noise ratio is only 60 dB, the separation of left and right hand channels is only 30 dB. The mechanical tracking causes wear, and damage due to operating errors cannot always be avoided. Careful handling is needed if the quality of the disk is to be maintained. Distortion under maximum recording levels can be 4%.

THE LP REPLY

A signal to noise ratio of 60 dB is perfectly adequate and sensible for home reproduction. Channel separation of 20 dB will yield excellent stereo effects. Mechanical tracking might become bothersome if a record is played hundreds of times. In practice no record is played enough to wear it out, if high quality stereo pick-up heads and styli are used in replay. If damage due to operating errors means "snap, crackle and pop" in the original record making process, then this is due to the manufacturer electro-plating the original master and the subsequent copies too quickly, to save time and money. As for the distortion claim, 4% is a maximum, at normal recording levels; at 20 dB down it drops to 0.4%. Loud speaker distortion is ignored by the critics.

NOISE PROBLEMS ON DISK

There is *one* very valid technical reason for CDD's, the problem introduced by the handling of the disk. By comparison, vinyl is soft, it is easily scratched. It can be electrostatically charged by friction and thus attract to itself dust particles which can lodge in the grooves causing nasty transients during playback. Poor handling can put finger and grease marks on the disk. Even smoking in the same room as the playing disk has been blamed for dirt in the groove. These cause extraneous noise. Sometimes "record cleaners" can add foreign matter to the groove, adding its own noise.

THE CDD

Advances in electronic digital techniques have enabled Philips and Sony to develop the CDD. The disk is 120 mm in diameter. It has a maximum playing time "to allow the recording of the Beethoven 9th symphony on one disk". The recording track is 0.6 microns wide and has a pitch of 1.6 microns. It is optically scanned at a constant velocity of 1.25 m/s and the rotational speed of the disk varies from 8 to 3.5 revs/s. The modulation is digital, a series of pits (a depression in the disk surface) and lands (the undisturbed surface). This surface is protected by a layer of transparent plastic. Scanning is by a laser beam. A "one" is generated when the beam travels from a pit to a land or vice versa, otherwise the signal is considered as a zero.

CDD SIGNAL PREPARATION

The original analogue signals are first passed through low pass filters with very sharp cut-offs at 15 kHz. The amplitude of each signal is then sampled discretely 44,100 times a second. These histogram values are then converted by analogue-to-digital converters into digital numbers of 16 digits or bits producing 65536 discrete levels. For each stereo track this means a basic rate of 705,600 bits per second. Since there is only one bit stream on the record the two stereo channels are interleaved. The accuracy of the numbers stated is deliberate, the whole process is crystal controlled frequency-wise.

Since the main philosophy of CDD is to correct errors and defects in manufacture and in playback (both machine and manmade) extra error correcting code pulses are added. Further, as no information is visible on the disk surface, CONTROL and DISPLAY bits are added. These provide information to the listener such as the piece or track being played, as well as timing and information to the pick-up control mechanism as to the required track to be played.

Other complications added to the pulse stream to ensure an error free replay are as follows. Each 8 bits are modulated to 14 bits to improve further the error correcting system and three merging bits are added. Finally each six original samples have 27 synchronising bits added to yield a final bit rate of 4.32 megabits per second. This stream of pulses modified to produce pits or lands to indicate a one, as described before, excites the cutting laser. The shortest distance on the disk that represents two consecutive "ones", that is from land to pit and pit to land is a distance of 0.3 microns.

MAKING THE MASTER DISK

The cutting laser light illuminates the light sensitive layer of a rotating glass disk. The surface is developed photographically then etched to produce pits which are about 0.12 microns deep. After the surface has been covered with a thin layer of silver an electroplating process produces a nickel impression called a metal *father*. Further electroplating processing produces a metal *mother* from the father and from this latter disk stampers are produced. These are used to press the play disks in a thermoplastic material. The active surface is given a reflective coating of monomolecular thickness aluminium. This layer must be free of defects since any defects could be read as pits or lands by the laser. A layer of clear transparent plastic covers the aluminium.

PLAYBACK

The laser reading spot is about 1 micron in diameter, it overlaps the track. Due to the refractive index of the plastic that covers the pits the optical depth of the pit is about 1/4 wavelength, so the reflected light will cause destructive interference in the return beam. The signals to four photo diodes are used to centre the beam on the track as well as provide the recorded information. This also controls the movement of the laser across the disk. The laser reading system must also be moved to compensate for any out-of-flatness or tilt of the disk in replay so that the laser beam remains in focus on the disk.

Further, the diameter of the spot at the plastic surface of the disk is about 2 mm thus effectively removing the effect of small pieces of dust, scratches and other foreign matter on the intensity of the light illuminating the tracks.

After the bit stream read from the disk has been demodulated (the inverse process to that before recording) the error correction network handles defects that can cover up to 2.5 mm of track length, for example a surface scratch. It can reproduce the original signal from the flawed data stream. Longer time errors can be handled by a Concealment Interpolation and Muting network. If this network detects an error it can interpolate between the preceding and succeeding samples. If the error is too large to be compensated by this device then the system reduces the output signal to zero and back again without inserting unwanted transients.

Up to this point the whole system is digital electronics. Everything is tightly controlled frequency-wise. The pulses must come through the network in a perfectly timed sequence. Like all digital processes there are only two types of signal flow, the perfect or chaos.

DIGITAL TO ANALOGUE CONVERSION

The bit stream is now divided into the left and right channels and these go to digital to analogue converters. The two output signals are histogram waveforms consisting of the wanted audio signal plus the sampling frequency and its harmonics. These latter signals must be filtered before the wanted signals are fed to the outputs of the system at a level suitable for feeding the next component in the audio chain. There should also be a time delay in one channel to compensate for the interleaving of the two tracks on the disk. While this is only 11 microseconds some audio experts claim that, if this is not done, audible defects result, especially if the two tracks are combined to produce a mono signal.

There is only one place where there can be argument about differences in the output signal quality of CCD players. It is at this conversion point. Some manufacturers use digital filters, some double the pulse rate before filtering to provide a greater audio-to-sampling frequency difference. Others use a passive filter network, expensive but probably the best.

DOMESTIC CDD PLAYERS

"Stereo Review", January 1986, concludes after a test of six CD players, ranging from the cheap to the exotic, that "audible differences do exist but they don't matter unless you think they matter".

That is on the technical side. On the buying side, considerations should include ease of handling the equipment, length of warranty for repairs and maintenance, quality of manufacture, reputation of the manufacturer and whether the cosmetic additions are worth the extra cost.

The whole approach depends on VLSI (very large scale integration circuits). It is complicated, a mix of mechanical, optical and electronic controls and is close to the edge of present technology.

THE REPLAY PROBLEM

As mentioned before, a dynamic range of an LP disk is 60 dB. An SPL of 100 dB in a normal living room is a satisfactory maximum. For a stereo system using loudspeakers of sensitivity 90 dB per watt at one metre, 40 watts per channel will achieve this level. To use this LP dynamic range a background of 35-40 dB is necessary. How many living rooms have this background level?

To go any louder, say 110 dB you will need a soundproof room — why go on? A signal-to-noise ratio of 96 dB is a number to sell the CDD.

PERSONAL PREFERENCE

Another claim for the CDD is its zero background level. I am one of those who find this clinical and unreal. Microphones have their own inherent background noise level. This mania for zero background noise means that recordists are placing microphones very close to the musical instruments to drive up the signal-to-noise level at the microphone. It also results in a greater relative high-frequency recorded level together with a lack of "reverberation" and "warmth" in the recording. The music from such a recording is now an entirely different genre from the concert hall. As long as numbers sell equipment and recordists chase numbers in recordings the two sounds will differ.

The LP disk has warmth and reverberation because recordists understand there is no sense in chasing unattainable signal-to-noise recording levels.

DIGITAL AUDIO RECORDERS

Claims of immortality for CDDs are beginning to fade. They are more prone to signal degradation than first claimed; they must be handled carefully. Some of the plastic used in the first disks shows deterioration. Disks have grown fungus between the reflective surface and the plastic. To add to these problems the Japanese have released a DARH (Digital Audio Rotating Head) cassette magnetic tape recorder.

CDDs are difficult to manufacture. They require "clean room" techniques. The equipment to make them is extremely expensive. To recover such money outlay requires the sale of lots of disks at expensive prices. The arrival of the DARH with the same overall specifications as the CDD, albeit at a price of A$7,500 has caused curious reactions. This recorder overall produces the same result as professional recorders five to eight times the price. Of course it is only a two track recorder and it will only record or replay at the one time, there is no simultaneous monitoring.

Recorder specifications are as follows:

Cassette size	73 by 54 mm
Tape width	3.81 mm (standard cassette size)
Linear tape speed	8.15 mm/s
Playing time per cassette	2.0 hours
Sampling frequency	48 kHz
Number of pulses per sample	16
Signal to noise	96 dB
Record head speed	3.3 m/s
Angle of track to tape edge	6 degrees
Angle between head and track	+/− 20 degrees

(The +/− means that if one head is considered to have the head gap at an angle of 20° to the azimuth the other gap is 20° to the azimuth in the other direction. This achieves two ends. It reduces interaction between adjacent tracks and is used by the tracking circuitry to keep the heads on the correct track.)

The tape is in contact over 90 degrees of the periphery of the rotating drum which carries the two record-replay heads which are at an angle of 180 degrees apart. These heads move across the tape at an angle of about 6 degrees to the tape length. The tape speed along the drum is 8.15 mm/s while the head rotates at 2000 rpm and has a diameter of 30 mm.

The two stereo tracks are interleaved and the same error correction code as discussed in the CDD is used in assembling the pulse stream. Because the heads can only record during 180 degrees of their rotation, that is half of the "real" time, the bit rate is compressed to half. The actual recorded bit rate is 9.4 million bits per second or 3 bits per micrometre. The same arguments hold about distortion and signal to noise as for the CDD system.

Wow and flutter must be absent in digital recorders. The pulse rate is controlled by a quartz crystal oscillator. Random time variations of tens of nanoseconds are allowable but a gross variation in tape speed would mean that one set of pulses would be treated by the electronics as belonging to another set. The result would be chaos. During playback the tape transport is controlled by feedback interaction between the crystal oscillator pulses and time pulses deliberately recorded on the tape.

THE PIRATE PROBLEM

Choice of the sampling rate of 48 kHz is deliberate. It ensures that CDD disks cannot be copied digitally from disk to tape without digital-to-analogue-to-digital conversion. Thus direct pirated tape copies of CDDs are slightly inconvenient to make on this recorder. Being forced to make the digital-to-analogue-to-digital conversion will reduce the signal to noise ratio by a maximum of 6 dB: unnoticable.

The original 44.1 kHz sampling was chosen at the insistence of the Japanese as it gave a favourable number to allow cassette video recorders to be used as digital audio recorders.

However, the American CDD manufacturers have petitioned the American Congress to make it legally mandatory for recorders sold in the USA to include a "spoiler" circuit in the system. This is a circuit that will recognise the absence of a band of frequencies 200 Hz wide centred on 3838 Hz. This lies between C sharp and D flat four octaves above middle C. The idea is that manufacturers will filter this band from all CDD disks and the recorder circuit will recognise the lack and stop recording the disk being copied.

This is naive thinking. Even a filter with cutoffs as sharp as third octave filters will pass enough of the frequencies from B sharp to E sharp to affect the playback. Further a sharp cut-off filter rings when excited, to add its own signature to the recording.

There is one big question about this new machine. How reliable is it? To repeat (ad nauseam): Digital techniques require perfect timing. Will this recorder be as trouble-free as its analogue companion?

THE UNKINDEST CUT

In conclusion may I quote Michel Flanders of Flanders and Swan fame.

"All the highest notes neither sharp nor flat,
The ear can't hear as high as that,
Yet I ought to please any passing bat,
With my high fidelity.

"With my tone control with a single touch,
I can make belle canto sound double Dutch,
But I never did care for music much,
It's the high fidelity!"

Neural bandwagon

Bandwagons are fun to watch, provided that you're not choked by the dust they raise. Now there's yet another bandwagon — more of a wagon train in reality — which has had one or two false starts over the years, but now seems set to travel far. It has a plurality of names, the main ones being neural networks, connectionism and parallel distributed processing.

The Eldorado for this wagon train is, at least for some people, "The computer that works like a brain". Rosenblatt had a good stab at a solution 25 years ago when he invented something called the "perceptron". This was supposed to recognise all sorts of patterns, much as the human eye and brain were believed to do. Alas, the technology of the time wasn't quite up to it. What was worse, an influential book by Minsky and Papert more or less tore perceptrons to shreds and for the next ten years publications in this field had something of the flavour of *samizdat*, with only the bravest of the brave persisting.

The early 1980s saw a resurgence of activity as workers in several fields began to model, analyse and simulate some of the properties of the brain, notably its pattern recognition ability. It was also realised that Minsky and Papert had been over-critical: perceptrons could (in theory) solve many recognition tasks, while neural networks with larger numbers of interconnections could solve any type of logical or numerical problem. A particularly strong stimulus was provided in 1982 when Hopfield described a neural network which could store, and recognise, certain types of contribution: a fair comment might be that he wrote a useful lucid paper, published at the right time and in the right place.

A criterion for scientific bandwagonhood is the number of papers and meetings generated. From 1970 to 1983 there were perhaps 10 or 20 papers a year; last year there were about 300 and this year more than 100 at one meeting alone. Why all the excitement? The simplest explanation is that this is an idea whose time has come, but an important factor has been the availability of computers with enough power to confirm theoretical predictions, and to allow empirical testing of ideas when theories were inadequate.

All sorts of people are riding on the bandwagon, from physicists to psychologists, electronic engineers to eager entrepreneurs. Physicists have applied spin glass theories to neural networks. Psychologists and computer scientists have devised speech recognition systems. Human vision has been a source of inspiration in image processing, and silicon foundrymen have built VLSI chips based on neural network principles.

One tempting prospect is that of being able to teach a black box to recognise something, without having to write a complicated program. Just show examples of the classes to be distinguished, with appropriately-applied reward/punishment being fed in (or fed back). Bingo: a universal categoriser! Unfortunately the results are not yet quite good enough for the real world.

Simulating the human brain's capabilities is still a long way off: existing theories remain quite primitive. It is also going to be very difficult to build hardware to match the density of interconnections in organic neural networks. Nevertheless, the prospects are better now than they have ever been, and physicists are well to the fore in this field. A warning, though — discrimination filters should be applied to some of the ideas which drift around in the dust raised by this bandwagon.

Michael Forshaw, Univ. College, London
From Physics Bulletin, January 1988

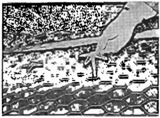
TECHNICAL NOTES

Australian Film Studios—sound stage

Australian Film Studios recently purchased a disused dairy product factory at Broadmeadows, Victoria, with a view to developing it into film studios. Bradford Insulation was approached to offer technical advice on reducing both sound transmission from outside and sound reverberation within the building.

Bradford developed a system to meet the needs of Australian Film Studios: Fibertex R4 Ductliner (50 mm thick in 1,500 mm x 2,250 mm sheets) was supplied. This is a high density rockwool product with tested sound absorption co-efficients. In addition, the product has thermal insulation and condensation control functions. The product was faced with Black Regina tissue which improves sound absorption and appearance and stops the possibility of fall-out.

The insulation was secured top and bottom to vertical brick walls, with special "Hilti" nylon speed clips. Galvanised wire netting was run vertically over the insulation and stapled to vertical timber battens to protect the insulation from possible damage.



At the Australian Film Studios R4 sheets were fixed, top and bottom, to brick wall utilising special "Hilti" nylon speed clips.

Eight film studios were insulated — a total area of 4,611.8 m^2. One of these studios is reputed to be the largest sound stage in the world and is the location for the filming of the Lindy Chamberlain story, featuring Meryl Streep.

Gill Harper

Information on Bradford acoustic insulation products may be obtained from the Bradford Insulation Office in your State.

Turning an iron mine into a gold mine

Bruel & Kjaer machine-condition monitoring systems have been implemented successfully in a very wide variety of industries, and the latest success story comes from an open-cast iron-mine in northern Canada. A new Application Note called *A Case Study from an Iron-Ore Mine* gives the full story of the experiences of the Quebec Cartier Iron Mine at Mount Wright, Canada. At the same time it illustrates what a powerful tool machine-condition monitoring using vibration analysis can be.

The monitoring programme covers the shovels, haulage trucks and various machines in the mine's concentrator plant. Since its introduction there have been numerous instances where large amounts of money have been saved. Average truck life has increased from 7,800 hours to 10,900 hours and shovel availability from 45% to 65%. In one specific instance, four $160,000 diesel engines were saved from destruction by the detection of a faulty critical engine component.

Vibration monitoring at the mine began in 1980 when Portable Balancing and Analyzing Set Type 3517 was used. This allowed the mine's maintenance engineers to successfully monitor the condition of a number of machines. Simultaneously they gained experience of vibration signatures and their relevance for each type of machine.

As the engineers became more experienced with the system, the number and variety of monitored machines were increased, and this culminated in the upgrading of the programme in 1985 to a desk-top-computer-based system. This system is capable of storing and processing large amounts of data and, additionally, has powerful fault-detection and fault-diagnosis facilities.

Ultrasonic scanning and imaging system

An automated ultrasonic scanning and imaging system for detecting internal flaws in large complex-shaped solid objects, such as castings or forgings, is now at a stage where collaborative development of a commercial version is being sought.

A laboratory prototype, developed at CSIRO'S Division of Applied Physics, scans steel castings or other solid objects to detect internal flaws and displays images of them on a monitor. The flaws may be as small as 0.5 mm in cross-section.

The system can be also used for making dimensional measurements of the external surfaces of complex-shaped objects with an accuracy of better than 0.1 mm.

The principle of operation is simple. A transducer transmits pulses of high-frequency (typically about 10-MHz) sound waves towards the test object through a liquid coupling medium, and subsequently detects the echoes reflected from the surfaces of the defects. These signals are digitized by a fast analogue-to-digital converter, and a computer collects and processes the large amount of data generated per scan and reconstructs images of the defects.

The technology used is not new or novel, but the combination of ultrasonic transducer, data acquisition system and computer software is. Conventional ultrasonic methods cannot achieve the sub-millimetre resolution required to image small flaws in large, complex-shaped objects.

Normally, radiography is used for high-resolution detection of flaws in steel castings, and then only for expensive, quality pieces.

This methodology has disadvantages: for thick test pieces, a linear accelerator is required to produce sufficiently high fluxes of high-energy X-rays; it may take hours to test a complex casting since a number of long exposures must be taken; there is also a contrast problem, since the difference in transmission of X-rays through a region containing a small flaw and the bulk of the casting is minimal; then there is the inherent safety factor with radiation equipment.

The ultrasound scanner, on the other hand, will do the job much faster. Also, the difference between echoes from a defect and from the surrounding material is substantial — sound scatter from a flaw is generally much greater than the "background" scatter from the material of the object.

Depth and size

Flaws with dimensions comparable to or greater than the wavelength of the transmitted waves (about 0.6 mm for 10-MHz sound in steel) can be successfully imaged at this stage, but smaller flaws may be detected.

For fairly homogeneous materials a higher frequency could be employed to detect smaller flaws that may be present; for a course-grain material a longer wavelength is employed, but the size of detectable flaws will be larger. A compromise must be struck between the depth of penetration and the size of flaws to be detected.

The development work was funded as a two-year Applied Physics Industrial Program project supported by the Steel Co. of Australia. The aim of the project was to demonstrate that it was possible to scan forgings and castings and produce meaningful 3-D images of flaws.

Further information: Dr. Don Price, CSIRO Division of Applied Physics, PO Box 218, Lindfield 2070. Telephone: (02) 467 6211.

Underwater sonic booms

Stun grenades occupy a key place in the weaponry of commandos. The disorientation the weapons create can provide a decisive advantage in a surprise assault; by the same token sonic booms have been used to confuse hijackers. As so often happens, nature appears to offer a model for such innovations: recordings of dolphins and whales in the wild suggest that some of them generate intense pulses of sound that may stun fish, rendering the prey helpless.

It is well known that several species of dolphins and other toothed whales find prey by echolocation, emitting ultrasonic "clicks" in rapid succession and listening for echoes returning from objects in the water. According to **Kenneth Marten** of the Long Marine Laboratory at the University of California at Santa Cruz, the clicks may be "jet-engine loud" if the object is far away. Marten and his fellow worker **Kenneth S. Norris** wondered whether the clicks might not also disturb the sensitive lateral lines of the prey: organs in fish that detect minute movements in the water. Furthermore, several anecdotal reports describe fish as appearing to be stunned immediately before being eaten, and whale stomachs often contain fish that seem undamaged.

Yet Marten and Norris were not able to show that even very loud echolocation clicks affect prey. Recently the fish-stunning hpyothesis has regained ground. Several investigators, starting with **Virginia L. Cass**, formerly at the La Jolla Southwest Fisheries Center of the National Marine Fisheries Service, found that wild bottle-nosed dolphins and killer whales produce banging noises while feeding. Tape recordings of the bangs show that they are much lower in frequency than clicks and so coincide with the hearing range of the prey; they are also much louder and last about 1,000 times longer.

The recordings feature ascending trills of clicks followed by what sounds exactly like a gun firing — or a stun grenade exploding. Sometimes the bangs sound like machine-gun fire. Similar noises are made by dolphins in threatening social interactions, suggesting that for a dolphin a bang might be the equivalent of bared fangs for a dog. Analysis of the sounds rules out a nonvocal source, Marten believes. Sperm whales have also been recorded making banging noises, although it is not known whether they were feeding.

Marten points out that the recordings do not prove the fish-stunning hypothesis. Bangs are not always produced when toothed whales and dolphins feed, and captive dolphins have not been heard to make the sounds (Marten speculates that they might be unbearably loud in a confined tank). He plans to investigate the effect of recorded bangs on captive prey fish.

From Scientific American, October 1987

BOOK REVIEWS

THEATRES FOR DRAMA PERFORMANCE:

Recent Experiences in Acoustical Design

R. H. Talaske and R. E. Boner (Editors)

Published by the American Institute of Physics for the Acoustical Society of America, 1987; 160pp, soft covers.

Available from the Acoustical Society of Amercica, 500 Sunnyside Blvd, Woodbury, NY 11797, USA. Price $15(US) per copy, $12.50(US) per copy for minimum order of five.

In 1985, a number of acoustical consultants from North America, Europe and Japan met for a special poster session organised by the Architectural Committee of the Acoustical Society of America. This book comprises the posters presented at this session, plus some additional contributions as well as seven invited essays which were intended to place the consultants' work in the proper perspective.

Each of the essays are around four pages long. The first, by S. Leonard Auerbach, on theatre design, compares and contrasts the roles of the designer. The second, by Dixon Bond, examines the role of the building manager while the third, by Stewart A. Donnell, outlines an approach to cost management and the cost planning process. The views of the architects are presented by Brian Hall and Paul A. Saporito who have both had considerable experience in theatre design. The role of audio in the theatre is discussed by R. K. Thomas and Robert W. Wolff addresses the acoustic conflicts and/or opportunities in the design of drama spaces.

These essays are easy to read as they do not provide a lot of technical details or references. They are simply the views of the authors based on their experiences. As such, they do not cover the subject areas extensively, but they do provide a good introduction to all the areas which are important in the production of theatres for drama.

The main part of the book (122 pages) is the poster presentation material for 49 theatres. Most of these are from USA with three from Canada, seven from Japan and five from the Netherlands. For each theatre there is an outline of the history of the project and the general requirements. A general explanation of the specific requirements, for example, where special attention had to be given to the sound isolation, is given without specific details of how this was achieved. For most projects the approximate costs are given; these range from the $300,000-$500,000 range up to $32,000,000 for centres for the performing arts comprising a number of spaces.

The actual details about each space vary. For every theatre there is a plan and at least one section; some of these are without a scale and some are difficult to read because of the amount of reduction. For the majority these are accompanied by photographs of the inside or outside of the theatre. The acoustical data ranges from a listing of the reverberation time plus the volume and capacity of the hall, to graphs showing the reverberation time variation with frequency, background noise levels, reflection sequence diagrams, echograms, etc. For a large number of the theatres some form of reverberation control and a volume control has been incorporated in the design. These adjustable devices allow the spaces to be adapted for the different types of performances.

This book provides a useful compilation of a variety of theatres and would be of interest to all involved with the design and construction of drama theatres. It shows what has and can be done, with an indication of the costs. The major limitation is an assessment of the effectiveness of the theatres. In most cases no comments are made. Statements such as "The theatre has been well received by staff, students and the community" do not provide adequate assessment. One does acknowledge that the theatre is "slightly overly reverberant for contemporary music presentations" but then simply states that "it would benefit from the introduction of more absorption above the sound transparent ceiling plane".

Marion Burgess

NON LINEAR UNDERWATER ACOUSTICS

B. K. Novikov, O. V. Rudenko and V. I. Timoshenko

(Translator R. T. Beyer, Technical Editor M. F. Hamilton)

Acoustical Society of America and American Institute of Physics, 1987, 270pp. Review copy from: Acoustical Society of America, 500 Sunnyside Blvd, Woodbury, NY 11797. ISBN: 0-88318-522-9. Price (US)$25.

This is a timely publication in English of the Russian text (circa 1981) of a topic which has assumed considerable importance in sonar developments. Notwithstanding the title of the book the subject matter is restricted to the application of non linear theory to parametric sound sources. Not included are discussions of non linear phenomena such as interactions of surface waves or turbulence at solid boundaries. Despite this it is a valuable reference book of relevant theories and derivations with worked examples — a specialist book best suited to those working in this field of acoustics or applied mathematics.

Chapters 2-4 (by Rudenko) expose the theory of the non linear interaction of sound beams and discuss in detail the various mathematical techniques available for some general applications — non linear interaction of plane waves, use of the parabolic equation. He then discusses in detail the basic theory of operation of parametric sound sources showing methods of calculations of source characteristics.

The practical limitations of parametric sources and receivers are examined and comparisons made between theory and the measured characteristics such as directivity, frequency, amplitude and phase. The performance of some Soviet equipment designed for measurement, reception, telemetry, sonar, fathometry and geolocation using parametric sources are described.

Some reliance is made on the use of monograms (appendix) for design purposes which although useful for intuitive development seems to have been replaced by computer modelling in the West.

John Dunlop

FASTS

The AGM of the Federation of Australian Scientific and Technological Societies (FASTS) was attended by **Neville Fletcher,** on behalf of the Australian Acoustical Society. The new President of FASTS is **Professor Frank Larkin** (Univ. Tasmania) and the Board Member for Group 9 (which includes the AAS) is **Dr. Mike Waterworth** (Univ. Tasmania).

At its 1987 AGM FASTS established five Standing Committees on —

- Government Science and Technology policy at both State and Commonwealth level;
- Industrial policy;
- School Tertiary Education interface;
- Tertiary education employment interface;
- Government Research and Development agencies — such as DSTO, CSIRO.

These committees will have a "watchdog" role to alert FASTS to any emerging problems as well as the role of developing policy for FASTS Board to consider. FASTS can then promulgate this policy in delegations to government(s) and through releases to the media.

The committees will be convened by FASTS Board Members and member organisations of FASTS will be asked to nominate people to serve on FASTS. Any interested members should contact their Divisional Committee of AAS.

One current activity of FASTS is a survey of the commercialisation of research. This survey has been commissioned by AUSTRADE and the questionnaires will be distributed to all members of the societies associated with FASTS.

NEW PRODUCTS

Australian Metrosonics

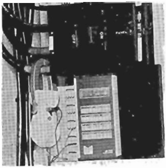
A Portable Electrical Power Consumption Rate Monitoring System

Australian Metrosonics Pty. Ltd. announces the advanced design model fk-7011P Energy Monitoring System. This system was specifically designed to monitor, record, and output formatted reports profiling average and peak demand usage on a time history/amplitude basis. The fk-7011P system is especially suited for end users, utilities, and energy management companies in auditing power consumption rates.

With non-intrusive sensor measurement, the system can store 3500 power readings or accumulations of maximum, minimum, or average values occurring in user defined consecutive time intervals. Data can be reviewed on an integral display at the site or transferred to the system printer, remote terminal or computer.

Data communications, via RS232, will produce on the system serial printer, or a remote computer, completely formatted records combining graphics, tabular data tables, and real time correlation. These permanent records completely, and easily document the power usage values and usage patterns occurring during process operations. Remote monitoring and output report generation is available at any time without interrupting continuous data acquisition.

Adjustable high and low alarm points can be set by the user anywhere within the entire measurement span. Data can be logged continuously at preset time intervals or only when alarm points are exceeded, providing the option for data acquisition only within preset time periods or when measured power usage exceeds predetermined limits.



The data logger units are battery operated in rugged, watertight aluminium extrusion enclosures.

Further information: John Vestergaard, Australian Metrosonics Pty. Ltd., P.O. Box 120, Mt. Waverley, Victoria 3149. Telephone (03) 233 5889.

Bradford

R-value Roofing Blanket

Bradford Insulation's building blanket range has been expanded to include the all new 'R value' blankets. The products in this range have a specified R value, which is the measure of a material's resistance to the flow of heat through it.

The new range, which is used for the thermal and acoustic insulation of roofs, walls and floors, has the ease of installation that have made Bradford products the biggest selling range of insulation products in Australia. The product range consists of Tuff-skin fibreglass blankets, Rockwool blankets and Anticon foil faced blankets.

Tuff-skin fibreglass 'R value' blankets, are available in R1.5, R2.0 and R2.5. The standard width is 1200 mm which facilitates rapid installation over large areas. They have a very high tensile strength making them easy to handle and resistant to damage.

Rockwool 'R value' blanket, which is available in R1.5 and R2.0, is the premium blanket. Rockwool is a denser product that fibreglass and has a superior acoustic properties. The blanket has a flexible skin on one surface for ease of handling.

Anticon 'R value' blanket is available in R1.5 and R2.0 with a standard width of 1200 mm. Anticon is fibreglass 'R value' blanket faced on one side with foil, which acts as a vapour barrier. The standard product comes faced with a choice of three different grades of foil: Thermofoil Lightweight 731; Thermofoil Mediumweight 730 and Thermofoil Heavyweight 750.

Details:
Bradford Insulation in your State.

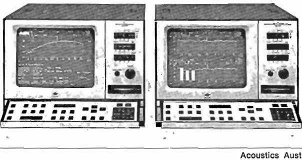
Bruel & Kjaer

Real-time Single- and Dual-channel Frequency Analyzers 2123 and 2133

These two new signal analyzers from Bruel & Kjaer define the state of the art in digital-filter-based signal analysis. Digital filtering allows real-time analysis in 1/1-, 1/3-, 1/12- and 1/24-octave bands at frequencies of up to 20 kHz. Dual-channel Type 2133 adds measurement of all intensity functions as well as other dual-channel functions to the auto-spectrum and time record analysis offered by the Type 2123 single-channel Analyzer. Type 2133 is the cornerstone of a complete sound intensity analyzing and postprocessing system, which features Sound Intensity Probe Type 3545, Sound Intensity Calibrator Type 3541, Remote Control Unit ZH 0354, and the BZ 7021 Intensity Mapping Program.

Fundamental to the ease of use and powerful spectrum-processing capabilities of these analyzers is the "multi-spectrum": spectra are measured and recorded in one-, two- or three-dimensional "multi-spectrum" arrays, allowing hundreds of spectra to be manipulated, stored and post-processed as a single unit. The internal memory of the analyzer can hold over a thousand 1/3-octave spectra in a single multi-spectrum array.

A high-level block math language allows complex data processing to be keyed directly into the analyzer in a very simple manner — and no programming experience is needed. Spectra can be processed as they are being recorded, or they can be recalled from



the internal memory or from the disc for processing singly or as multi-spectra.

The IEEE-488 interface gives you full remote control of the analyzer, with its easy-to-use programming language which uses plain English words as an aid to program documentation. Data can be transferred to and from the analyzers in a variety of formats ranging from easily-interpreted ASCII coding to high-speed compressed binary formats.

Further information: Bruel & Kjaer Aust. Pty. Ltd., 24 Tepko Road, PO Box 177, Terrey Hills, NSW 2084. Telephone (02) 450 2066. Fax (02) 450 2379.

Vipac

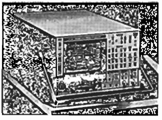
Portable Low Price FFT Analyser

We often hear customers say that they wish they could take dual channel FFT analysis capabilities with them into the field, in a lightweight portable form.

The CF-350 by ONO SOKKI does just this. It provides high performance FFT analysis and portability at a surprisingly low price.

The dual-channel FFT analyser provides an extremely simple means of obtaining signal transmission such as frequency response, time delay, and the effects of noise and vibration.

The CF-350 provides a wide range of basic FFT functions, including easy-to-use impulse response, orbit, cross spectrum, phase spectrum, transfer function, coherence function and many other functions.



The CF-350 represents an important breakthrough — and now makes dual-channel analysers within the reach of many potential users.

Ono Sokki is represented and fully supported in Australia by Vipac Pty. Ltd., 275 Normanby Road, Port Melbourne. Telephone: (03) 647 9700. For further information on this release please call Mr. Nick Prescott.

The south Australian office of Vipac Pty Ltd has recently moved to:

South Australian Manufacturing Park
853 Port Road
Woodville SA 5011
Tel: (08) 347 1799 Fax: (08) 347 1456

Over the last two years traditional consulting activities have been expanded to include contract R & D in the areas of underwater acoustics and software development. Local staffing has increased to six engineers and scientists to provide these wider services.

New Publications

The following publications have been received by the Society and are held, temporarily, in the Acoustics Laboratory, School of Physics, University of NSW. They are available for inspection or loan by members. Photocopies (not in contravention of copyright conditions. Books are ordered on written Cronulla Secretarial Services on (02) 527-3173. A charge will be made for photocopying and postage.

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JOURNALS

Acta Acustica

Vol. 12, No. 6 (Novembr 1987)

Vol. 13, No. 1 (January 1988)

Applied Acoustics

Vol. 22, No. 4 (1987)
Vol. 23, No. 1 (1988)

Contents include: **J. L. Davy,** The variance of decay rates at low frequencies.

Vol. 23, No. 2 (1988)
Vol. 23, No. 3 (1988)

Contents: **B. Hay,** An overview of EEC directives on noise from products and projects; **B. Hay,** Noise limits in the member states of the EEC for four-wheeled motor vehicles; **R. Hedges,** Noise limits for motorcycles in the member states of the EEC; **R. M. Stayner,** Maximum permissible noise levels emitted by wheeled agricultural and forestry tractors in the member states of the European Community; **L. J. Fennell,** Noise limits in the member states of the EEC for subsonic aeroplanes (as at 1986); **A. C. Pike,** Helicopter noise certification; **P. W. Roberts,** Environmental impact assessment: A framework for project and product evaluation.

Australian J. of Audiology

Vol. 9, No. 2 (November 1987)

Bulletin d'Acoustique

Liege University
No. 2 (June 1987)

Chinese J. of Acoustics
(in English)

Vol. 6, No. 3 (July-September 1987)
Contents: The 16th International Conference on Noise Control Engineering.

Vol. 6, No. 4 (October-December 1987)
Contents include: **Ma Dayou,** Status of community noise in the People's Republic of China; **G. Fant,** Studies of the human voice source; **Qin Dahua,** Measurement, analysis and model calculation of traffic noise near the road intersections.

Vol. 7, No. 1 (January-March 1988)
Contents include: **Zhu Weiqing,** Evolutionary spectra of backscattering wave in moving medium; **Zhu Zhichi** and **Wang Zhiguo,** A new finite difference method for computing sound field in lined ducts; **Zeng Lijun** and **Malcolm Crocker,** Literature review on machinery noise source and path identification using sound intensity technique; **Shen Junxian** and **Guan Li,** Song production and hearing in the bush cricket Deracantha Onos.

I. INCE Newsletter

Nos. 47, 48

Shock and Vibration Digest

Vol. 19, No. 12 (December 1987)
Includes feature article: Dynamics of cables and chairs by **M. S. Triantafyllou.**
Vol. 20, No. 1 (January 1988)
Includes feature article: Rotor dynamic behaviour of centrifugal pumps by **J. J. Verhoeven** and **S. Gopalakrishnan.**
Vol. 20, No. 2 (February 1988)
Includes feature article: Recent progress in the dynamic applications of piezoelectric crystals by **M. C. Dokmeci.**

REPORTS

ISVR Technical Reports

No. 149. Further investigation of tests for susceptibility to noise-induced hearing loss, 50 pp.

B. W. Lawton and D. W. Robinson.

No. 154. Visualisation of the air flowing through a dynamic model of the vocal folds, 33 pp.

C. H. Shadle, S. J. Elliott, P. A. Nelson.

Royal Institute of Technology, Stockholm

Quarterly Progress and Status Report, October 15, 1987.

Contents include: Speech Analysis and Speech Perception, Speech and Hearing Defects and Aids, Musical Acoustics.

☆ ☆ ☆

Music and Digital Technology

The Audio Engineering Society has published *The Proceedings of the AES 5th International Conference: Music and Digital Technology.* This is the newest collection of papers presented at the AES's renowned international conferences devoted to specialized topics in audio.

In May 1987, 34 experts in the forefront of digital music-making drew an international gathering of engineers and musicians to Los Angeles, California. The intensive three-day conference chaired by John Strawn came at a critical time in the art of digital music, when technological breakthroughs have opened up new worlds of compositional concepts and techniques. The conference explored all aspects of an art in transition, in sessions ranging from the history of digital music-making to the frontiers of computer-assisted music.

Now 20 of the papers presented at the conference have been reprinted in *Music and Digital Technology.* Twenty-seven authors have contributed their knowledge and experience to a publication that recreates the excitement of a unique event in music and technology. It is timely and valuable reading for engineers, musicians and audiophiles.

Further information: Audio Eng. Soc., Inc., 60 E. 42nd St., Rm. 2520, New York NY 10165-0075, USA. Price — members $US25; non-members $US35.

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Volume 15 1987

Format: Author, issue, pages, title

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B. REPORTS

C. AUTHOR INDEX

D. INTERVIEW

E. LETTERS

NEW PUBLICATIONS . . .

AIUM Annual Convention

The American Institute of Ultrasound in Medicine AIUM has produced its **Official Book of Abstracts** — a complete collection of abstracts from AIUM's 32nd Annual Convention held October 6-9, in New Orleans, LA.

This 172 page compilation of papers includes 218 abstracts of scientific sessions, categorical courses and works-in-progress presented at AIUM's annual meeting. Topics covered include abdomen, bioeffects, breast, Doppler, instrumentation, neurosonology, obstetrics and gynaecology, ophthalmology, pediatricts, peripheral vascular, tissue characterisation and ultrasound in animals. Cost of publication $(US)13 for members AIUM, $(US 26 for non-members.

Further details: Publications Department, AIUM, 4405 East-West Highway, Suite 504, Bethesda, MD 20814, USA.

Information for Contributors

Articles for publication normally occupy 4-5 printed pages (approximately 4 pp. double-spaced typing per page). Authors may be asked to pay additional typesetting charges for pages in excess of 5. Frequent headings and sub-headings are desirable and an abstract of approximately 200 words should be included. Reprints may be ordered, preferably prior to printing (they are then cheaper).

Diagrams will normally be reduced to single column width: authors are requested to plan diagram proportions and letter size accordingly. Full stand-alone captions should be provided for each diagram (these will be typeset).

Types of articles accepted include technical, tutorial and review. Short reports (1 page printed) on current research or a group's activities are welcome, as are shorter notes for inclusion under Technical Notes.

Articles and reports may be submitted in the form of a computer disk, accompanied by a hard copy for editorial purposes.

ADVERTISER INDEX

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

FUTURE EVENTS —

● Indicates an Australian Conference

1988

May 4-7, BUDAPEST
9th CONFERENCE ON ACOUSTICS
Details: Optical, Acoustical & Filmtechnical Society, Budapest, Fo u.68., H-1027.

May 11-13, HUNGARY
15th AICB CONGRESS
Noise Abatement — State of the Art & Application.
Details: 15th AICB Secretariat, c/- Scientific Society for Transport, Kossuth ter 618, Budapest, Hungary — 1055.

May 16-20, SEATTLE
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Mr. Murray Strasberg, A.S.A., 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

June 5-9, JERUSALEM
19th INTERNATIONAL CONGRESS OF AUDIOLOGY
Details: 19th Inter. Cong. Audiology, PO Box 50006, Tel Aviv 61500, Israel.

June 6-10, YUGOSLAVIA
XXXII ETAN CONFERENCE
Details: Prof. P. Pravica, Electrotechnical Faculty, Bulevar Revoluci je 73, YU-11000 Belgrade.

June 15-17, TAMPERE
NAM 88
Nordic Acoustical Meeting.
Details: NAM 88, Tampere Univ. of Technology, Ms Pia Kaila, PO Box 527, SF-3101 Tampere, Finland.

June 9-10, LONDON
NVC 88
2nd International Noise & Vibration Control Conference.
Details: Trade & Technical Press Ltd, 13/15 Creek Rd, East Molesey, Surrey KT8 9BE, England.

June 20-22, PURDUE
NOISE-CON 88
Noise Control Design: Methods and Practice.
Details: Conference Secretary, Ray W. Herrick Labs, Purdue Uni., West Lafayette, IN 47907, USA.

August 21-25, STOCKHOLM
5th INTER. CONGRESS ON NOISE AS A PUBLIC HEALTH PROBLEM
Details: Noise '88, C/- Reso Congress Service, S-113 92 Stockholm.

August 22-26, EDINBURGH
7th FASE SYMPOSIUM ON SPEECH
Details: Mrs. C. Mackenzie, I.O. Acoustics, 25 Chambers St., Edinburgh, EH1 1HU, Scotland.

August 30 - September 1, AVIGNON
INTER-NOISE 88.
"Sources of Noise."
Details: Inter-Noise 88 Secretariat, CETIM, BP67, Senlis, France 60304.

September 5-7, CRACOW
CONFERENCE ON NOISE CONTROL 88
Details: Dr. R. Panuszka, Organising Committee Conference Noise Control 88, Inst. of Mechanics & Vibroacoustics AGH, A1. Mickiewicza 30, 30-059 Krakow, Poland.

October 3-5, CHICAGO
IEEE ULTRASONICS SYMPOSIUM
Details: Univ. Illinois, Bioacoustics Research Lab., Atten.: W. D. O'Brien Jr., Urbama, Illinois 61801, USA.

October 4-7, HIGH TATRA
ELECTROACOUSTICS
27th Conference.
Details: House of Technology, Eng L. Goralikova, Skultetyho ul. 1, 832 27, Bratislava, Czechoslovakia.

October 17-21, WASHINGTON
WFUMB/AIUM MEETING AND 2nd CONGRESS OF SONOGRAPHERS
Details: AIUM, Conventions & Education, 4405 East-West Hwy., Suite 504, Bethesda, MD 20814, USA.

November 2-4, SHANGI
WESTPAC III
Developments of Acoustics in the Western Pacific Region.
Details: Secretariat Westpac III, Institute Acoustics, Academia Sinica, 17 Zhongguancun St, Beijing, China.

November 14-18, HONOLULU
2nd JOINT MEETING OF ACOUSTICAL SOCIETIES OF AMERICA AND JAPAN
Details: Secretariat ASA-ASJ Joint Meeting, Ac.Soc.Japan, Ikeda Bldg 4F, Yoyogi 2-7-7, Shibuya, Tokyo 151, Japan.

November 14-17, KOBE
9th INTERNATIONAL ACOUSTIC EMISSION SYMPOSIUM
Details: Prof. Dr. I. Kimpara, Dept. Naval Architecture, Faculty of Eng., University of Tokyo, 3-1, Hongo-7, Bunkyo-ku, TOKYO 113, JAPAN.

● November 24-25, VICTOR HARBOUR
NOISE INTO THE NINETIES
Details: R. P. Williamson, School of Built Environment, SAIT, Nth. Terrace, SA 5000.

November 28 - December 2, HONG KONG
POLMET 88
Pollution in the Metropolitan and Urban Environment.
Details: Polmet 88 Secretariat, c/- Hong Kong Institution of Engineers, 91F, Island Centre, No 1, Great George St, Causeway Bay, Hong Kong.

1989

March 7-10, HAMBURG
86th AES CONVENTION
Details: Herman Wilms, Exhibition Director, Zevenbunderslaan 142/9, Brussels, Belgium 1190.

April 25-29, GLASGOW
INTERNATIONAL CONFERENCE ON ACOUSTICS, SPEECH AND SIGNAL PROCESSING
Details: Inst. Elect. & Electronic Eng., Conference Co-ordinator, 345 E 47th St., New York, NY 10017, USA.

May 22-26, SYRACUSE
MEETING OF ACOUSTICAL SOCIETY OF AMERICA
Details: Murray Strasberg, ASA, 500 Sunnyside Blvd., Woodbury, New York 11797, USA.

May 23-27, GDANSK
4th SPRING SCHOOL ON ACOUTO-OPTICS
Details: Prof. A. Sliwinski, Inst. of Experimental Physics, University Gdansk, Wita Stwosza 57, 80 952 Gdansk, Poland.

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

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

August-September, YUGOSLAVIA

August 24-31, BELGRADE
13th ICA

September 4-6
SYMPOSIA
Sea Acoustics — Dubrovnik.
Electroacoustics — Zagreb.
Details: 13 ICA Secretariat, Sava Centre, 11070 Belgrade, Yugoslavia.

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

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

AUSTRALIAN ACOUSTICAL SOCIETY

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(* Indicates Councillor)

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