THE BULLETIN

OF THE

AUSTRALIAN ACOUSTICAL SOCIETY

Volume 6, Number 3 & 4, September/December 1978

REGISTERED FOR POSTING AS A PERIODICAL – CATEGORY B

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N.S.W. Division (includes Queensland & A.C.T.): Dr. M. Hall, C/— Science Centre, 35 Clarence Street, Sydney, 2000

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THE BULLETIN

OF THE

AUSTRALIAN ACOUSTICAL SOCIETY

FROM THE PRESIDENT

FROM THE PRESIDENT

Since the previous issue of the Bulletin we have received the welcome news that the Australian Acoustical Society has been awarded a place on the International Commission on Acoustics. Mr. J. A. Rose, as principal organiser for the 10th International Congress on Acoustics, will be the new Commissioner.

This is indeed an honour for our Society as membership of the Commission is limited to twelve and very few of the world's two hundred or more countries have ever been represented. However representation at this stage imposes a great obligation on members of our Society not only to make a success of the 10th I.C.A. in Sydney, 1980 but to make a significant contribution to acoustics in the future. I am confident that members of the Society will meet the challenge.

In conclusion I wish to offer my personal congratulations to our new Commissioner and to the many members of the Society who have worked tirelessly over the years to achieve our present position.

G. A. B. Riley
President.

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Volume 6, Number 3 & 4, September/December 1978

— *The Bulletin is published quarterly by the Australian Acoustical Society, Science Centre, 35 Clarence Street, Sydney, NSW. 2000*

SUSTAINING MEMBERS

OF THE AUSTRALIAN ACOUSTICAL SOCIETY

The Society values greatly the support given by the Sustaining Members listed below and invites enquiries regarding Sustaining Membership from other individuals or corporations who are interested in the welfare of the Society. Any person or corporation contributing $160.00 or more annually may be elected a Sustaining Member of the Society. Enquiries regarding membership may be made to The Secretary, Australian Acoustical Society, Science House, 35-43 Clarence Street, Sydney. NSW, 2000.

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GUEST EDITORIAL

The invitation to write this editorial came shortly after I retired from CSIRO after 34 years with the National Measurement Laboratory. During this time my major interests and responsibilities have been in the field of mechanical vibration, particularly vibration measurement and isolation.

Probably most acousticians regard mechanical vibration as relatively unimportant because they are not interested in vibrations that have no audible effects; and if the vibration has audible effects they are interested in the effects not the cause. Mechanical people, on the other hand, tend to think of acoustics as a branch of mechanical vibration, for most acoustical phenomena originate in mechanical vibrations, rotations and impacts. This polarisation of interest is evident even in publications and conferences that attempt to bring the two interests together. We need more specialists who have a deep understanding and interest in both fields if we are to attack unwanted noise at the interface where mechanical events generate noise.

Meanwhile, as one who is admittedly polarised in the mechanical sense, I offer some comments on the mechanical scene.

In the 1940's we made vibration measurements with mechanical, optical and electromagnetic vibrometers mostly of our own devising, and analysed the results by inspection or graphical analysis of recorded waveforms. Today, as a result of intensive commercial development we have a wide range of high quality transducers, and instrumentation that presents comprehensive spectral analyses and statistical parameters of vibrations while they are happening. With all this it is no less necessary now than it was then for the user to understand the instrumentation, to guard against being hypnotised by the almost miraculous generation of indigestible amounts of data, to recognise the relevant and relate it to the phenomena under investigation.

There have been interesting developments in vibration isolation such as those in the design and application of air springs and the bridge-bearing type of elastomeric isolator for whole-structure isolation. However, there seems to have been little improvement in the level of general practice. In the 1940's the design of mountings was based on the single degree of freedom model. Isolators were specified to have a static deflection that promised an acceptable attenuation of vibration of a certain frequency. The simple formula was used with little consideration of the characteristics of the excitation, the linearity or otherwise of the isolator stiffness, the dynamic symmetry or otherwise of the installation, or the dynamic response characteristics of the equipment being installed or that of the supporting structure. Today, the basic theory available for the design mountings taking all these factors into account is still being ignored or bypassed by some designers of important and costly installations.

The disparity between the available knowledge of the response of multi-degree of freedom systems to various excitations and the childlike trust of some practitioners in the single-degree model is only one example of the gap between theory and practice. The blame is not entirely with the practitioner, who cannot be expected to devote time to reading papers and attending conferences that so often turn out to be little more than vehicles for theoretical and mathematical showmanship. We need more papers describing worthwhile applications of theory in engineering practice and more tutorial and refresher courses and publications.

An almost barren area of the mechanical vibration field is that which should have yielded a crop of Australian standard specifications. While acousticians on the SAA committees have been working vigorously to meet Australian needs, mechanical people have done little more than maintain a watching brief on the documents prepared by the industrious ISO Technical Committee 108 on mechanical vibration and shock. I hope the newly constituted SAA committee ME/41 on mechanical vibration will remedy this.

In writing this editorial for the Australian Acoustical Society the thought has occurred to me: there is no Australian Vibration Society nor is there an Acoustic and Vibration Society of Australia. Should there be one? The situation at present is that mechanical vibration people are well catered for in conferences, workshops, and publications of the Institute of Engineers, Australia, through its Vibration and Noise Panel of the National Committee on Applied Mechanics. Many vibration and acoustical people enjoy the benefits of membership in both AAS and I.E. Aust. I cannot see a need for an independent Vibration Society.

In concluding, let me say a word of appreciation of the friendly collaboration that colleagues and I at NML have enjoyed over the years with members of AAS in technical consultations, in conferences of AAS and IE Aust, and in the development of the Acoustic and Vibration Measurement field of the National Association of Testing Authorities.

JOSEPH A. MACINANTE
Honorary Senior Research Fellow
National Measurement Laboratory

NEWS & NOTES

BOWING OUT

This is the final issue of The Bulletin that we will be editing. For three years, as of the beginning of 1979, editorial responsibility for The Bulletin will be taken by the Victorian Division of the Society.

We would like to take this opportunity to say that we have enjoyed editing The Bulletin. We hope that you have enjoyed reading it and that it has been of some interest and value to you. We would also like to apologise for the delays in publication over the last 18 months.

Finally we would like to wish our colleagues in Victoria (especially Robin Alfredson, who will take editorial responsibility for the first year), all the best and urge you, as a reader, to also become a contributor, whether it be in the form of a letter, paper, snippet of information or anything else.

FERGUS FRICKE
RICHARD HEGGIE
JOHN IRVINE
TED WESTON
(Editorial Committee)

AUSTRALIAN NOISE NEWSLETTER

The first number of the Australian Noise Newsletter will be issued in December 1978 and contain information for Australian residents on community noise problems. It will contain news, comments, facts, research results and advice on acoustical problems.

One of the principal areas of coverage will be the environmental impact of road traffic noise, and cover noise surveys, the reduction of noise in homes and the establishment of community noise standards.

The first number of the Australian Noise Newsletter will be issued to 2000 residents that are affected by road traffic noise from expressways, highways, main roads and secondary roads in Australia.

Further information from
I. A. Furzer
46 Park Road
GREENWICH, NSW 2065

NEW ADDRESS FOR THE BULLETIN

As of the 1st of January 1979 the Editorial Address for The Bulletin will be:

The Editor
Australian Acoustical Society Bulletin
National Science Centre
191 Royal Parade
Parkville, VICTORIA 3052

'NOT ALL AS IT SOUNDS'

Caleb Smith
(Unofficial Historian of the Australian Acoustical Society)

Rome, Autumn, 20BC

Laurentius Hegvoldus, owner of the Forum's most exclusive Toga Salon was disappointed he had agreed to attend this evening's performance of the Minstral Players. A few days ago, the sudden drop in temperature and the cold north wind had left him with a head cold and he longed for the warmth of his bed.

The opening items were dull. There was not the usual crispness and clarity of sound from the fiddle during the solo passage. Even the wind instruments sounded lifeless in this small banquet hall. He could tell that the players were not giving of their best. They could probably sense it themselves. Maybe they were catching cold too.

His friend, Barry Helmholtz remarked that more of his echia were required to enhance the sound. Laurentius did not agree, as there were quite a number of sounding vases around the podium area. He reminded his friend of the excellent performance of the Minstral Players during the Summer of the previous year. He recalled the encores and standing ovations given the Players for their superb performance. Still, Barry Helmholtz believed that the arrangement of the echia was the problem.

Their companion, Normanus Cartercius, who was interested in music and played the fiddle quite proficiently in a local instrumental group, did not agree with either of them. In his opinion the performance was good. It must be that Laurentius's head cold had reduced the acuteness of his hearing.

The small banquet hall was crowded with patrons. Laurentius had noted many were wearing thick woollen togas and cloaks to keep out the cold. However, it was not long before the room became quite warm and cloaks were being removed. His head cold seemed to ease a little also.

In no time the Minstral Players, responding to the warmed atmosphere, were playing superbly.

Laurentius, Barry and Normanus thought the performance was not so bad after all, although they each agreed that it was fairly dull at the start.

Later in the evening while on their way home they discussed the matter again, each giving their own reason for the change in the musical performance. Normanus believed that the players just needed to warm up, while Barry reasoned that the change in temperature in the room caused the sounding vases to respond more efficiently than when cold. He had noted the phenomena himself when the warm newly-fired clay pots sang with his own voice as he stacked them in the open yard. Laurentius was not sure about either reason. Privately, he thought the improvement in his head cold had cheered him up a little and his mood more receptive to the music.

It was during this discussion that Laurentius remarked that the performances of the Minstral Players were definitely better in summertime than in wintertime.

Laurentius gave the matter no more thought that evening. Tomorrow he would be fully occupied seeing to the finishing details of his new spacious Toga Salon. At midday the Emperor Augustus was to perform the official opening and Laurentius would present his exclusive summer collection. For the opening ceremony, he had asked Normanus Cartercius' amateur group to play a selection of music to entertain his guests while waiting for the Emperor to arrive. The small orchestra was placed in the collonade entrance to the Forum well before noon and when the Emperor arrived all was in readiness. What Laurentius had not planned was the unintelligible speech given by Augustus. This was not due to any disability on the Emperor's part but on the echoing and reverberant nature of the Forum. It was almost impossible to separate one word from another. Laurentius was embarrassed, the guests were embarrassed, the officials were embarrassed and the Emperor was furious.

On his return to the palace Augustus summoned the Imperial Architect Marcus Vitruvious. What was wrong with the Forum that it could not carry his voice clearly. The problem did not occur within the Palace. In future when the Emperor made a speech outside the Palace Marcus Vitruvious was to ensure that the place responded clearly.

Following the Emperor's hurried departure from the Forum, Laurentius quickly busied himself with the needs of his guests — not forgetting his own cup — while his mannequins displayed themselves and his summer collection of gowns. Later, he thought, he would make for the Tavern and really unwind. Perhaps he could persuade Normanus Cartercius and one or two mannequins to join him.

It was there, some hours later, that Laurentius found the Imperial Architect.

While it could not be said that Marcus Vitruvious was drunk, he had, never-the-less, paid homage to the handmaids of Bacchus since leaving the palace in the early afternoon. He was in a very carefree mood and in this state of high spirits Laurentius learned of the Emperor's edict to his architect.

Feeling that he was partly responsible for the Emperor's displeasure and the problem now facing his architect, Laurentius jovially offered his assistance not realising the ultimate implications of this gesture. Normanus also offered his help, though in what manner he could not imagine.

Marcus Vitruvious did not wait long before calling in his friends Laurentius, Barry and Normanus for help with his acoustical problem. The Emperor would be expecting effective results at his next public audience.

The opportunity came at the dinner party given by Tullius Cicero, the President of the Lawyers Society, at his sumptuous residence overlooking the city. There they discussed the short-comings of the Emperor's speech, agreeing that usually it was unintelligible inside and practically inaudible outside.

They compared the quality of his voice in the Theatre of Marcellus, in the Forum, in the circular Temple of Vesta and in the Imperial Bath House, with its thermal pools, its Halls and its porticos. They also agreed that his speech was sometimes unintelligible outside, but on these occasions there were walls or buildings nearby.

By the end of the evening they had decided the environment that usually caused speech to be unintelligible was mostly beneficial for listening to music.

Marcus pointed out that the size of the banquet hall or meeting room had some effect. Also, the number of people present seemed to make a difference. But they could not agree on any suitable size of room or on the optimum number of people.

To make his task a little easier, Marcus Vitruvious indicated to each of them the potential business that could ultimately be gained by solving this problem together. He revealed none of the fear of his own fate if he failed in his task.

In order to carry out the tests he had in mind, Marcus required a room that echoed and reverberated to the sound of speech. There he would use all manner of materials, furniture, fabrics, people and apparel in order to quell the echo and thereby clarify the Emperor's speech.

He chose the room carefully, finally selecting the banquet hall at the Villa Farnesina. He measured the walls and floor, calculating the surface areas and volume of the room. He began his first series of tests using the poets and rhetoricians who usually frequented the halls of the Imperial Bath House.

Marcus had arranged for a number of institute students to score their subjective impressions on the clarity of speech while the rhetoricians harangued the walls and the poets endeavoured to placate them. He then called on Laurentius to provide as many mannequins as possible, having them dress in clothing ranging from the flimsiest voile to the heaviest of wool fabrics. The institute was able to provide one hundred students as extras to Laurentius' regular mannequins.

The tests began with the hall empty, then increasing the numbers of mannequins all dressed in the flimsiest summer clothing, until the hall was crowded. Laurentius endeavoured to keep his mind on the task of observing the acoustical effects of the hall, the speech and the mannequins in spite of the distractions.

When the tests had been repeated with the mannequins wearing heavier clothing, Marcus and Laurentius noted from the students' score sheets, that after the first groups of mannequins spread around the room the clarity of speech did not improve. They concluded that the sound was being effectively controlled, except for the space overhead where the sound was continuing to reverberate.

In an effort to control this area of concern, Marcus had workmen construct tiered trestles along one wall. When the mannequins arranged themselves on the trestles and about the floor area, the reverberation disappeared and the speech was clear although difficult to hear, away from the speaker.

The tests were becoming laborious and tedious. Marcus decided he would think the matter over a little further so Laurentius dismissed his mannequins for the evening leaving their extra clothing on the trestles for further tests.

Marcus paced up and down the hall muttering to himself about the problem. Calling to his companion that the time would be better spent in the tavern, he suddenly realised that not only did Laurentius hear him but the sound was clear and without echo. That was it. The mannequins had absorbed too much of the sound — their clothing was all that was required.

Thinking back through the earlier tests, Marcus now knew the answer to the problem — people on the floor, fabric on the walls. Tomorrow they would prove it with a new series of tests.

Slowly, Laurentius began to visualise the huge business potential that Marcus had predicted. With their success assured they repaired to the tavern.

The series of tests were almost complete and both Laurentius and Marcus hoped they would never have to listen to a poet or rhetorician again. The final tests would be on the assessment of music. However, contrary to expectations, the tests did not go as planned. It was exam time for many of the students, both mannequins and scorers, and they did not arrive at the banquet hall until quite late in the day. When they heard the music they believed it was celebration time.

It did not take long for Laurentius and Marcus to realise that the tests had come to an end, for the time being, at least. No manner of persuasion could turn the students away from their frivolities. Entering into the spirit of the occasion, they sent a messenger to Barry Helmholtz to bring wine, food and friends and come to the party. The poets and rhetoricians soon heard of the festivities and they too arrived. The party continued well into the night with music and dancing. It was a congenial conclusion to a very absorbing series of tests.

Summer, 19BC

Laurentius Hegvoldus stood in the arcade entrance to his Toga Salon idly arranging some coloured fabrics around the portico hoping that the striking colours would attract the attention of the passing citizens. Business had been brisk during the Autumn and Winter months, but now the heat of summer was upon the city few patrons ventured out during the day.

The fashions were changing. He noted many of the maidens, once eager to show off their figures with close fitting or girdled robes now abandoned these for the one piece caftan of the lightest cloth. The fabric flowed freely about their bodies for the faintest breeze to release the entrapped heat and provide cooling relief. Togas were becoming shorter too. Soon, he thought, these maidens will be wearing short tunics. He mentally noted that he would dress one of his mannequins in a short 'skirt' tunic to see if the idea was worth pursuing. The lightly clad vibrating figures hurried past him to their places of work in the Forum and Laurentius' thoughts stirred with enthusiasm. Maidens with short skirts, he mused.

AUSTRALIAN ACOUSTICAL SOCIETY

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30th JUNE 1978

EXPENDITURE		*INCOME*	
To Transfer of Levies to ICA	1690.00	By Sustaining Members	2480.00
Bulletin Expenses	1785.60	ICA Levies	2220.00
Legal Expenses	67.45	Special Levies on Divisions	1014.00
Subscriptions INCE	143.14		
Postages, Stationery, Typing	39.36		
Travelling Expenses	501.00		
Bank Fees	14.00		
Audit Fee	45.00		
Registered Office Fees	429.50		
	4715.05		
NET SURPLUS FOR YEAR	998.95		
	5714.00		5714.00

BALANCE SHEET AS AT 30th JUNE 1978

LIABILITIES			*ASSETS*	
Accumulated Funds		1660.29	Commercial Banking Co. of Sydney	
Balance as at 30th June 1977	661.34		Crows Nest	2695.89
Add Surplus for year	998.95			
	1660.29			
Sundry Creditor — Bulletins		1035.60		
		2695.89		2695.89

I report that I have examined the records of the Australian Acoustical Society for the year ended 30th June 1978, and in my opinion the above Balance Sheet and Income and Expenditure Account are properly drawn up so as to give a true and fair view of the state of affairs of the Society.

Signed F. J. MORTON
Registered under the Public Accountants
Registration Act, 1945, as amended

20th July 1978

ANNUAL REPORT OF THE COUNCIL TO THE EIGHTH ANNUAL GENERAL MEETING : SEPTEMBER 1ST, 1978

1. COUNCIL MEETINGS

There have been two meetings of Council (the minimum prescribed by the Articles) during the past year. These were held in Perth (in September 1977) and in Melbourne (25th and 26th February 1978). A further meeting planned to be held in Adelaide in May 1978 was cancelled because of the absence overseas of the President and others at that time. Urgent business since the February meeting has been conducted by mail.

2. 10TH INTERNATIONAL CONGRESS ON ACOUSTICS

During the year Council formally appointed its organizing committee for the 10th I.C.A., with Mr. J. Rose as Chairman and the powers and obligations of the committee (known as the AAS/ICA Executive Committee) have been laid down.

Satellite symposia will be held in Perth, W.A., and Adelaide, S.A. During the year the Victoria Division withdrew its offer to hold a satellite symposium in Melbourne.

It is likely that the International Union of Pure and Applied Physics will appoint an Australian member of the International Commission for Acoustics at its Plenary Meeting in Stockholm in September 1978, because of the need for the Commission to maintain close contact with the AAS during the planning and running of the 10th I.C.A.*

3. MEMBERSHIP

3.1 **Numbers.** The total membership has experienced a net increase of 8 during the past year to give a total of 373 at 20th August 1978. A further 6 membership applications are currently under consideration by Council's Standing Committee on Membership.

3.2 **Fellows.** The Society presently has only one Fellow, although it is considered that there are additional members eligible for election to this grade. The matter has been the subject of lively discussions for several years but some members believe that the conditions for election to the grade, as prescribed by the Articles make the selection of Fellows unnecessarily difficult. Council considers that the issues should be decided by the general membership and a document proposing changes to the Articles, together with arguments for and against the proposal, will be submitted to all members in the near future. The matter will subsequently be decided by a vote of members at a General Meeting of the Society.

3.3 **Federal Membership Committee.** The nineteenth meeting of Council set up a standing Federal Membership Committee the Chairman of which will have the option of endorsing new applications (in straight-forward cases) or of referring them to the full Membership Committee for consideration. The subsequent treatment of Applications endorsed by the Chairman of the Membership Committee will ensure that the time required to process them will be substantially reduced as compared with that required by the previous procedure. Council has appointed Mr. P. Dubout Chairman of the Committee.

4. **BULLETIN**

The AAS Bulletin has been, so far, produced on a quarterly basis by the N.S.W. Division's Publicity Subcommittee. However that Subcommittee has had difficulties in keeping up with publication deadlines as a result of pressure of other commitments on members of the Subcommittee. Consequently, although adequate editiorial material and advertising has been available, issues following the June 1977 issue (Vol. 5 No. 2) have suffered significant delays.

As the Bulletin has received a gratifying acceptance from AAS members and other subscribers, means are being considered by the Society to relieve the current difficulties in its editing and production. The Victoria Division is examining the possibility of undertaking the primary Bulletin responsibilities and the practicability of engaging supplementary professional assistance in production and distribution is under consideration by the Council.

5. **REGISTERED OFFICES OF THE SOCIETY**

After incorporation of the Society in 1971, the Company was registered in all States except Queensland, and registered in A.C.T. and N.T. However during recent years it has been found to be unnecessarily expensive, in view of the advantages gained, to retain the registrations in the Territories. Accordingly, Council has decided to withdraw those registrations and this was done during the second quarter of 1978.

On behalf of the Council,

D. A. GRAY, GENERAL SECRETARY.

* Jack Rose has now been appointed the Australian Member of the International Commission for Acoustics. Ed.

THE AUTHORS

MARSHALL HALL

Dr. Hall is a senior research scientist in the Ocean Sciences Group at the R.A.N. Research Laboratory (RANRL), Sydney. He joined RANRL in 1967, after one year as a high school mathematics teacher in Western Australia. He was awarded a Ph.D. by the University of N.S.W. in 1974. His thesis, "Aspects of Acoustic scattering in the Ocean", was based mainly on research carried out with RANRL under joint supervision. He is currently studying the effects of surface roughness and volume inhomogeneities on underwater sound propagation. The work involves regular participation in oceanographic cruises, and Dr. Hall has passed through most of Australia's seaports, as well as Noumea and Jakarta.

N. GABRIELS

Mr. N. Gabriels is an architect and environmentalist working in the Environmental Design Section of the Western Australian Public Works Department. He has had extensive experience in hospital design and construction, and has recently become a Member of the Australian Acoustical Society.

MS N. CONSTANT

Ms N. Constant is a research assistant and draftsman in The Environmental Design Section of the Western Australian Public Works Department. She was responsible for the detailed construction design of the ceiling described in "Development of a Sound Absorbing and Attenuating Ceiling".

N. L. CARTER

Norman Carter joined the National (then Commonwealth) Acoustic Laboratories soon after graduation as B.A. (Hons.) in 1956. For four years he was engaged in clinical audiology and research. From 1960 to 1962, while on leave of absence from CAL he worked as a research associate with Dr. Karl Kryter at Bolt, Beranek and Newman Inc. in Boston, U.S.A. From 1962 he has carried out psychoacoustic research, since 1966 as head of NAL's psychoacoustic research section, and in 1972 gained the degree of M.A. with first class honours in psychology from Sydney University. Norm, who is at present studying full time at Sydney University under a Public Service Board Postgraduate scholarship, is also an accomplished violinist and holder of the diploma of Associate in Music, Australia.

CONFERENCE & SYMPOSIUM ANNOUNCEMENTS

INTERNOISE 79

GENERAL INFORMATION

The eighth International Conference on Noise Control Engineering will be held in the conference rooms of the Palace of Culture and Science in the centre of Warsaw, Poland on 11-14 September 1979. The conference will include technical sessions consisting of invited, contributed: verbal and poster form presentations in all branches of noise control activities and an exhibition of the latest equipment and instrumentation for noise control.

English will be the working language for presentation and all printed records.

SPONSORSHIP

INTER-NOISE 79 is sponsored by the International/INCE and is organised by the Institute of Fundamental Technological Research of the Polish Academy of Sciences/IPPT-PAN in co-operation with the Acoustical Committee of the Polish Academy of Sciences, the Polish Acoustical Society and other leading professional and governmental organisations.

INVITED AND CONTRIBUTED PAPERS, ABSTRACTS

Contribution on the following topics have been selected for the technical program:

1. Community Noise
2. Aircraft and Airport Noise
3. Rail Transportation Noise
4. Traffic Noise Abatement
5. Machinery Noise Reduction at the Source
6. Reduction of In-Plant Noise
7. Noise Control Engineering in Buildings
8. Designing and Planning for Industrial Noise Control
9. Noise Measurement, Analysis and Instrumentation
10. Materials and Products for Noise Control
11. International Standards and Legislative Requirements for Noise Control
12. Construction Noise

Abstracts should be informative rather than descriptive and be typed double-spaced on standard letter paper. The text of the abstract should be 400 words in length, including equations and references.

Authors should include name, complete mailing address, phone number, and they should indicate the program topic to which the abstract is directed. Abstracts are due on 15 December 1978. Authors will then receive special masters on which their manuscripts must be typed. The firm deadline for receipt of manuscripts is 15 March 1979. Abstracts and manuscripts should describe new material that has not previously been presented at a conference or published in a journal. Instructions relating to the presentation of accepted papers will be sent to each author. At INTER-NOISE 79, standard 2 x 2-inch and overhead projectors will be provided. Requests for special facilities should be added to the abstract as a footnote.

PARTICIPATION

These individuals who will return the Application Form will receive further information concerning the participitation conditions and forms for registration and hotel booking. The Conference is open to all who have registered and paid the registration fee.

PROCEEDINGS AND FINAL PROGRAM

All invited, contributed and poster form papers will be included in the Proceedings, available to all participants at final registration. Final program will be mailed to all participants who have registered by 1 July 1979.

EXHIBITION

A comprehensive exposition of noise control equipment and materials will be featured at the Conference. There will be opportunities for viewing exhibits and demonstrations and for discussion with manufacturer's representatives. Parties interested in sponsoring an exhibit at the exposition should contact the Conference Secretariat.

GENERAL ENQUIRIES

INTER-NOISE 79
IPPT-PAN
Ul. SWIETOKRZYSKA 21
00-049 WARSZAWA, POLAND

LETTERS

Mozart Strasse 1,
6087 Buettelborn,
West Germany.

Dear Sir,

I am interested in working in Australia in the field of acoustics and noise control.

Briefly my career details are as follows: I have a B.Tech. honours degree from Loughborough University of Technology in Aeronautical Engineering and Design. I worked for almost two years as Research Assistant to the Controller of Acoustics Research for B.P.B. Industries (British Plasterboard and British Gypsum) working on building acoustics, factory noise, sound insulation from aircraft noise etc. Then I worked for two years for Wiltshire County Council as head of the noise section in the Department of Highways and Transportation. It was this section's job to predict the number of houses which would be affected by new road schemes and to estimate the cost of sound insulation and barriers etc. There was also a lot of other noise control related work, for instance, to calculate or measure noise levels in houses near large plants or building sites and to act as consultants for nearby councils or government departments which did not have their own noise engineers.

I have been unable to find full-time work as a noise engineer in Germany since I moved here with my husband two and a half years ago. I am however a full member of the British Institute of Acoustics and have been receiving all the papers published by them.

I would very much appreciate it if any of your readers may have a suitable post vacant in the near future. My husband's contract ends in Spring 1979 and we would both like to go to work in Australia.

Yours sincerely,

DAWN L. POWELL, B.Tech, M.I.O.A.

Editor: Full Curriculum Vitae available

Dear Sir,

My overall purpose on my study leave here in the U.S. is to come abreast of the latest in noise control engineering in this country. I can report that the consulting business is thriving and that industry is concerned about OSHA hearing conservation regulations. I can also report that the U.S. Federal Government is spending a lot of money on noise control for aircraft, highway traffic and mining but nil on industrial noise control. Thus those people in Australia who reckon that they will fix their industrial noise problems by buying solutions overseas, for example from the Yanks, may have to wait quite a while.

I can further report that while some very good work on understanding saw noise has been done in the U.S. on private money, our work at Adelaide under the direction of Fred Zockel is as good as any and right on course. In fact I believe that we have a very good chance of finding ourselves in the position of being able to sell a fix to the Yanks.

Sincerely,

DAVID ALAN BIES

EVEN MORE ON WIRES AND NETTING

Dear Sir,

Recently Strathfield Town Hall was redecorated. Incredible as it may seem, nylon fishing netting was hung from the ceiling. Flabergasted, I rang the Town Clerk to find out who had recommended that the netting be put in and why it was thought necessary as the acoustics are very good anyway.

It turned out that the Mayor had suggested the netting for the Mayoral Ball . . . to hold balloons in. The balloons had been taken down but the netting, being almost invisible, had been left up, for future occasions.

Yours faithfully,

FERGUS FRICKE

SOME INTRIGUING ASPECTS OF UNDERWATER ACOUSTICS

MARSHALL HALL
R.A.N. Research Laboratory
P.O. Box 706, Darlinghurst, N.S.W. 2010

Paper presented to a meeting of the Victorian Division of the Australian Acoustical Society on 8 June, 1978.

ABSTRACT

The three main fields of underwater acoustics are propagation, scattering, and ambient noise. Aspects of each of these fields are discussed, with a view to emphasizing the surprising nature of some of the results that have been obtained, and also to explain why certain problems have not been solved. The topics covered include: cut-off frequency; surface-duct propagation; chemical absorption; surface scattering; scattering by bubbles and fish bladders, deep scattering layers; and wind-generated ambient noise.

INTRODUCTION

Sound waves are used for exploring the ocean medium because they are attenuated far less than any type of electromagnetic radiation. Even so, the ocean is far from being an ideal medium for underwater sound waves. Temperature gradients cause gradients in the sound-speed profile, which in turn cause sound waves to be refracted. Rough boundaries between water and air, and between water and sediment, cause sound energy to be reflected in various directions, and small inhomogeneities in the ocean cause a portion of the sound energy that may be travelling in a beam to scatter in all directions. Moreover, just as it is sometimes difficult to listen to a particular sound in air because of background noises, it is occasionally difficult to hear important underwater sounds for the same reason.

While many important problems in underwater acoustics are still being studied, others have been solved using either analytical or numerical techniques. Some of the results are quite curious. The aims of this paper are to highlight particular examples of these results, and also to discuss some of the problems that have yet to be solved.

PROPAGATION

The ocean is a layer of water whose thickness varies from zero to several kilometres, although the slope of the sea floor is usually very small. If a sound-source is placed in the ocean, the acoustic pressure or intensity at any range and depth is calculated from solutions of the linear wave equation. The "propagation loss" is defined as the ratio of the intensity at unit distance from the source, to the intensity at the position being considered. The wave equation includes the sound-speed as an important factor, and sound-speed varies with temperature, hydrostatic pressure, and salinity. In many circumstances, and usually so in the deep ocean. variations of sound-speed with horizontal position are negligible, and the medium is said to be stratified.

a. Phenomenon of Cut-off Frequency.

Three types of acoustic wave-guide or duct occur in the ocean: the region between two reflecting surfaces (for example, the surface and the sea-floor); regions where the sound-speed as a function of depth has a minimum; and regions close to a reflecting boundary where the sound-speed increases with increasing (vertical) distance from the boundary. In the first case, sound energy is trapped by reflection only; in the second case energy is trapped by refraction only; and in the third case energy is trapped by a combination of both reflection and refraction. If the wavelength of the sound is sufficiently large (corresponding to a low frequency), the duct may be relatively too thin to have an appreciable effect on the sound field. If we start with a sound source transmitting at a high frequency and then steadily lower the frequency, a receiver placed some distance along a duct will hear an almost steady signal level until, at a particular frequency, the signal level will commence to decrease. This "threshold" frequency is called the "cut-off frequency" of the duct. The cut-off frequency depends on the thickness of the duct, the change in sound-speed from within to below (or above) the duct, and, to a lesser extent, on the shape of the sound-speed profile within the duct. To illustrate the significance of these parameters, we will consider two simple examples. The first, which is applicable to "shallow water" propagation, comprises a homogeneous layer of thickness H and sound-speed C_o between a vacuum (or air) and an infinite half-space and sound speed C_1 ($C_1 > C_o$). An example of such a waveguide is shown by the cashed-curve profile in fig. 1.

The cut-off frequency is given by

$$f_c = \frac{4C_o}{H[1 - C_o^2/C_1^2]^{1/2}} \qquad (1)$$

As C_1 approaches ∞, f_c approaches $\frac{4C_o}{H}$

Curves of f_c as a function of H, for values of C_o/C_1 = 0.7 and 0.9, are shown in Fig. 1 by the cashed curves labelled n = .7 and n = .9. The cut-off frequency decreases as the ratio of the sound-speeds decreases.

The second example, which is applicable to propagation in a surface isothermal mixed layer, comprises a surface layer in which the sound speed increases linearly with depth, below which is an infinite half-space in which the sound-speed approaches zero at infinite depth. This layer is a duct because sound is refracted upwards by the positive sound-speed gradient and is reflected downwards at the water/air boundary. The cut-off frequency is given by

$$f_c = \frac{9\,C_o}{16\sqrt{2H}} \left[\frac{C_o}{gH}\right]^{1/2} \qquad (2)$$

where C_o is the surface sound-speed and g is the sound-speed gradient in the duct.

For an isothermal surface-duct (g = 0.016/s), the values of f_c as a function of H are shown by the solid curve in Fig. 1. f_c is proportional to $H^{-3/2}$ for the refractive duct, whereas it was proportional to H^{-1} for the reflective duct. This effect occurs because for a given g, the ratio of the sound-speeds C_o and C(H) decreases as H increases. If we set

$$C_o = C_1 - gH$$

in eqn (1), we obtain the dashed curve labelled n = 1 – gH/c in Fig. 1 for f_c as a function of H. On comparing this curve with the curve of eqn (2), we see that for fixed minimum and maximum sound speeds the cut-off frequency of a duct between two reflecting boundaries is less than that of a duct which has only one reflecting boundary.

b. **Effect of surface-roughness on surface-duct propagation**

Sound-speed profiles measured during a particular surface-duct propagation experiment are shown in Fig. 2 (numerals indicate horizontal range from receiving position in kilometres). Also shown are the source depth (Δ), and the depths of the two receivers (o and x).

The sea-surface is moderately rough (swell-height 1.2 m, wind-wave height 0.3 m, RMS slope 0.2). The variation of the surface-duct thickness with horizontal range is small in this case, and is not expected to have any measurable effect on the sound field. The experimental results for acoustic propagation loss are shown in Fig. 3 (frequencies 8 and 16 kHz) and Fig. 4 (frequencies 1, 2 and 4 kHz). Also shown are normal-mode theoretical curves applicable to the sound-speed profile as measured (Normal-mode theory is valid if the sea-surface is smooth).

There is reasonable agreement between theory and experiment at the lower frequencies, but at the highest frequency (16 kHz), the experimental results show little agreement with the theory. The in-duct results are attenuated by about 10dB, whereas the below-duct results are attenuated at short range, but become stronger than the theoretical predictions as the receiver passes into the shadow zone (at range 5.4 km). These effects are attributed to surface scattering, because the surface roughness is the only significant feature of the environment that is not taken into account by normal-mode theory. This theory cannot be used directly when the surface is rough, because the sound-speed is then a (non-separable) function of range as well as of depth; the wave equation, a partial differential equation, cannot be separated into ordinary differential equations. (Approximate solutions are being produced by treating the surface roughness as a perturbation of the flat-surface model.). Nor can the "ray approximation" be used directly, because the horizontal distance between points at which rays are multiply-scattered, due to upwards refraction, is small for some rays. When this ("skip") distance is comparable with the correlation distance of the boundary roughness, the standard scattering models are no longer applicable. An approximate solution could be produced by assuming that there is no diffuse scattering of these particular rays (which do strike the surface at grazing angles smaller than those of any of the other rays).

c. **Absorption**

Absorption is defined as the attenuation of sound due to properties intrinsic to the medium. (Attenuation due to the effects of inhomogeneities is termed "scattering".) Empirical curves for absorption in sea-water, at frequencies ranging from 0.5 to 40 kHz, are shown in Fig. 5. At frequencies above about 8 kHz, absorption is due to relaxation mechanisms of dissolved magnesium sulphate ions (relaxation time is about 8 μs). At lower frequencies, relaxation of boron ions is predominant. This effect occurs (in spite of the fact that the ratio of concentrations of boron compounds to magnesium sulphate is only 1%), because the relaxation time of the boron ions is about 1 ms.

The concentration of boron in sea-water does not vary significantly around the world, but the concentrations of the ions which "relax" are influenced by the pH of the water. pH does vary from one ocean to another, as can be seen in Fig. 6. A theoretical curve for absorption by boron ions as a function of pH, together with experimental results obtained in various ocean areas, is shown in Fig. 7. The agreement is good except with one measurement made in a low pH region.

The absorption coefficients at low frequencies are very small, and propagation over large distances is necessary in order to obtain accurate measurements. It is only with the discovery in the last few years that boron ions do have a relaxation time of about 1 ms, that such experimental results are being generally accepted as measurements of genuine absorption.

The concentration of boron in sea-water is extremely small (about 26 mg of boric acid in 1 tonne of sea-water), and yet this element has a measurable effect on long-distance sound propagation. Furthermore this effect is often greater than that due to other (easily-measurable) features of the ocean, such as small-scale fluctuations in the sound-speed profile.

SCATTERING

a. **Surface Roughness**

When a sound beam is incident on a randomly rough surface or boundary of the medium, the result is a coherent beam reflected in the specular direction together with a radiation of diffuse energy in a (generally broad) beam pattern. This radiation of diffuse energy is termed surface scattering, and the component radiated backwards along the path of the incident beam is termed "back-scattering". Its practical significance is that it causes "reverberation", or unwanted signals masking reflected signals of interest. Consider the theoretical and experimental results for back-scattering from the ocean sea surface, shown in Fig. 8. In this example the rough surface has an RMS elevation of 0.15 m and an RMS slope of .2, and the acoustic wave-length is 0.4 m. These parameters were chosen so that the first-order Kirchhoff theory would be valid at grazing angles of up to 30 degrees, and also that the (equally simple) asymptotic form of the Kirchhoff theory would be valid for grazing angles of 45 to 90 degrees. (The Kirchhoff theory is popular because it is comparatively simple. It assumes that the sound field and its gradient at any point on the rough surface are the same as if the only surface present were a flat plane tangential to the point in question.) At small grazing angles, the Kirchhoff theory predicts a scattering strength of about −30 dB (solid curve), to which a shadowing correction is applied (dotted curve). The measured values are 10 to 20 dB weaker than these theoretical values, and this result illustrates the adequacy of the Kirchhoff prediction. The main problem is that the Kirchhoff model requires that the rough surface have large radii of curvature everywhere, whereas the crests of sea-waves (in particular) have very small radii. However there is no model available at present for scattering from a randomly rough surface, that yields good agreement with experiment over a wide range of conditions.

b. **Free Gas Bubbles**

If small inhomogeneities are placed in a sound beam, the main effect is that each inhomogeneity radiates sound as if it were a source. This process is called scattering. If the radius of the inhomogeneity is much smaller than the acoustic wavelength, the scattering is omni-directional. The strength of the scattering from an inhomogeneity increases with increasing "mismatch" of the acoustic impedances of the inhomogeneity and the surrounding medium.

The most important type of inhomogeneity in sea water is the gas bubble, either free or enclosed in a fish swim-bladder. Gas bubbles have a low acoustic impedance and are efficient scatterers of sound — and spectra of scattering by bubbles show that each bubble has a resonance frequency.

The pressure-amplitude (p) and phase (ϕ) spectra of sound scattering by a bubble are shown in Fig. 9 (top right-hand corner). The resonance frequency is given by

$$f_r = \frac{1}{2\pi a} (3\gamma P_o/\rho)^{1/2}$$

where a is bubble radius
P_o is ambient hydrostatic pressure
ρ is density of surrounding medium
γ is the ratio of specific heats of the bubble gas
(γP_o is the bulk modulus of the gas in the bubble).

The resonance frequency of a bubble as a function of bubble radius, for 2 values of hydrostatic pressure (or depth below the surface), is shown in Fig. 9. Bubbles exist in the sea, close to the surface, mainly as a result of surface waves breaking. The most common radii of these ambient bubbles is 60 to 100 μ, and the resonance frequency of these (typical) bubbles is 30 to 50 kHz.

The effect of ambient bubbles on sound transmission at frequencies of 30 to 50 kHz is that a sound beam will be attenuated as part of its energy is scattered in all directions.

c. **Fish Gas-Bladders**

Many species of marine fish possess gas-filled "swim-bladders". Data from experiments to determine the resonance frequencies of particular gas-bladders, and of the fish and gas-bladder combination, are shown in Fig. 10. In these experiments, the target is placed in a steady sound field (whose frequency is slowly varied) and the total sound pressure (incident plus scattered) close to the surface of the target is measured. At high frequencies, there is partial destructive interference between the incident and scattered waves ($\phi = 180^\circ$ and $P_s < Pi$). The sharp minimum occurs at the frequency where $P_s = P_i$ (and $\phi \cong 180^\circ$).

The isolated gas-bladder has a higher Q than the intact fish-with-bladder; this effect is due to the relatively high "viscosity" of the fish tissue.

d. **Deep Scattering Layers**

Acoustic scattering layers, both deep and shallow, are widespread in all of the world oceans. An example of a layer, and its variation with time of day, is shown in Fig. 11. Part of the layer descends during the early daylight hours from the surface to depths of several hundred metres, and returns to the surface region towards sunset. This behaviour is the same as that of many species of mesopelagic fish and the larger species of zoo-plankton. Most mesopelagic fish have gas-filled swim-bladders; and the most common acoustic resonance frequency of these bladders is about 5 kHz.

The effect of these relatively strong scattering objects distributed through the volume of the ocean is to cause "volume reverberation", appearing as an unwanted return signal when an active sonar beam is used. In this way the return signals of interest may be masked and escape detection.

AMBIENT SEA NOISE

The ocean is a noisy environment and the type of noise are classified as:
wind dependent
biological and
(ship) traffic

The significance of ambient noise is that it determines the background level against which radiated noise from target-vehicles is to be detected (by "passive" sonars).

Biological and traffic noise are straightforward in concept (although difficult to predict accurately), whereas the basic mechanisms of wind-dependent noise have yet to be explained.

Empirical spectra of wind-dependent noise in Australian waters for several wind-speeds are shown in Fig. 12. These levels are too high to be explained by presently available theories of noise generation by wind-driven turbulence. At the low wind-speeds, the spectra contain a broad peak at about 500 Hz, and there is probably another peak at a low frequency (of the order of 10 Hz or less). It is possible, although it remains to be demonstrated, that the low-frequency peak would be associated with the conventional spectrum of the sea-surface roughness, which peaks at frequencies of 0.5 to 1 Hz. The relationship cannot be one of simple proportionality, because the roughness spectra at high frequencies are independent of wind-speed (the phenomenon of "saturation" of capillary waves).

Other than the low-frequency surface-roughness spectrum, the only spectrum with a peak, that is known to occur naturally in the ocean, is the distribution of sizes (and hence of resonance frequencies) of air bubbles that we have alluded to in the section on scattering. The only peaks of these spectra are at frequencies of 30 to 50 kHz, and it is possible that wind-dependent noise may possess some interesting properties at these frequencies. So far, however, measurements have been sparse.

The question that remains is: what causes the peak in the wind-dependent ambient noise at 500 Hz?

CONCLUDING REMARKS

The phenomenon of cut-off frequencies in stratified underwater acoustic ducts has been successfully modelled, and is of general interest because the duct thickness is much larger than the acoustic wavelength at which cut-off occurs. (The same effect occurs in acoustic or electro-magnetic ducts in the atmosphere).

Scattering of sound by individual gas bubbles is also a comparatively simple problem and has been satisfactorily modelled. This phenomenon is of interest because, at resonance, the scattering cross section of a bubble is far greater than its geometric cross-sectional area. The bubble scatters more sound energy than is directly incident on the bubble itself.

Scattering of sound waves by the periodically undulating boundary (with no random roughness) of a homogeneous medium can be solved exactly, although the effort required is considerable. An exact solution for a randomly rough boundary can be obtained in principle by considering the spectrum of the surface roughness. As yet, however, this final step has not been carried through to completion, and the Kirchhoff approximation is still a popular, but inadequate, model.

The transmission of sound waves in a stratified medium with flat boundaries has also been successfully modelled (the "normal-mode" method). However, the combined problem of transmission is a stratified (as distinct from a homogeneous) medium with a rough boundary has not yet been solved.

Wind-dependent sea-noise at frequencies above, say, 100 Hz is louder than can be explained by present theories. It is not known how there can be a peak in the spectrum at about 500 Hz.

It is hoped that the foregoing discussion of some aspects of what is a complex assembly of interrelated effects has interested the non-marine scientist. There are many analogies between the problems of underwater acoustics and those of fields such as radar transmission or airborne acoustics. Much striking work has been done, and more remains to be done.

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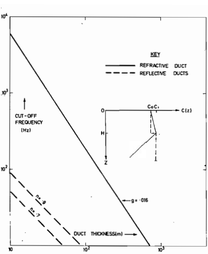


Fig. 1. Cut-off frequency vs duct thickness, and example sound-speed profiles for refractive and reflective ducts.

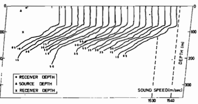


Fig. 2. Sound-speed profiles for surface-duct propagation experiment.

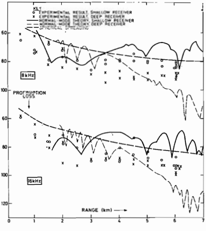


Fig. 3 Surface-duct propagation loss results. Frequencies 8 and 16kHz.

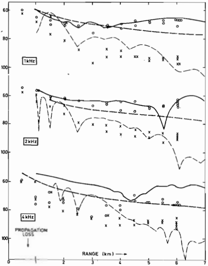


Fig. 4 Surface-duct propagation loss results. Frequencies 1, 2, 4 kHz.

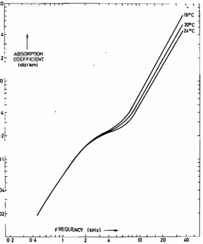


Fig. 5. Absorption of sound in the sea as a function of frequency, at several temperatures.

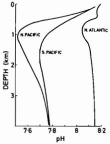


Fig. 6. Typical pH profiles.

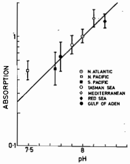


Fig. 7. Experimental (sea) and predicted values of absorption versus pH.

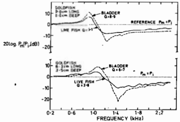


Fig. 10(a) Frequency response of the acoustic scattering from two live goldfish and from their bladders.

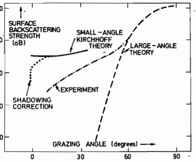


Fig. 8. Example of theoretical and experimental surface backscattering. Frequency 4 kHz.

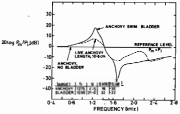


Fig. 10(b) Frequency response of the acoustic scattering from a live anchovy and from its bladder.

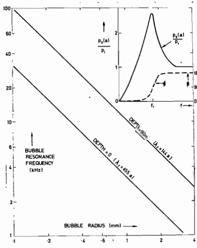


Fig. 9. Resonance frequency of a free bubble in water, and spectra of the amplitude (p) and phase-change(Ø) of the scattered sound wave.
a is bubble radius
λ_r is acoustic wavelength at resonance.

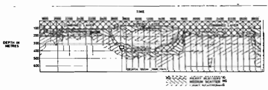


Fig. 11 Diurnal variation of a deep scattering layer.

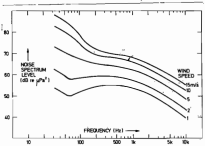


Fig. 12. Empirical wind-dependent-noise spectra determined for water near Australia.

DEVELOPMENT OF A SOUND ABSORBING AND ATTENUATING CEILING

N. I. GABRIELS & N. CONSTANT

SUMMARY

A sound absorbing and attenuating ceiling has been developed for use in hospital buildings. Its room-to-room sound attenuation and single ceiling sound insertion loss properties were measured, and the results evaluated for speech privacy and attentuation of noise from above ceiling noises.

INTRODUCTION

The need for a sound absorbing and attenuating ceiling in hospitals has long been recognised. There are some ceiling constructions available with adequate absorption and attenuation properties, but none can also provide for the stringent medical and engineering requirements of Western Australia's major public hospitals.

The modern hospital is a highly serviced building with the normal acoustic requirements of sufficiently low background noise levels and adequate speech privacy, but has additional, special requirements for cleanliness, low maintenance and accessibility to above-ceiling services.

In the past, adequate noise control and speech privacy have been achieved in the traditional manner of extending walls to the underside of the slab or roof. With current hospital requirements and trends in design, this is becoming both uneconomical and impractical. Mechanical, plumbing and electrical services are of such an extent that very large spaces are required to contain them, and these spaces are usually located above ceiling level. Ceiling voids of up to 1350 mm are not uncommon. Additionally, in many instances, it is not possible to locate mechanical ducts where desired, and they often run directly above, and parallel to wall partitions which need to be full height to achieve acceptable room-to-room sound transmission losses.

Acoustic masking or "perfuming" has been used on a number of occasions in hospitals and has been included in several Perth hospital buildings. In one system, based on individual office control, the results have not been satisfactory. It has been found that some patients object to the noise at the volumes necessary to achieve sufficient masking, and another major drawback is that some doctors do not use the system, which is only effective if operating in both of the adjoining consulting rooms.

The noise of equipment in the ceiling space can also be of major concern. For example, mechanical design is tending to high velocity air conditioning systems incorporating terminal mixing boxes. These boxes emit considerable noise, particularly in the case of the larger boxes, and often require an enclosure or some form of barrier to reduce the noise emitted to the occupied areas below to an acceptable level. Other equipment which often requires attention includes pneumatic tubes, "telelift" runs (an automated distribution system), steam traps and above-ceiling mounted fans.

DEVELOPMENT

The development of the ceiling commenced with an examination of hospital requirements, followed by a survey of available ceiling systems and constructions.

As previously mentioned, two major requirements in hospitals are cleanliness and ease of access. For a ceiling to comply with the standards of cleanliness it must be scrubbable. Maintenance requirements dictate that the ceiling be fully accessible and that panels be easily removable and replaceable without sustaining damage.

A survey of the available ceiling constructions indicated that the commonly used perforated metal-pan suspended ceiling system was the most suitable for cleanliness and access, as well as providing adequate sound absorption. It was therefore decided to substantially modify this system to incorporate greatly improved sound attenuating properties.

The areas of concern in redesigning the metal-pan ceiling were:—

(a) Maintaining the acoustic absorption properties;

(b) Providing the panel and its junctions with adequate sound annenuating properties, in this case not less than Sound Transmission Class (STC) 40-42, room-to-room; and

(c) Maintaining the structural performance and accessibility.

DESIGN DETAILS

To achieve an STC of not less than 40, the ceiling system was designed with the following construction:

The face of the ceiling panels were to be of a 0.56mm thick zinc annealed sheet, with 2.4 mm diameter holes in a square array at 6.75 mm centres, giving a 10% open area. (This is similar to the normal metal-pan ceiling and was used to maintain acoustic absorption properties, as well as a sufficiently low weight for ease of handling.) The panel was to be backed with 1.6 mm black iron, pop rivetted to the face of the zinc annealed sheet, and filled with two 25 mm thick layers of fibreglass of 40-48 kg/m^3 density (two layers were selected rather than one for ease of construction). All edges of the panel were to be rebatted and to incorporate a 12 mm x 3 mm non-interconnecting foam seal to maintain the sound transmission loss properties of the panel at its junctions. (See Figure 1 for construction details.)

The support system was to consist of a 38mm x 25mm aluminium box section, filled with plaster, suspended by means of a threaded rod. Perimeter support was to be by means of an aluminium angle.

To maintain the sound transmission loss, all fittings were to be surface mounted.

FIELD TEST

A prototype ceiling was constructed and field tested for sound insertion loss. The results obtained were encouraging and it was therefore, decided to have laboratory tests carried out for both room-to-room sound attenuation and single-ceiling sound insertion loss.

LABORATORY TESTS

The test ceiling was constructed in accordance with the design details (see Figure 1). The perimeter of the test ceiling was fully sealed with a non-setting caulking compound, and fittings that were to be installed in the ceiling, i.e., lights, a speaker box and fire sprinkler outlets, were surface mounted.

The laboratory tests were carried out at the CSR Building Materials Research Laboratories, N.S.W. The test procedure for the room-to-room attenuation was in general accordance with A.M.A.-I-II, March 1959, "Ceiling Sound Transmission Test by Two-Room Method." This test represents two adjacent rooms separated by a wall partition which does not extend, or only extends slightly into the ceiling plenum. The procedure is to measure the sound energy generated in one room that reaches the other room through the ceiling and common plenum space alone. Results of the measurements are shown in Figure 2. The results at 630 Hz and above indicate those frequencies at which the ceiling's sound transmission loss was comparable to the sound transmission loss of the wall dividing the laboratory test rooms, and can therefore be considered as minima. The ceiling achieved a room-to-room S.T.C. of 48. The results are shown in Figure 2.

The single ceiling sound insertion loss test was carried out by mounting a loudspeaker in the plenum space above the ceiling before the ceiling itself was installed. The sound pressure levels were then measured in the room below, with and without the ceiling in place. The difference between the two levels, the sound insertion loss, was then determined. The results are shown in Figure 3.

DISCUSSION OF RESULTS

The ceiling exceeded the design value of not less than STC40 by 8 units. This is thought to be partly due to the use of the mastic seal around its perimeter in the laboratory installation.

To further assess the acoustic performance of the ceiling, two of the major acoustic requirements in hospitals, speech privacy and attenuation of noise from above-ceiling noise sources, were examined.

1. Speech Privacy
   The dotted lines in Figure 4 indicate the room to room sound transmission loss required to achieve an adequate degree of speech privacy between rooms with background noise levels of N.R. 30, 35 and 40. It can be seen from the diagram, that the room to room sound transmission loss performance of the ceiling is in excess of the attenuation required to achieve adequate speech privacy in rooms with background noise levels of N.R. 30 and, as such, is therefore generally suitable for use in consulting rooms and executive offices.

2. Above-Ceiling Noise Sources
   As typical examples of above ceiling noise sources, two air conditioning variable volume boxes were considered in relation to the ceiling's sound insertion loss. Noise from these boxes generally results in levels well in excess of the acceptable levels in occupied spaces, according to A.S. 2107 – 1977 "Ambient Sound Levels for Areas of Occupancy Within Buildings". Hence, the boxes often require encasing. This creates problems in extremely tight ceiling spaces, makes access for maintenance more difficult and substantially increases costs. Figures 5 and 6 indicate the resultant sound pressure levels in a typical hospital room with a variable volume box located above the ceiling. (A "typical room" is defined as a two-bed ward with a volume of 70 m^3, reflective wall surfaces with an N.R.C. of 0.02, a medium density carpet and an absorbent metal-pan ceiling.) It can be seen from the figures that the resultant noise level in a room with a 640 litres per second terminal box in the ceiling space is N.R. 40, or to N.R. 36, if the box is lined with 0.8 mm thick lead sheet. This makes it possible for these boxes to be located above wards and offices, if necessary. Noise from the larger boxes, such as those handling 940 litres per second, is reduced to N.R. 47, or N.R. 43 if these boxes are lined with 0.8 mm lead sheet. While obviously more care has to be taken in positioning these larger boxes, it will be generally acceptable for them to be located above service areas, general offices, and the like.

CONCLUSIONS

The modified ceiling system achieved its main objectives of:

1. Significantly reducing the number of walls which require to be extended the full height of the above-ceiling space for acoustic purposes;
2. Allowing more freedom in the location of above-ceiling noise sources;
3. Being fully accessible;
4. Allowing for easy cleaning; and
5. Providing an acoustically absorbent surface, i.e. having a Noise Reduction Co-efficient of approximately 0.65.

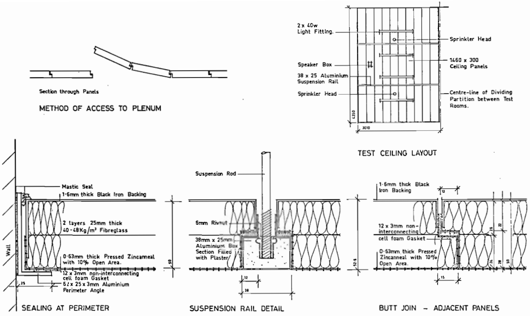
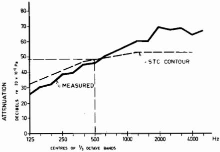


FIGURE 1 CONSTRUCTION DETAILS

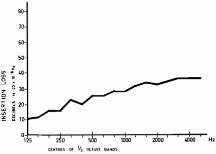
125	25
160	30
200	32
250	38
315	39
400	44
500	45
630	50
800	53
1000	57
1250	60
1600	60
2000	69
2500	67
3150	68
4000	64
5000	66



CEILING ROOM-TO-ROOM SOUND ATTENUATION

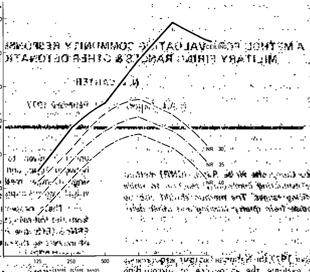
FIGURE 2

125	10
160	11
200	15
250	15
315	22
400	20
500	25
630	25
800	28
1000	28
1250	31
1600	33
2000	32
2500	34
3150	35
4000	35
5000	35



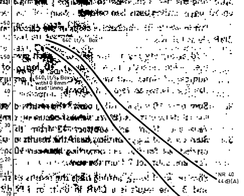
SINGLE CEILING SOUND INSERTION LOSS

FIGURE 3



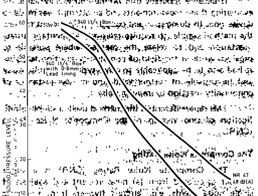
ROOM-TO-ROOM ATTENUATION REQUIRED TO MAINTAIN SPEECH PRIVACY AT VARIOUS BACKGROUND-NOISE LEVELS

FIGURE 4



RESULTANT SOUND PRESSURE LEVELS IN TYPICAL HOSPITAL ROOM WITH 640 litres/sec PLAIN OR LEAD-LINED TERMINAL BOX ABOVE CEILING

FIGURE 5



RESULTANT SOUND PRESSURE LEVELS IN TYPICAL HOSPITAL ROOM WITH 940 litres/sec PLAIN OR LEAD-LINED TERMINAL BOX ABOVE CEILING

FIGURE 6

A METHOD FOR EVALUATING COMMUNITY RESPONSE TO NOISE FROM MILITARY FIRING RANGES & OTHER DETONATION SOURCES

N. L. CARTER

N.A.L. Report No. 67, February 1977

SUMMARY

A modified Composite Noise Rating (CNR) method is described for evaluating community reaction to noise from military firing ranges. The method should also be applicable to noise from quarry blasting and other detonations.

Introduction

In November 1972 the National Acoustic Laboratories were asked to evaluate the annoyance to surrounding communities caused by weapon noise from the Mount Stuart military firing ranges, near Townsville, North Queensland. Noise measurements were made in the form of photographs of acoustic waveforms fed to the screen of a cathode ray oscilloscope, frequency modulated tape recordings and sound level meter (SLM) readings. The SLM measurements were made in the dBA (hold) mode. Maps of the area were obtained and interviews carried out with some of the nearby residents (Carter, et al., 1973).

It became apparent that no method was available for evaluating these measurements and an attempt was made to devise one. In doing so it was considered important to keep the method simple, to require relatively elementary instrumentation and to relate the method where possible to previous work in the field of community reaction to noise. It had also to be applicable to other types of impulse noise and be capable of further validation in new instances of community reaction to impulse noise.

This report describes the method used, a simple modification of one version of the Composite Noise Rating (CNR).

The Composite Noise Rating

The Composite Noise Rating (CNR) is a single number calculated from (a) measurement and analysis of single noise events, e.g., aircraft flyovers from a specific aircraft type; and (b) the number of such events (flyovers) occurring during one typical day. The CNR value is then entered in a graph drawn from a collation of 'case history' data on the reactions of communities to noise. The probable reaction of communities to the introduction of a new noise into their environment, or the reaction of future planned communities to noise can then be estimated (Kryter, 1970).

A general description of the CNR method is to be found in Kryter (1970), pages 436, 437, 439. Its main features are – (a) CNRs from different types of aircraft can be added logarithmically to give a CNR for e.g., the total operations of an airport; (b) a penalty 'weighting' (of 10dB units) is given to each aircraft noise event occurring between 10pm and 7am; and (c) it can be used with any single number method of describing the noise from individual flyovers expressed in logarithmic (dB) units.

These properties of the CNR method are evident from the following procedure for calculating CNR using the EPNdB (Effective Perceived Noise Decibels) as the method of expressing the noisiness of single aircraft flyovers (after Kryter (1970)).

$$\begin{aligned} CNR = \{ ([EPNL_1 + 10 \log_{10} 0_1] \,|+|\, [EPNL_2 + 10 \log_{10} 0_2] \\ |+| \ldots |+| [EPNL_n + 10 \log_{10} 0_n] \quad - 12 \} \,|+| \\ \{ ([EPNL_{1p} + 10 \log_{10} 0_{1p}] \,|+|\, [EPNL_2 p + 10 \log_{10} 0_{2p}] \,|+| \\ \ldots |+| [EPNL_{np} + 10 \log_{10} 0_{np}]) \quad -2 \} \ldots\ldots (1) \end{aligned}$$

where $0_l \ldots 0_n$ are numbers of occurrences of sounds of EPNLs l through n during the hours of 7am to 10pm and $0_{lp} \ldots 0_{np}$ are occurrences of sounds of EPNLs l through np during the hours of 10pm to 7am. | + | means addition on 10 $\log_{10}$ antilog basis (see below).

Put in words, the successive steps in the calculation of CNR are as follows:

1. Add arithmetically to the EPNL of each given value (i.e., each aircraft type flyover), 10 $\log_{10}$ of the number of times that value (flyover type) occurs per day (i.e., between 7am and 10pm).
2. Sum on a 10 $\log_{10}$ antilog basis* the results of step 1 for all flyover types (EPNL values) occurring between 7am and 10pm and subtract 12 from this sum.
3. Sum on a 10 $\log_{10}$ antilog basis the results of step 1 carried out for flyovers occurring between 10pm and 7am and subtract 2 from the sum.
4. Sum on a 10 $\log_{10}$ antilog basis the results of steps 2 and 3. The result is a CNR in units of EPNdB. As stated, previously, other units of individual noise measurement or assessment can be used.

Having calculated the CNR in the above manner, an estimate of probable community reaction can be made from Figures 1 and 2, again after Kryter (1970). Figure 1 summarises some data relating CNR to community reaction to noise. Figure 2 gives a smoothed curve which may be used for predictive purposes or perhaps evaluate existing community activity in response to noise.

* By 'sum on a 10 $\log_{10}$ antilog basis' is meant: divide the respective values by 10, take their antilogarithms and add them, then multiply the logarithm (to the base 10) of this sum by 10.

Modification of CNR for Weapon Noise

It is customary to distinguish between gunfire noise and e.g., that due to subsonic jet flyovers by the term 'impulse' as opposed to 'steady state' noise. There are no rigorous physical definitions of these terms but to the ear there is an obvious distinction in the time domain, associated in the case of impulse noise with a very fast rate of onset, high peak to average (or rms) sound pressure level, and very brief overall duration of a few milliseconds (a little longer when the noise is reflected from objects in the immediate vicinity of the listener, e.g., parts of a weapon, walls, etc.). Sonic booms from supersonic aircraft, the sounds of drop forges, quarry blasting, fireworks are other examples of impulse noise.

A previous and we believe influential extension of the CNR to impulse type noise was proposed by Kryter (1969). In that paper the author summarised the results of experiments in which people were asked to compare the noisiness of aircraft flyovers (measured in peak PNdB) to actual and simulated sonic booms (measured in terms of peak overpressure — (dB linear, peak)). From these results he suggested the use of some simple measurements of sonic boom equivalent in their 'subjective' noisiness to measurements of subsonic aircraft flyovers. The result was a reasonable attempt to predict the future reaction of large numbers of Americans to daily flyovers of supersonic airliners, a contentious issue at that time. (Kryter found that some millions of people could be expected to be disturbed by this noise and even if he was in error by an order of magnitude in his estimates, it was obvious that the social repercussions within the U.S. would have been considerable).

Kryter's starting point in extending the CNR to sonic booms was human judgement data (Kryter, 1969, p. 364), indicating the equivalent noisiness of sonic booms (measured in peak SPL) and subsonic aircraft noise (measured in peak PNdB). No exact equivalent can be expected but on average a number of residents of Edwards Air Force Base, California, when asked to compare sonic booms from actual 'staged' B-58 flyovers with subsonic jet flyovers, rated a sonic boom at 1.7 psf equal in 'noisiness' (equally intrusive or disturbing of normal domestic activities) to subsonic jet noise measured at 109 PNdB. These residents were of course very used to both subsonic jet flyover noise and sonic booms and were presumably dependents of service personnel or connected occupationally with the U.S. Air Force. Kryter cites other data indicating that 'unadapted' civilians used to subsonic aircraft noise but not sonic booms rate a sonic boom from a B-58 aircraft at 1.7 psf equal in noisiness to subsonic jet noise measured at 119 PNdB.

In the simplest form in which a metric of the PNdB type is used, the formula for CNR is as follows:

$$\text{CNR} = \text{PNdB} + 10 \log N - 12 \quad \text{.......(2)}$$

where CNR = Composite Noise Rating,
PNdB = the calculated or measured peak PNdB (PNdB calculated from the highest octave band values reached during the overflight. See the note below on the meanings of different PNdB Units).
N = Number of noise events per day, all events taking place between 7am and 10pm (The constant 2 applies to CNRs calculated on events outside this time).

Thus Kryter estimated that a sonic boom of about 1.9 psf will be subjectively equal, after adaptation resulting from several years of exposure to sonic booms, to subsonic aircraft noise of 110 PNdB (all measurements made outdoors) implying, for one sonic boom a day, a CNR of 98 (CNR = 110 - 10 log 1 - 12). Since a CNR from 100 to 110 represents a level at which vigorous legal and other community reaction take place, the situation (one sonic boom per day at 1.9 psf) was regarded as marginal even for 'adapted' communities.

A further extension to this line of reasoning to cover community reaction to impulse noise generated on the ground appealed to us for the following reasons. First, it is simple and requires only one type of measurement of weapon noise, i.e., dB (linear, peak). Second, the reasoning behind it is publicly identifiable — there are no mysterious steps which would prevent others from arriving at the same CNR as ourselves, given similar data. Some assumptions are made but they are defensable and specifiable, so that particular parts of the method might be modified or even rejected on the basis of future data without rejecting the whole approach and having to start again. Third, a distinction is made between daytime (7am to 10pm) and night time operations (10pm to 7am), important because firing ranges are sometimes used after 10pm. Fourth, CNRs from different noise sources and source locations (and day and night) can be summed. This is an advantage if the combined effects of noise from several firing points have to be assessed, or the noise from both the firing weapon and the impact of its projectile are audible at the same noise sensitive location. In principle also, CNRs from vehicles, aircraft and fixed installations could be calculated and added to the CNR from firing ranges to give a 'total CNR' to estimate the overall effect of noise from a defence facility on nearby communities.

The first step in developing a CNR procedure appropriate to military firing ranges was to consider the linear peak levels and PNdB levels, which we would regard as equivalently 'noisy'. From the paper by Kryter already referred to and other results on human judgement data (von Gierke and Nixon, 1972) we set up the following equivalents, which also convert the psf (pounds per square foot overpressure) values into dB (linear, peak) values.

1.7 psf = 132dB (linear, peak) = 119 PNdB for communities 'non adapted' to impulse noise,

1.7 psf = 132dB (linear, peak) = 113 PNdB for communities 'moderately adapted' to impulse noise, and

1.9 psf = 134 dB (linear, peak) = 110 PNdB for communities 'adapted' to impulse noise.

The numerical differences between the dB (linear, peak) values given above and PNdB values suggested the following substitutions for PNdB values in the CNR equation.

(Y - 13) for 'non adapted' communities
(Y - 19) for 'moderately adapted' communities
(Y - 24) for 'adapted' communities

where Y is the dB (linear, peak) value of the impulse noise. Thus, to this point, the equation for CNR becomes

$$\text{CNR} = (Y - 13) + 10 \log N - 12 \quad \text{.............(3)}$$

for 'non adapted' communities exposed (daily, see below) to impulse noise between the hours of 7am to 10pm.

There are several obvious objections to this procedure. However, we think these can be met to some extent without beginning on refinements which must be rather futile at this stage of our experience with the method, in view of the serious limitations on accurate prediction of community response (due to lack of knowledge of e.g., topographical, meteorological (Cook et al, 1962) and sociological variables) evident in the broad relationships between CNR and community response derived by Kryter and adapted in Figures 1 and 2.

The first of these objections is that noise from a weapon fired outdoors has only one peak, whereas the sonic boom has two quite distinguishable peaks (one positive, one negative) separated by about 100 milliseconds. Data on the effect of repeating an impulse on overall loudness suggests that this would raise the total loudness by the equivalent of 3dB (Carter, 1965). However, it is also true that the rise time (the time elapsing between onset of the impulse and its peak level) of weapon noise is typically somewhat less than that of the sonic boom by several milliseconds. In this range of values of rise time, loudness (and noisiness) is estimated to increase by the equivalent of one dB for each millisecond reduction in rise time (Zepler and Harel, 1965; Carter, 1966, 1972; May, 1971). These two effects should therefore cancel out, but even so the predominating effect of peak level of the impulse over other parameters on loudness means that minor discrepancies due to differences between weapon noise and sonic booms in rise time and overall duration will be relatively unimportant.

The other objections which may be raised to our use of CNR in the form given above is that CNR assumes 'daily exposures for a period of at least several months' (Kryter 1970, p. 436). The several months part of this statement is taken care of in the 'adaptation' component, but there is no data, of which we are aware, on the effect of reducing the number of days per week or month that the noise is encountered. In the absence of anything better, we made the assumption that this, like number of exposures per day, would add logarithmically according to the proportion of working days per month or year the range was used, i.e., if the series of noises occurred on only one-half of the working days the value 10 log 0.5 was added to the right hand side of equation (3). If this proportion is called T, our CNR would be:

$$CNR = (Y - 13) + 10 \log N + 10 \log T - 12 \quad \ldots (4)$$

for 'non adapted communities.

Military ranges also frequently require that volleys of single shots or simultaneous bursts from up to eight machine guns are fired. To account for this variation and in line with published data on the effect of repetition rate on the loudness of impulses we also added one other term to the CNR equation. This is 10 log R, where R is the number of rounds fired in each noise 'event' e.g., 8 in the case of single shots from eight SLRs, or 64 in the case of 8 M60 machine guns each firing an eight round burst.

The final equation we suggest for CNR is:

$$CNR - (Y - 13) + 10 \log N + 10 \log T + 10 \log R - 12) \quad \ldots (5)$$

for 'non adapted' communities exposed to noise from a single firing range, the firing taking place within the hours 7am to 10pm.

Given the equation above, the CNR for a location exposed to N events each of YdB (linear, peak), etc., can be calculated. The extent to which an excessive CNR value can be lowered by reducing N, T, etc., can be studied. However for planning purposes it may be desired to superimpose criterion CNR contours on a map of the area around the firing ranges. Locations outside these contours could then be regarded as suitable for residential use, those inside the contours as unsuitable for such use.

To do this the CNR value would be set at say, 90 and equation (5) solved for Y. The distance from the firing point at which the noise equals YdB (linear, peak) would also define the radius of a circle centred at the firing point, corresponding to the equal CNR 90 contour.

Our use of CNR requires that accurate measurements be made of the propagation of the particular noise in question outdoors, in the actual locale of the firing range being studied and under known, typical meteorological conditions. For one set of firing ranges we arrived at the following equations.

$$Y = 111.75 - 44.2 \log d \quad \ldots (6)$$

for grenade ranges,

$$Y = 88.08 - 26.14 \log d \quad \ldots (7)$$

for ranges using machine guns, and

$$Y = 82.34 - 33.61 \log d \quad \ldots (8)$$

for ranges where rifles are fired singly or in small groups. d is the radius in thousands of yards of a circular CNR contour corresponding to the assumed CNR value. Use of these equations in either circumstance is not recommended.

Note 1

The Perceived Noise Decibels (PNdB) metric exists in several slightly different forms (see Kryter, 1970, chapter 8). In all of them the (aircraft) noise is analysed into octave (or half or third octave) bands, the level in each band converted to psychophysical units called Noys and these values summed according to a formula. The present paper has invoked three forms of the PNdB. These are:

(1) Peak PNdB, calculated from the highest value of the respective octave band sound pressure levels occurring during the overflight;

(2) EPNdB (Effective Perceived Noise Decibels), which integrates a number of 'momentary' PNdBs, separated by 0.5 second, in a flyover and adds an onset correction proportional to the duration of sound preceding the greatest of these 'momentary' PNdBs (the Maximum PNdB);

(3) Maximum PNdB (PNdB Max) — the highest PNdB level reached during an overflight.

Peak PNdB was used to derive the equivalent noisiness of impulse noises and subsonic aircraft overflights, whereas EPNdB was the basis for the computation of the CNRs in Figure 1 (Kryter, 1970). In the absence of EPNdB measures for e.g., the Edwards Air Base flyovers, it cannot be stated with confidence the amount of error in the CNRs that this discrepancy might lead to. However since EPNdB integrates a number of PNdBs, it might not be very different from the Maximum PNdB. This in turn is generally only 1-3 PNdB less than the Peak PNdB (Kryter, 1970) so we are looking at an overestimate of about that amount in using the present modified CNR for impulse noise, a small error in relation to the effect of e.g., meteorological and socioeconomic conditons in real life situations (Cook et al., 1962).

Note 2

The predictive value of our modified CNR method remains to be proved in a systematic way, but several applications of it to military and civilian firing ranges and a military demolition range have shown that it gives results which agree well with the behaviour of people living nearby and in accord with commonsense and the views of experienced acousticians. It is an objective method and provided it is applied conservatively in land use planning, should avoid most of the problems encountered heretofore in respect of annoyance caused by impulse noise. The method refers only to air blast but previous work (Cook et al 1962; Kringel 1960) indicates that this is the predominating source of community annoyance, structural damage and annoyance due to ground shock appearing only as a secondary and very rare effect from much greater explosive charges.

Note 3

The method described above was developed in 1972-1973. Last year we became aware of a similar if somewhat more complicated application of CNR to the same problem by the U.S. Environmental Protection Agency, the U.S. Army Environmental Hygiene Agency and the Construction Engineering Research Laboratory of the (U.S. Army) Corps of Engineers (CERL). We have now acquired two of the five reports published by CERL on this subject. Much of this material is devoted to the propagation of impulse noise outdoors, but we have also learned that further research on this subject is to be done, also in the U.S.A. Naturally we will be looking to this material for information to add to or improve our procedure in this area of work.

We would be happy to make these reports available to any member of the Acoustical Society who may be interested.

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FASCINATING RHYTHM

The music that Dr. John Diamond hears most is rock, punk, heavy metal, acid — all the power chord stuff. But he is no fan. "It's organized noise," he said, "and it's dangerous."

A lot of parents have been telling their kids that for years, but what makes Diamond different is that he has spent years studying popular music and developing his theory.

He is convinced that the rock beat that pulsates through much of the Top 100 hits is as addictive as drugs — and as dangerous.

"It fragments our brain waves and weakens our muscles," Diamond argues. "It undermines our health, increases our aggression, and poisons our environment."

It isn't the volume that worries him. It's the beat. The offending rhythm, Diamond said, is two short beats followed by one long beat, and he says that five of the country's top 10 selling songs at any given time use this beat. The classic example, he contends, is the Rolling Stones' hit of a few years ago, "I Can't Get No Satisfaction." A more recent example is Glen Campbell's best-selling "Southern Nights."

Diamond is a 43-year-old Australian psychiatrist and former professor of psychiatry at New York's Mt. Sinai Hospital. He also is the incoming president of the International Academy of Preventive Medicine.

He became involved in the hazards of rock music three years ago when he wandered into a New York record store and was staggered by the amplified boom of music. It was so loud and "strange," he said, that he developed an instant headache and depression.

"I came out feeling nervous, angry, and stressed," he said. "It occurred to me that we should check the effect of music on the body."

There have been other studies of music's effects on the mind and body. One study even measured the difference in the amount of milk given by cows listening to tunes by the Beatles or Bach.

The Journal of the American Medical Association said in 1975 that rock concerts pose health hazards because blaring, amplified music can damage the hearing. But Diamond's studies were more off-beat. They contrast with findings reported three years ago by psychologist Claire Wilson of Temple University, who said that her studies showed that disturbed children were calmed by the sounds of rock music. (She said the Beatles worked best in calming children who suffered emotional or behavioural problems).

Diamond argues that his study is more sweeping in scope and more comprehensive in outlook. He started simply enough, with one question: "Why do conductors of symphony orchestras live so long and why do so many rock musicians die so young, and often violently?"

Diamond then enlisted the help of musicians (and, oddly enough, poets) to analyze the characteristics of 20,000 or so records. It took him three years to isolate the villain beat — two short beats, one long.

It turned up most often, he said, in records of the Doors, the Band, Janis Joplin, and the Rolling Stones. Curiously enough, he said, he did not find it on records by the Beatles, Bob Dylan, or Elvis Presley.

"The beat is probably subjecting us to the most serious form of pollution of all," Diamond said, "I think it is more destructive than DDT."

What it does, he said, is heighten stress and anger, reduce productivity, increase hyperactivity, and weaken muscle strength.

Weaken muscle strength? Diamond said that he would prove it, on me, with a test.

He asked me to extend one arm at shoulder height and to hold it rigidly while he tried to push it back down to my side. Normally, he said, it takes about 45 pounds of pressure to force down a resisting extended arm.

I extended my arm. He pressed down. Diamond pushed my arm again, this time while he played some music. With a waltz beat, my resistance was as strong as it was without any music. Nor did rhumbas or sambas weaken my resistance.

Then Diamond played a disco version of "What I Did for Love" — and he easily pushed my arm down.

I was flabbergasted. I asked him to play another type of rhythm. He did. I was able to keep my arm up despite his pressure.

Diamond said he had tested hundreds of people, using an electronic strain gauge to measure muscle strength.

Nine of every 10 people, he said, had registered an almost instantaneous loss of 75 per cent of their normal muscle strength while listening to rock songs.

So what? "The heart and blood have strong first-beat rhythm patterns." Diamond said. "The rock beat is the opposite of the biological rhythms, and I think that it triggers some warning message to the body that something is going wrong."

In the music industry, understandably, record producers and promoters think that Diamond is needling their music out of proportion.

"That guy doesn't like rock," an RCA official said. "So he's decided there is something wrong with it. I don't think anybody will take him seriously." —Chicago Tribune, 22 February 1978.

100 YEARS OF MICROPHONES

ADRIAN HOPE

Although the invention of the microphone is difficult to pin down exactly, it is generally taken to date from the paper proposing the carbon-granule instrument that Professor David Hughes read to the Royal Society on 9 May, 1878.

This time 100 years ago inventors were introducing much of the technology that we take for granted today. The centenaries of telephony and recorded sound have just passed and the centenary of electric light is due very soon. As we move towards the 1980s we move towards the centenary of the car, the dynamo, the pneumatic tyre, the fountain pen, the typewriter and the steam turbine. In each field there is room for dispute over who exactly was first to make the breakthrough invention. The microphone is no exception. Although microphones had already been constructed this time 100 years ago, it was on 9 May, 1878, that Professor David Edward Hughes read a paper to the Royal Society in London that included proposals for a carbon granule microphone. Arguably it was this disclosure and demonstration that made the telephone as we know it today a practical working possibility. Certainly the microphone in the handset of a modern telephone is based on the design which grew directly out of Hughes's 100-year-old proposal. As with all invention histories it is important to set the scene and establish the climate of technology at the time. Only then does each individual breakthrough stand out in perspective.

The telegraph, a means of coding word messages into switched electrical signals for transmission along wires for reception and decoding at a distant location, was almost simultaneously devised by Samuel Morse in America, and Wheatstone and Cooke in England. The first demonstrations of telegraphy were in 1836. But the first equipment was primitive and the first Morse message was not sent until 1844. By 1850 there was a submarine cable between England and France. Inevitably attention turned to the possibility of transmitting messages in pure words, without the need to code and decode. Alexander Graham Bell, who left Edinburgh for Boston in the US, was the first to succeed following his studies of the human eardrum and its response to fluctuations in air pressure, ie sound waves. This study led Bell to conclude that sounds could be transmitted as a continuously fluctuating current, rather than the rigid on/off pulses of a telegraph. Bell patented his speaking telegraph in 1876, but the transmitter and receiver, that is to say the microphone and earpiece, were primitive electromagnetic devices that produced only very low levels of sound. It is important to remember that all this was many years before the invention of the thermionic valve and the amplifier. There was no reliable means available of boosting low-level sounds in volume. Without such a system of boost the telephone could only remain an intriguing toy.

Inventors soon turned their attention to the possibility of a telephone transmitter that *modulated* a supply of power from a battery, rather than *generated* electricity by converting sound waves direct into inevitably tiny electrical currents. All manner of modulation ideas were tried. Bell himself experimented with a liquid transmitter, the vibrations of sound in air being used to move a diaphragm and with it a small quantity of acidic water. The water was in circuit with a battery. Acoustic vibration altered the area of liquid contact and with it the resistance of the circuit.

Thomas Alva Edison, in 1877, patented a telephone transmitter in which the sound waves vibrated a diaphragm which modulated the extent of contact and with it, he hoped, also the resistance between contacts covered with a semi-conductive material. As a suitable material plumbago (graphite) was suggested. The patent was the subject of much legal wrangling; in the UK it was printed and reprinted no less than four times over a five-year period. In his laboratory Edison found most success with a "button" of compressed lamp-black which varied in resistance under pressure. Although an advance on Bell's microphones, the Edison solid-carbon button was by no means perfect. It was, for example, fairly insensitive.

In June 1877 Emile Berliner (later to be hailed as inventor of the disc gramophone) filed an application for a patent on his ideas for a microphone. Again the aim was to modulate a steady DC current by arranging for the sound waves to vary the pressure between contacts and so modulate their electrical resistance and "valve" a current flowing through the circuit. Berliner first used metallic contacts but then moved onto carbon. Initially, at least, the behaviour of the contacts was extremely erratic and sensitivity was poor. Meanwhile in London, on 8 May, 1878, the Royal Society received a paper by Professor David Hughes "On the action of sonorous vibrations in varying the force of an electric current".

Hughes was born in London in 1831 (he died in the same city in 1900) but his family emigrated to the US when he was seven years old and in 1850 he became professor of music at St Joseph's College, Bardstown, Kentucky. His successful work with a type-printing telegraph won him fame in Europe and in the 1870s Hughes turned his attention to telephony. Looking for an improved microphone he deliberately worked only with very simple components. He connected a telephone earpiece in series with a battery of simple copper cells and tested a variety of different transmitters or "microphones". He was incidentally the first worker to revive, and emphasise, this word which had originally been used by Wheatstone in a different context.

For one microphone experiment Hughes used a sounding board with French nails laid side by side and separated from each other by a small space, with similar nails lightly held in the gaps. Vibration of the nails varied the gap contact area and pressure which, according to Hughes, modulated the DC and produced sound in the earpiece. By using as many as 20 nails at a time, and coating the contacts with a mixture of zinc and tin powder, the inventor, in his own words, "reached a perfection leaving nothing to be desired".

But Hughes, it seems, was a man prepared to tamper with perfection. He went on to describe a similar arrangement which relied on artists' willow charcoal as the contact members. One advantage of charcoal, as he pointed out, is that it does not oxidise. Hughes demonstrated to the Royal Society audience a transmitter formed from a glass tube two inches long, a quarter of an inch in diameter, and packed with separate, loose, quarter-inch chunks of willow charcoal. These served as loose contacts between connecting terminals at each end, and the tube was mounted on a resonant board. It proved to be a remarkably efficient transducer of sound into electricity when connected in series with a battery. Hughes expounded his theory on how his loose contact carbon microphone worked. It was that by using a number of separate pieces of carbon, each in loose contact with the next and thus electrically in series, there is an overall variation in electrical resistance when sound waves cause the carbon to vibrate and the number of points of surface contact to vary. Essentially the hypothesis still holds good today. As a considered decision Hughes did not patent his carbon microphone and the basic loose contact idea was developed and improved over the subsequent years.

Although carbon microphones were used for both recording and broadcasting it was inevitable that for such applications they would eventually be replaced by moving coil, condenser and other more modern types of higher fidelity. (Although the moving coil microphone was patented by Professor Oliver Lodge of Liverpool in 1898 its low output meant widespread adoption had to wait for the advent of electronic amplification.) Replacement of the carbon microphone in studios was inevitable because it suffers from various inherent disadvantages. Fidelity is relatively low and the carbon granules tend to pack together if supplied with too high a voltage. A similar effect can occur naturally over a long period of time, the microphone gradually becoming less sensitive and more noisy. The particles can be unpacked by tapping. Hence the need even today occasionally to tap the headset of a telephone. For although modern telephone systems of course incorporate amplifiers they still employ the old carbon-microphone principle. Carbon microphones are used because there is still no more efficient way of simultaneously transducing sound into electricity and amplifying the signals produced.

The granules of a modern carbon microphone are formed from selected anthracite coal, treated by crushing, sieving, washing and heating. Large coarse granules are used where a large electrical output is required; finer grades give a lower output but higher fidelity of reproduction. Failure to sieve out the very finest grains, however, causes the background noise known as "frying". Some of the carbon mikes used by the BBC in the 1920s are capable of surprising quality when used with modern ancillary equipment. Morganite supplies the anthracite granules used for modern British Post Office telephone microphones. These represent arguably the best possible compromise between noise, fidelity and efficiency, delivering an output which is, on average, about 50 milliamps.

Clearly to replace the carbon microphones of a modern telephone system with moving-coil equivalents would require the introduction of much more powerful amplifiers to boost the moving-coil outputs up to a level equivalent to that available from the variable resistance carbon insert. Moreover, although the fidelity of telephone reproduction would improve if moving-coil inserts were used, there is no need for high-fidelity reproduction on a telephone. The phone is designed and intended for one purpose only – to convey speech with the maximum of clarity and intelligibility. To replace the traditional carbon insert with a high-fidelity equivalent would probably cause far more complaints than congratulations. The addition of bass frequencies not currently heard over the telephone would reduce intelligibility. An attempt to transmit the high frequencies available from a moving coil or condenser transducer would offer little extra clarity or intelligibity but would open the door to all manner of unwanted background noise.

On a purely psychological basis we are now accustomed to the telephone sounding as it does. So any attempt at upgrading performance by retiring the carbon microphone, and its characteristic sound, in favour of a more modern equivalent would almost certainly produce a dramatically hostile reaction. Like the internal combustion engine, the carbon microphone may not be perfect but it does the job it was intended for better than anything else – even though it is 100 years old.

Reprinted from New Scientist
11 May 1978

AIRCONDITIONERS AND THEIR NEIGHBOURS

As the summer weather sets in, and fortunate people retreat to comfort-cooled living rooms, many airconditioner owners and their neighbours are becoming aware that a carelessly sited appliance can become a noise nuisance.

According to Dr. Don Gibson, if you mount a current model room airconditioner on the side of your house, close to the neighbouring house, it is more than likely that its noise will offend your neighbours at night.

Regulations in all states lay down maximum sound levels allowable at the boundary of a property. These levels vary according to location and time of day. But at present, the consumer has no way of forecasting whether a particular airconditioner will upset his neightbours, with its exterior noise, or even his own household, with its interior noise.

No guidelines are available, because the noise problem depends not only on the appliance itself, but also on local conditions. Shape and location of surrounding walls, placement of fences, proximity of neighbouring buildings, and the presence of other noise sources (traffic, factories) help determine whether exterior noise will cause problems. Room size and furnishings will affect interior noise.

During the last decade, the Division has used its experience in comfort cooling and noise control to study the problem of noisy airconditioners. Division scientists have been able to reduce interior noise substantially in some commercial models by modifications to the aerodynamic design. They have also designed a simple baffle that absorbs and redirects exterior noise that cannot be eliminated.

However, to make conventional refrigerated airconditioners quiet enough to meet all noise limits in all situations would be prohibitively expensive. Therefore, the Division is studying alternative airconditioner designs.

Reducing Fan Noise

Mr. Don Pescod began studying the noise problem in 1968 with a project sponsored by an airconditioner manufacturer. His brief was to reduce the airconditioner's interior noise without significantly increasing the cost to the consumer.

The most obvious noise sources were the two fans. By changing the design of the fans and surroundings, he not only reduced the noise but also improved the performance. Production costs were kept down because parts were designed to fit all models.

Attacking Compressor Noise

The improved airconditoner was a commercial success, and other companies subsequently developed their own quieter models. Pescod says, "But the quieter we made the fans, the more obvious the noise of the compressor became. We've now gone about as far as we can to reduce noise, using the conventional airconditioner design and working within the cost constraints. Now we really need to attack the compressor and look at other possible arrangements and designs." Pescod has now begun experimental work to see whether a completely new airconditioner with a low sound emission could be developed.

Sound-absorbing Barrier

Working on a more immediate problem, Mr. Ian Shepherd recently studied noise sources in a bank of airconditioners that were installed near a boundary fence and were drawing strong complaint from a neighbour. By making minor adjustments to the fan position, and by blocking part of a louvred opening, he obtained a more uniform flow past the condenser fan with little reduction of airflow. These modifications eliminated an annoying tone and reduced the noise level of the airconditioner by about 4 decibels.

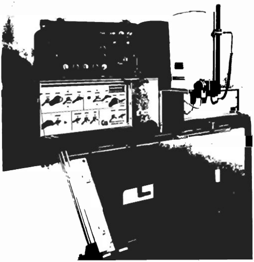
Remaining noise was caused by turbulent airflow through the fan and condenser coil. There is no simple way of eliminating this noise. Instead, Shepherd designed a simple clip-on barrier to absorb some of the noise, or divert it sideways and upwards from the unit. The barrier preferentially shields the neighbour opposite.

At present, this baffle is not manufactured commercially, but it could be made simply and sold as a clip-on unit for existing airconditioners.

Reprinted from CSIRO "Eng Events".

NEW PRODUCTS

ULTRASONIC FLAW DETECTORS

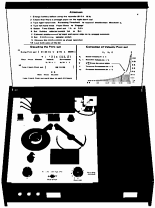


The new portable Mark IV Ultrasonic Flaw Detector has been designed and manufactured to rigid military specifications to withstand the rigors of field handling wherever ultrasonic flaw detection and thickness measurements are required. Applications vary from the inspection of high temperature steel pressure vessels to the location of minute surface cracks in helicopter rotor blades.

The Mark IV, a new design from Sonic, can match the performance of laboratory instruments in detecting defects such as cracks, porosity and foreign inclusions in materials such as bar and plate, tubing, castings, forgings and extrusions, and in welded assemblies. It is also capable of thickness gaging to locate flaws or determine the physical thickness of test objects. The unit maintains a readable resolution of within 0.005 inches over a 1.0 inch range.

Easy, reliable field usage was kept uppermost in mind throughout the design of the unit. It is packaged in strong, lightweight, drip and dust-proof enclosures. Built-in batteries provide sufficient power for 10 hours of continuous operation. The CRT displays on the Mark IV measure 5.5 inches and 3 inches. An operating temperature range of -20°F to +160°F permits the unit to be used in tough environment and rugged field conditions.

For further information, please contact John Morris Pty. Ltd., Sydney 407 0206; J. M. Scientific Pty. Ltd., Melbourne 873 2711; J. M. Scientific Pty. Ltd., Brisbane 52 4072; John Morris Pty. Ltd., Adelaide 42 5809.



BUMP RECORDER
Type 2503

BUMP RECORDER

A completely self-contained fully electronic instrument that records the level and time of occurrence of mechanical shocks is announced by Bruel & Kjaer.

The primary application of type 2503 is monitoring goods items during transport where rough handling methods often expose them to higher shock levels than they are designed to withstand. Shocks occurring in any direction are picked up by a triaxial transducer and if they exceed a chosen trigger level, their maximum velocity and acceleration, together with the time of occurrence, is printed on a 6 mm wide paper strip.

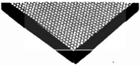
With an optional high sensitivity pickup the recorder is ideal for monitoring ground vibrations due to heavy traffic, explosive detonations, pile driving, etc.

Further details are available from Bruel & Kjaer Australia Pty. Ltd. Telephones: Sydney – 736 1755, Melbourne – 37 8169, Adelaide – 31 0271, Perth – 295 1658.

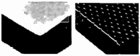
ABSORPTION

SOUNDFOAM
Urethane foam developed specifically to absorb maximum sound energy with minimum weight and thickness. Used to absorb airborne noise in industrial and EDP equipment, machinery enclosures, over-the-road and off-highway vehicles and marine and airborne equipment. Meets UL 94, HF-1 flame resistance test procedure.

SOUNDFOAM (Embossed)
The surface pattern increases sound absorption performance 25 to 35 percent in the most critical low and mid-frequency bands when compared to other foams of the same thickness and density. Ideal solution for low frequency absorption problem. Meets UL 95, HF-1 flame resistance test procedure.



CABFOAM
An outstanding sound absorbent foam with a tough, abrasive-resistant film surface designed specifically for use where unprotected foams won't hold up, and where appearance is important, such as in over-the-road and off-highway vehicle cabs and equipment enclosures.

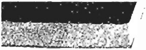


SOUNDFOAM (With Films)
Highly efficient Soundfoam acoustical foams are available with a surface of Tedlar, metalized Mylar, urethane film or vinyl film. Surface treatment provides attractive appearance and resistance to various chemicals and sunlight.

SOUNDFOAM (With Perforated Vinyl)
Provides a tough, handsome finish for use in vehicles and other places where appearance is important. Leather-looking surface is bonded to highly efficient acoustic foam.

DAMPING

GP-2 DAMPING SHEET
A thin (0.050") sheet of pre-cured damping compound with pressure sensitive adhesive backing. Easily and inexpensively die cut and shaped to fit and form to flat areas and simple curves.



FOAM DAMPING SHEET
Consists of a thickness of embossed foam bonded to a sheet of highly efficient GP-2 damping material. Provides a single solution to damping and absorption problems.

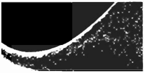
DYAD
A polymer specifically developed to provide effective constrained layer damping on thick, heavy, metal plates. Applied by cementing the polymer sheet to both the structure being treated and a metal constraining layer.

EPOXY 10
A quick curing resin based damping paste which can be applied by trowel or spray. Completely resistant to severe environmental conditions, including water, acid and alkalis. Popular for marine and outdor applications.

GP-1 DAMPING COMPOUND
A non-toxic, non-flammable plastic which is applied by trowel or spray. Cures quickly in air or oven. A thin coating on steel (1/2 to 1 times metal thickness) removes tinniness and ringing.

BARRIERS

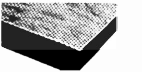
SOUNDMAT LF
Soundmat LF is made up of a vibration isolation layer of foam, a lead septum sound barrier, and a layer of embossed foam to provide maximum absorption, together with noise attenuation.



SOUNDMAT FV
Soundmat FV has 1# limp mass barrier layer bonded to a 1/4 inch layer of acoustic foam. A heavy, scuff-resistant black vinyl skin is optional. Particularly for vehicle cab floors and bulkheads. Also used as pipe lagging.

SOUNDMAT FVP
Consists of a clossed cell, hydrolytically-stable foam isolator and a layer of open cell Soundfoam M, with a lead barrier between the two. The surface is a tough, wear-resistant 1# mass for additional transmission loss.

SOUNDMAT LGF
An acoustic absorption/barrier material with a lead septum sandwiched between two layers of inert glass fibers. Designed for "fire hazard" applications. Will not support combustion or sustain flame. Excellent resistance to organic and inorganic chemicals.



SOUNDMAT (With perforated vinyl)
Has all the characteristics of Soundmat LF, plus a tough, handsome exterior finish for use inside vehicle cabs or other applications where good appearance must accompany noise control.

The above noise-suppression materials are available from:

NYLEX CORPORATION LIMITED

For literature and samples contact your local Nylex Sales Office:

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BOOK REVIEWS

TRANSPORT AND THE ENVIRONMENT

By David C. Hothersall and Richard J. Salter, Published by Crosby Lockwood Staples, London, 1977, 287 pp., ill., index. Price: $49.50

This is a useful book which puts the noise problem of transportation in perspective and reviews the current data on transportation noise, methods of assessment, and, to a more limited extent, methods of overcoming transportation noise problems.

The first chapter, on Impact Assessment for Transportation Proposals, sets the scene, indicating the factors involved (eg. aesthetics, culture, ecology). The Leopold matrix method of environmental assessment is outlined and public opinion surveys discussed. Visual intrusion and noise impact are then dealt with in more detail.

Most of the book is devoted to road traffic noise. There are three chapters on this aspect; Highway Traffic Noise, Prediction of Highway Noise, and Road Traffic Noise Control. The impression one is left with is that there is no theoretical method or basis for the prediction of road traffic noise, only a mass of empirical data. This is not so and it is a pity the authors did not try to cover the theory (some attempt at covering the theory has been made in the case of train noise). The empirical data presented, for road traffic noise, is mainly from Britain and North America. Little indication is given of the limitations and accuracy of the empirical predictions.

The other three chapters in the book are on Aircraft Noise, Train Noise, and Atmospheric Pollution; the latter being a very superficial coverage and out of place in a book that is dealing with noise. There are also three appendices on Fundamental Acoustics, the Human Response to Noise, and Insulation Against Noise. Overall the book is good and a welcome review of the state of the art of traffic noise prediction and control.

The emphasis on certain topics seems out of proportion to others, eg. 78 pages are devoted to aircraft and airport noise while there are only 15 pages on road traffic noise, two on rail traffic and four on household appliance noise. Though the content of a book should largely be the prerogative of the author, in a general text on noise control, such as this, the emphasis given to various noise sources should reflect the importance to the community of those noise sources.

In the fly-leaf it is suggested that the book will be equally useful to architects, builders, designers, planners, engineers and environmentalists. (It is doubtful if any text book could be of equal value to such a diverse group of practitioners.) The book may also be of use to lawyers in noise control cases brought to court.

Like the previous edition the book is a very readable one. It is unfortunate though that the references have not been updated and that the index and bibliography have not been made more comprehensive.

FERGUS FRICKE

ACOUSTIC DESIGN AND NOISE CONTROL, VOL. 2, NOISE CONTROL

Michael Rettinger, Chemical Publishing Company, New York 1977. 393 pp., ill., index, bibliography. Price: US$22.50.

This is an updated version of the 'Noise Control' section of the 1973 edition of 'Acoustic Design and Noise Control' by the same author. Like the 1973 edition it has an informal style, though not to the same extent as Volume 1 on 'Acoustic Design'.

The book consists of three sections, the Physics of Sound, Noise, and Noise Reduction. The main changes from the previous edition are in the second and third sections. In the second section a subsection has been added on 'Environmental Impact Statements'. In the third section a subsection has been added on 'Procedure for Determining the Noise-Control Requirements in Airconditioning Systems for Buildings'.

FERGUS FRICKE

VIBRATIONS IN ROTATING MACHINERY

Mechanical Engineering Publications Ltd, P.O. Box 24, Northgate Avenue, Bury St Edmunds, Suffolk IP32 6BW, 1977. 339 pp. $US74.

This is a collection of 43 papers read at a Conference held at the University of Cambridge on September 15-17, 1976; sponsored by the Institution of Mechanical Engineers and co-sponsored by the Japan Society of Mechanical Engineers and the Verein Deutscher Ingenieure. The papers are authoritative and wide in scope and will be valuable reading for all concerned with the design construction and operation of rotating machinery.

Reprinted from Engineers Australia

INFRASOUND AND LOW FREQUENCY VIBRATION

Edited by W. Tempest. Academic Press, NY. Available through Harcourt Brace Jovanovich, Centrecourt, 25-27 Paul Street, North Ryde, NSW 2113. 1976. 364pp.

A very thorough and well referenced text, this work deals in a comprehensive manner with a difficult and well written-up subject. The real difficulty of developing a suitable measurements technology is well covered, and the emphasis given to human aspects, the review of subjective aspects, physiology and pathology, science and technology all add up to a truly multidisciplinary approach. It is one of the few occasions when a difficult book is both informative and enjoyable.

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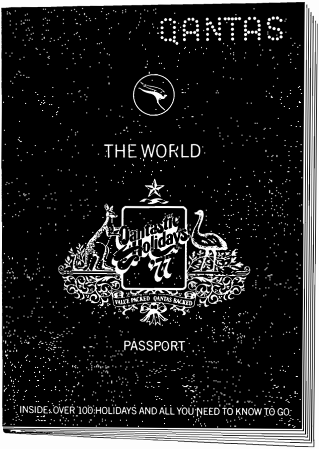

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