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canadian acoustics
acoustique canadienne

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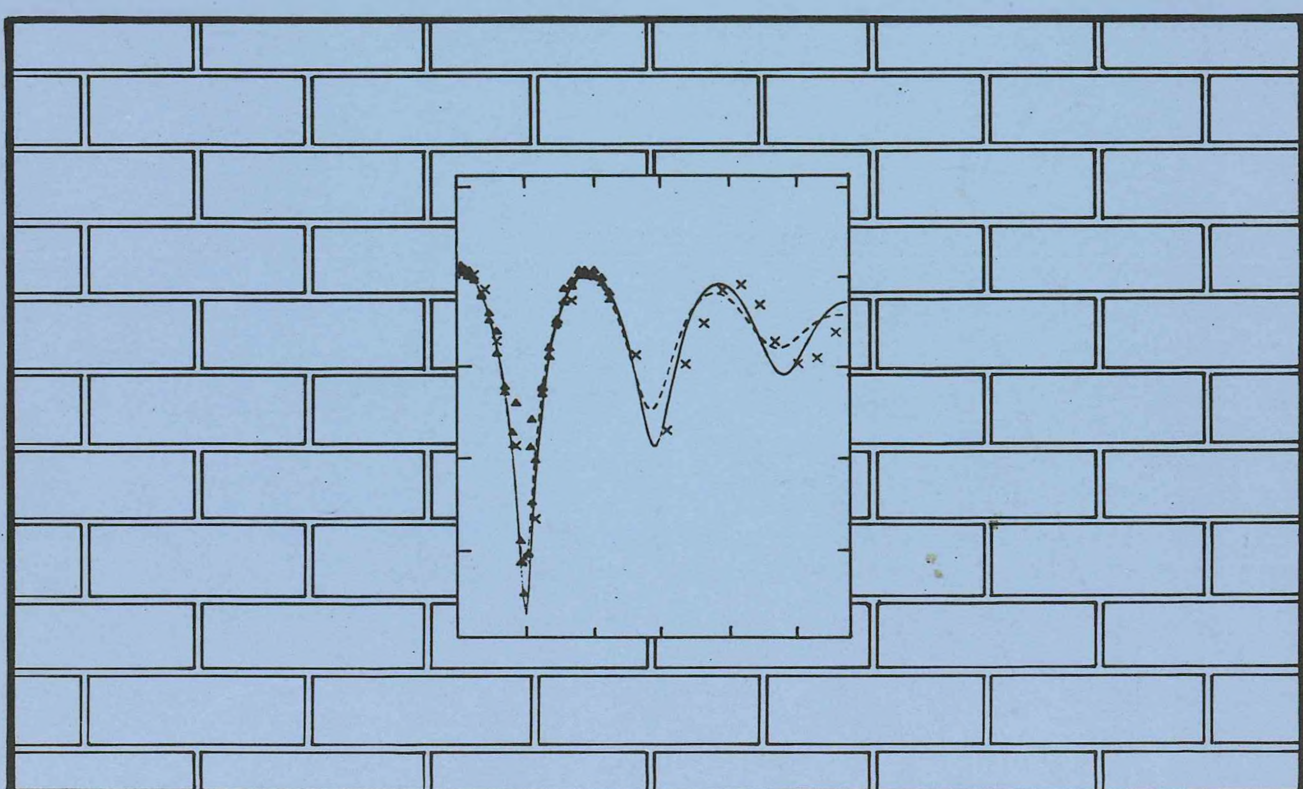

canadian acoustics

acoustique canadienne

The Canadian Acoustical Association
P.O. Box 3651, Station C
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l'Association Canadienne de l'Acoustique
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Ottawa, Ontario K1Y 4J1

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Prix: $4.00 (affranchissement inclus)

Articles an all aspects of Acoustics and Vibration in English and French are welcome, and should be addressed to any editor. All papers are reviewed.

Vous êtes invités à soumettre des articles sur tous les domaines de l'Acoustique et des Vibrations, en français ou en anglais. Prière de les envoyer à un des rédacteurs. Tout article est révisé.

EDITORIAL

This issue contains some changes to your journal. As always, we welcome your comments and suggestions. On the following pages you will find two new columns which we expect to be regular features, titled **NEWS FROM THE PRESIDENT** and **NEWS FROM 12ICA**, written by Cameron Sherry and Edgar Shaw, respectively. These should keep us all a little better informed.

We have a new cover layout and on the inside back cover you will find names of the 12ICA committee chairmen as well as the usual list of CAA officials. The 12ICA logo is also included but, unfortunately, not in colour.

In an effort to increase our circulation, we have written to 125 libraries suggesting that they might subscribe to CANADIAN ACOUSTICS. If your institution has a library, please encourage them to subscribe; a little local persuasion always helps.

Alf Warnock has struggled to resurect our mailing list from the backs of envelopes and other such places, and we now have an organized computer-based mailing list. Copies were being sent to people who had not paid and, in many cases, who did not even want to receive CANADIAN ACOUSTICS. Thus, at this time when Annabel Cohen is starting her efforts to increase our membership, our numbers, at least on paper, are shrinking. We need your efforts to increase our membership.

EDITORIAL

Ce numéro contient quelque changements pour mieux vous informer. La couverture a été redessinée pour faire place aux présidents de comité de l'ICA-12 ainsi que la liste habituelle des officiers de l'ACA. L'en-tête de l'ICA-12 y est reproduit mais seulement en blanc et noir. A l'intérieur vous trouverez l'addition des deux rubriques "Nouvelles du président" par Cameron Sherry et "Nouvelles de l'ICA-12" par Edgar Shaw.

Alf Warnock a réorganisé la liste des membres et l'a informatisée. Seul les membres en règle ont été retenu et par conséquence le nombre de members réels a diminué. Ceci arrive lorsque Annabel Cohen s'occupe activement d'augmenter les adhésions. Votre appui durant cette période est donc apprécié. A fin d'augmenter notre circulation nous avons écrit à 125 bibliothèques pour les inciter à s'abonner. Nous vous prions d'encourager votre bibliothèque de le faire.

L'organisation du congrès annuel dans la vielle capitale a commencé. On prévoit un programme chargé avec une bonne participation francophone. D'ailleurs J.G. Migneron fait le point dans ce numéro.

NEWS FROM THE PRESIDENT

Your editor has suggested that a note be written to you directly telling you what is happening behind the scenes. This will be the first such effort.

The organizers, Jean Nicolas and Jean-Gabriel Migneron, for our Quebec City "84" annual meeting have chosen the week starting 21 October. They are planning a few innovative changes. Look for more information in this issue and following ones.

Annabel Cohen is working very hard on your behalf preparing a program to bring new members into CAA. To aid her in this endeavour, a President's honour list will be prepared and published, identifying all those members who in "84" bring five or more new members to CAA. Let's all help ourselves and may we have a long honour list. Drop a note to Annabel when you have a new member sign on. (A.J. Cohen, Department of Psychology, University of Toronto, Scarborough Campus, 1265 Military Trail, Scarborough, Ontario, M1C 1A4, (416) 284-3329.)

The battle with the building code officials continues but the fruits of our labour will not appear until the 1990 building code at the earliest. Representations will likely be required at meetings in the next few years.

The 12 ICA Congress Committee has issued their first circular and now are active in further plans. Have you started to plan for the paper you will be presenting?

Jean Nicolas indicates that the Edmonton meeting of 1981 made about $500. A final accounting of the meeting in Toronto and Vancouver will be given in the next issue of the Journal.

A copy of the directory produced by our Australian acousticians has been received. It appears to be very well laid out. Is there a volunteer or two to help us prepare a directory for members of CAA? Alf Warnock has finally got all of you locked into his computer. This will help us greatly in producing a directory.

Deirdre Benwell says that some of you have not paid your dues. Is that right? Please correct this oversight immediately.

Cameron W. Sherry

NEWS FROM 12ICA

When the Executive Committee met in Ottawa at the end of February, we had before us copies of the first circular which is now being sent to acoustical societies and their members around the world including, of course, the members of CAA. The circular is printed in three languages on a very attractive folding sheet provided by the Government of Ontario, and includes a "provisional registration form" placing respondents on the mailing list for the second circular, the call for papers, to be sent out in March 1985. The Secretariat Committee is now preparing a filing system to handle the thousands of names and addresses and other information that will soon be coming in.

Perhaps the most important decision taken at last month's meeting had to do with meeting space. After a full briefing by Aubrey Edwards and Werner Richartz, the Executive Committee accepted a proposal from the Toronto Planning Committee to hold the Congress at the Metro Toronto Convention Centre now under construction on Front Street next to the CN Tower. Judging by the floor plan, it will be a fine building, well adapted to the needs of 12ICA, when it is completed later this year.

On the inside of the back cover, you will find a black and white reproduction of the 12ICA logo designed through the good offices of Bob Johnston, Chairman of the Committee on Support. The back cover also lists the various Committees which are now fully engaged in detailed planning. For example, Tony Embleton expects to have subject coordinators for the Technical Programme appointed by the time these words appear in print.

Edgar Shaw
Chairman, 12ICA Executive Committee

TORONTO REGIONAL CHAPTER NOTES

The first meeting of CAA Toronto chapter for the year 1984 was organized by the University of Toronto, Institute of Aerospace Studies, at their premises on 10 January. The meeting was opened by Prof. G.W. Johnston giving an overview of acoustical research work being carried out at UTIAS. Professor Johnston pointed out that the acoustic research at UTIAS progressed from other aerospace research and therefore concentrated in jet, flow, and other related noise phenomena. Some of the topics under current investigation are: interaction of acoustics and boundary layer, augmentation/interference of jet noise at forward velocities, sound field due to moving sources.

The 25 odd people assembled were then conducted through a tour of the facility. The major features being shown were an anechoic room and an anechoic wind tunnel where a number of the above experiments were being carried out. The meeting was closed with a presentation by Mr. E. Dellapena of an interesting discourse on "Sound From Moving Sources."

A most respectable 29 enthusiasts braved inclement weather to attend the 13 March 1984 meeting, held in the Ontario Hydro Auditorium. The two convenors, Alberta Behar and Andy McKee, officiated with three speakers giving thoughtful presentations under the general theme of Hearing Research.

Dr. Hans Kunov gave the first presentation on "Indices of Industrial Noise." Various types of industrial noise, their analyses using several indices and correlation coefficients between the indices were discussed. An Ear Simulator model, including hearing protection using real noise input, was discussed with emphasis on the stapes footplate displacement. One conclusion given was that this displacement was best predicted using the non-weighted sound pressure level index rather than dBA.

Dr. Sharon Abel then presented "Industrial Noise as a Masker in Perception." Sharon described experiments involving subjects with normal hearing and noise-induced hearing loss with both impulsive and steady state noise histories. The results of narrow band tone bursts being presented to the subjects with various types of industrial noise backgrounds were then discussed together with statistical results.

The final presentation was by Dr. Ivan Hunter-Duvar on "Cochlear Prostheses." Progress toward both single and multi-channel devices for the totally deaf were discussed and the complexity of such a project was soon appreciated. Engineering problems were discussed and progress by an Australian group was described.

A most successful evening was concluded with as many questions as time permitted.

The final meeting of the 1984/85 season is scheduled for 29 May 1984, when the theme will be "Transportation Noise."

DESIGN, INSTALLATION, AND CARE OF SOUND REINFORCEMENT SYSTEMS

Faculty of Extension
University of Alberta

This seminar is meant for the designer/installer who already has substantial knowledge and experience in the use of sound reinforcement systems and who wishes to update his technical expertise or fill in the gaps in areas where he may be deficient. It is an opportunity to learn from one of the leading designers of sound systems in North America. It will also be an opportunity to share knowledge with other class members.

It is expected that participants will have either technical or university training and some experience in designing or installing systems.

Dates: Monday through Wednesday, 27 to 29 February 1984, 8:30 a.m. to 5 p.m. (except to noon on 29 February).

Fee: $290 including two lunches.

Additional Information: Please call 432-5061 or 432-5532.

PROCEEDINGS OF THE 11th ICA/ACTES DU 11ème ICA

Proceedings of the main congress (Paris) and the two satellite symposia (Lyon and Toulouse) are available. The prices are (in French Francs): / Les actes du congrès principal de Paris et les actes des congrès satellites de Lyon et Toulouse sont disponibles aux tarifs suivants (en Francs Français):

Main congress of Paris (8 volumes: 600 FF for the 8 volumes (or 100 F each one) / Congrès de Paris (8 volumes): 600 FF les 8 (ou 100 F l'un).

Toulouse symposium (2 volumes): 200 FF both (or 100 F each one) / Symposium de Toulouse (2 volumes): 200 FF les 2 (ou 100 F l'un).

Lyon symposium (1 volume): 100 FF / Symposium de Lyon (1 volume): 100 FF.

Secrētariat du G.A.L.F.
Division TSS-CNET Lannion A - BP 40
22301 LANNION CEDEX - France

NELSON ACOUSTICS CONFERENCE

Nelson Industries, Inc. will again be sponsoring the Nelson Acoustics Conference to be held in Madison, WI on 17-18 July 1984. This Conference will feature presentations of the previously announced award winning papers of the 1983 Nelson Acoustical Paper Awards Program. These include such topics as the analysis of perforated element mufflers, an investigation of the exhaust system of a high performance engine, a study of the exhaust system and source impedance of a multi-cylinder engine, and a model for cavity-backed perforate liners in flow ducts. In addition, invited papers and presentations on a variety of topics related to mufflers, silencers, and general acoustical technology will be included. Attendance is open to the general technical community and a $100 registration fee is required.

Additional information on the Nelson Acoustics Conference may be obtained from Larry J. Eriksson, Corporate Research Dept., Nelson Industries, Inc., P.O. Box 428, Stoughton, WI 53589, (608) 873-4373.

JASA ANNOUNCES PAUL MERMELSTEIN SUCCEEDS BISHNU ATAL AS ASSOCIATE EDITOR

Dr. Paul Mermelstein of Bell-Northern Research, Quebec, Canada has been appointed Associate Editor of the Journal in charge of Speech Communication papers. He succeeds Dr. Bishnu S. Atal.

Paul Mermelstein was born in Mukacevo, Czechoslovakia, in 1939. He attended school in Budapest, Hungary; Vienna, Austria; and Montreal, Canada. He received his undergraduate education at McGill University, graduating with the B.Eng. degree in Engineering Physics in 1959. He pursued his graduate studies at M.I.T. receiving the D.Sc. in Electrical Engineering in 1974. Paul was a staff member at Bell Laboratories, Murray Hill from 1964 to 1973 carrying out research in speech analysis, synthesis, and recognition. From 1973 to 1977 he was a member of the research staff of Haskins Laboratories conducting research in speech perception and speech recognition. Since 1977 he has been with Bell-Northern Research where he serves as Manager of Speech Communication Research. He also serves as Visiting Professor at INRS-Telecommunications, University of Quebec, and Auxiliary Professor, Electrical Engineering, McGill University, coordinating a cooperative industrial-academic research program in speech communication. Paul's current technical interests include digital speech processing for transmission and storage, automatic speech recognition and synthesis, and human speech communication. He is a member of the Acoustical Society of America, the IEEE Transactions on Acoustics, Speech and Signal Processing Society, and the Groupement des Acousticiens de la Langue Française.

RONALD REAGAN'S EARS

The Bulletin of the Australian Acoustical Society quotes noted American hearing expert Aram Glorig as follows:

"People who complain that U.S. President Ronald Reagan won't listen to good advice could be right - he's partially deaf in both ears.

A visiting ear expert who has examined Mr. Reagan says he has trouble hearing in conference and should wear hearing aids in both ears.

Dr. Aram Glorig said Mr. Reagan was reluctant to wear his hearing aid in public because he was vain.

Mr. Reagan's hearing problem was due to the ageing process, Dr. Glorig said.

He compared the President to a man who drank beer to solve his hearing problem - When they asked the man why he wouldn't stop drinking he said, 'I like what I drink better than what I hear', said Dr. Glorig."

Maybe we should shout a little louder about acid rain?

NEW AMERICAN NATIONAL STANDARDS AVAILABLE

Auxiliary Tables for Vibration Generators - Methods of Describing Equipment Characteristics

S2.58-1983 (ASA Catalog No. 52-1983)

This standard provides a method for specifying the characteristics of eight types of auxiliary tables for vibration generators. It serves as a guide to the prospective user of auxiliary tables to assist him to objectively compare the performance of auxiliary tables available from differing manufacturers.

Electrodynamic Test Equipment for Generating Vibration - Methods of Describing Equipment Characteristics

S2.45-1983 (ASA Catalog No. 51-1983)

This standard provides a method for specifying the characteristics of electrodynamic test equipment for generating vibration and serves as a guide to the selection of such equipment. It applies to electrodynamic vibration generators and power amplifiers, both individually and in combination. The standard provides means to assist a prospective user to calculate and compare the performance of equipment provided by two or more manufacturers, even if the vibration generator and the power amplifier are from different manufacturers.

Back Numbers Department
American Institute of Physics
335 East 45th Street
New York, NY 10017
(516) 349-7800

SYMPOSIUM ON ACOUSTICS OF PROPELLERS TO BE HELD IN CANADA - OCTOBER 1984

An international Symposium on Aerodynamics and Acoustics of Propellers will be held in Toronto, Canada, 1-4 October 1984. The meeting is designed to bring together acousticians, fluid dynamicists, and propeller designers to share their knowledge and the results of their research. A number of topics will be discussed, among them the near field noise problems of propfans whose blade extremities become supersonic, requiring novel means to reduce cabin noise levels in propeller-aircraft. Another topic of interest to acousticians is wind energy devices which have certain commonalities with propellers, particularly in the area of aerodynamic design and acoustic disturbances.

Additional information can be obtained from L.H. Ohman, High Speed Aerodynamics Laboratory, N.R.C., Montreal Road, Ottawa, Ontario K1A 0R6, Canada.

CLOSE-RANGE ICE HAZARD DETECTION - SONAR

The Canarctic Shipping Company Limited has undertaken an extensive research program to develop new techniques for navigating in ice. Under the direction of contract #0SV83-00040 with Supply and Services Canada, Canarctic is developing the conceptual requirements of a Shipboard Ice Navigation Support System (SINSS). The objective of SINSS is to develop onboard the vessel a level of ice information and intelligence which will facilitate optimal route selection, and allow for monitoring and refinement of the selected track as the vessel proceeds through the ice. To be totaly effective SINSS must incorporate long-range strategic route planning, medium-range tactical support through the ice, and close-range detection and avoidance.

Satellite and airborne sensors, in conjunction with conventional marine radar sensors, have been successfully employed to meet the strategic and tactical information roles. However, experience during the last two shipping seasons has shown that the detection of ice hazards (i.e., icebergs, bergy bits, multi-year ice pieces) in the Arctic environment using marine radar suffers from poor reliability. Ships operating in the early summer season encounter extensive fog and white-out conditions from blowing snow, which effectively reduces visibility. In late fall low level light conditions or complete darkness may prevail, again limiting visibility. Steps are being taken to study methods for improving observer visibility, yet it is recognized that more needs to be done to aid the ship's personnel in detection of ice hazards.

Research efforts are being conducted by several groups who, through image processing and enhancement, hope to extract more information from marine radar displays. It is Canarctic's contention that similar efforts should be directed towards proving the feasibility of internally-mounted forward scanning sonars. It is envisaged that a sonar could be used to detect much larger masses of ice protruding below the water surface, thus increasing the reliability of ice hazard detection. Canarctic would like to hear from individuals, companies or universities with a demonstrated expertise in sonar and the proven ability to follow through the design and implementation of systems in a marine environment.

Interested parties are asked to respond to the address below:

Executive Vice-President
Canarctic Shipping Company Limited
Place de Ville, Tower 'A'
19th Floor
Ottawa, Ontario
K1A 0N7

THE INTER-NOISE 83 PROCEEDINGS AVAILABLE

INTER-NOISE 83, the Twelfth International Conference on Noise Control Engineering, was held in Edinburgh, Scotland on 13-15 July 1983.

A total of 294 papers on all aspects of noise control engineering were presented at the Conference and are included in the Conference Proceedings which contain 1242 pages.

Copies of the INTER-NOISE 83 Proceedings are available from Noise Control Foundation, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY, 12603, U.S.A. The price is $72; shipped postpaid except that overseas orders must add $25 if the books are to be shipped by air mail.

CALENDAR 1984

2-6 April
International Conference on Video and Data Recording
University of Southampton, U.K.

10-12 April
Institute of Acoustics Spring Conference
Swansea, U.K.

7-11 May
Acoustical Society of America
Norfolk, Virginia, U.S.A.
(Deadline for abstracts 20 January 1984)

28 May - 1 June
International Association Against Noise Conference
Sarajevo, Yugoslavia

25-28 July
Tenth International Symposium on Nonlinear Acoustics
Kobe, Japan

5-10 August
7th World Congress on Linguistics
Brussels, Belgium

21-24 August
Fourth FASE Congress
Sandefjord, Norway

26-30 August
17th International Congress of Audiology (ICA)
University of California Campus
Santa Barbara, CA, U.S.A.

1-4 October
Aerodynamics and Acoustics of Propellers
Toronto

8-12 October
Acoustical Society of America
Minneapolis, MN, U.S.A.
(Deadline for abstracts 22 June 1984)

22-26 October
CAA Annual Meeting and Seminars
Quebec City, Quebec

4-6 November
Institute of Acoustics Autumn Conference
Windemere, U.K.

3-5 December
INTER-NOISE 84
Honolulu, Hawaii, U.S.A.
(Deadline for abstracts 15 March 1984)

9-13 December
ASME Symposium on Flow-Induced Vibration
New Orleans, U.S.A.

NEW RESEARCH CONTRACTS

To G. Crawford, Victoria, B.C., $2,500, for "Literature review of theoretical and experimental work on acoustic scattering from turbulence, micro-structure and biological targets in the Pacific Ocean." Awarded by the Department of Fisheries and Oceans.

To G. Crawford, Victoria, B.C., $2,000, for "Study to develop the relationship between sound scattering temperature and velocity." Awarded by the Department of Fisheries and Oceans.

To Industrial Research Institute of the University of Windsor, Windsor, Ontario, $21,000, for "Development of objective tests for diagnosing the vibration syndrome in chain saw operators." Awarded by the Department of the Environment.

To Forest Engineering Research Institute of Canada, Pointe Claire, Quebec, $40,000, for "Conduct research on the noise and vibration of chain saws." Awarded by the Department of the Environment.

To Foundation Electronic Instruments Incorporated, Ottawa, Ontario, $20,545, for "Design and development of a digital seismic outstation." Awarded by the Department of Energy, Mines and Resources.

To Control Data Canada Limited, Ottawa, Ontario, $147,240, for "Continued investigation of advanced extremely low frequency noise cancellation techniques." Awarded by the Department of National Defence.

To Seakem Oceanography Limited, Sidney, B.C., $404,000, for "Development, construction and testing of correlation sonar current meter shipboard and ocean bottom mounted prototype systems - Phase III and Phase IV." Awarded by the Department of Fisheries and Oceans.

To Northern Environmental Research, Winnipeg, Manitoba, $38,376, for "Application of sonar and detection of marine mammal vocalization to the estimation of Arctic marine mammal populations and their distribution." Awarded by the Department of Fisheries and Oceans.

To Arctic Sciences Limited, Sidney, B.C., $30,000, for "Design study for a seabottom - moored acoustic wind velocity system." Awarded by the Department of Fisheries and Oceans.

To Sonoquest/Advanced Ultrasonics Research, Sudbury, Massachusetts, $48,024, for "Investigation of underwater acoustics propagation phenomena using seismic-acoustic ultrasonic modelling." Awarded by the Department of National Defence.

To Inverse Theory and Applications Inc., Vancouver, B.C., $19,734, for "Analysis of deep ocean marine seismograms by inversion techniques." Awarded by the Department of National Defence.

To ComDev Limited, Cambridge, Ontario, $89,952, for "Development of design and fabrication procedures and processes for surface acoustic wave band pass filters with minimum group delay ripple." Awarded by the Department of Communications.

To ComDev Limited, Cambridge, Ontario, $75,000, for "Study of reflective and dot array surface acoustic wave devices." Awarded by the Department of Communications.

To ComDev Limited, Cambridge, Ontario, $198,860, for "Development of spacecraft signal processing surface acoustic wave devices." Awarded by the Department of Communications.

To Memorial University of Newfoundland, St. John's, Newfoundland, $5,540, for "Sound scattering and attenuation in aqueous suspensions of sand." Awarded by the National Research Council.

To Centre de Recherche Industrielle du Québec, Ste. Foy, Quebec, $18,064, for "Solubilization of lignocellulosic residues through the effect of cavitation of ultrasonic waves." Awarded by the National Research Council.

To McMaster University, Hamilton, Ontario, $32,153, for "Median filter data normalization of two-dimensional acoustic data displays - final phase." Awarded by the Department of National Defence.

To Canadian Instrumentation and Research Limited, Mississauga, Ontario, $7,802, for "Improve performance of an experimental hydrophone." Awarded by the Department of National Defence.

POSITION WANTED

A B.A.Sc. graduate in Electrical Engineering (University of Toronto) currently studying for an M.Sc. in sound and vibration (ISVR, University of Southampton) is seeking a position to exploit a keen interest in building acoustics.

Experienced in most forms of acoustics and vibration work and related consultative services. Work in building acoustics would be preferable although other disciplines could be considered if management possibilities were apparent. Available for employment upon return to Canada in early October 1984.

For further information please contact:

Mr. John P.M. O'Keefe
c/o The Martin Centre for Architectural and Urban Studies
University of Cambridge
Department of Architecture
6 Chaucer Road
Cambridge CB2 2EB
United Kingdom

POSITION WANTED

Howard Patlik is seeking a full-time position in the field of acoustics. He will graduate as an acoustics engineering technician from George Brown College of Applied Arts and Technology in June 1984. He has completed two years at York University in the Psychology Degree Program (10.5 credits). He has recently been employed by the Ministry of the Environment on various projects including a construction site noise and small hand gun study. Employers may contact him at:

Howard Patlik
491 Winnett Avenue
Toronto, Ontario
M6C 3M6
Canada
Tel: (416) 787-2262

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1984
NOISE CONTROL
SEMINAR

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Canadian Pulp and Paper Association

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SÉMINAIRE
SUR LE CONTRÔLE DE BRUIT
1984

Parrainé par la Section technique
Association canadienne des producteurs de pâtes et papiers

10 - 12 septembre 1984
Hôtel Vancouver, Vancouver, C.B.

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THEME
'NOISE CONTROL AND THE PULP AND PAPER INDUSTRY'

THÈME
'LE CONTRÔLE ACOUSTIQUE ET L'INDUSTRIE DES PÂTES ET PAPIERS'

TENTATIVE PROGRAM / PROGRAMME PRELIMINAIRE

Monday, Sept. 10 — 0900 — lundi 10 sept.

Keynote Address: To Be Announced

SESSION I:
Principles of Noise and its Control/
Les principes du bruit et son contrôle

Chairman/ Président: D.P.W. POUNDS, Paprican, Pointe Claire, Qué.

1. Noise Control Theory, D.L. ALLEN, Vibron Ltd., Mississauga, Ont.
2. Effects of Noise on People, and Hearing Conservation, R.P. GANNON, Worker's Compensation Board of British Columbia, Richmond, B.C.
3. Modern Noise Source Identification Techniques, J. NICOLAS and G. LEMIRE, Université de Sherbrooke, Sherbrooke, Qué.

Monday, Sept. 10 — 1030 — lundi 10 sept.

SESSION II:
Government Involvement in Noise Control/
L'implication des gouvernements dans le contrôle acoustique

Chairman/ Président: W.B. HARDWICK, Tahsis Co. Ltd., Gold River, B.C.

1. Government Standards and Regulations and their Enforcement, C. SHERRY, Domtar Inc. Senneville, Qué.
2. Progress Report of CSA Standards on Noise Exposure Monitoring, T. KELSALL, Hatch Associates Ltd., Toronto, Ont.

Monday, Sept. 10 — 1400 — lundi 10 sept.

SESSION III:
Research and Techniques into Understanding Monitoring, and Controlling Noise/
Recherches et techniques portant sur la compréhension des modes de surveillance et de contrôle du bruit

Chairman/ Président: R. CARRIÈRE, Abitibi-Price Inc., Jonquière, Qué.

1. Modern Noise Source Identification Techniques, J. NICOLAS, Université de Sherbrooke, Sherbrooke, Qué.
2. Acoustical Materials, J. KANE, Higgot-Kane Industrial Noise Control Ltd., Scarborough, Ont.
3. Instrumentation in Noise Control, T. HO, Bruel & Kjaer Canada Ltd., Richmond, B.C.
4. Paper Machine Source Noise Control Techniques, J. CROUSE, Beloit Corp., Beloit, WI.
5. Effects of Noise on the Hearing, and Different Kinds of Hearing Protectors, H. LOFGREEN, Bilsom International Ltd., Toronto, Ont.

Tuesday, Sept. 11 — 0900 — mardi 11 sept.

SESSION IV:
Techniques Used to Control Noise/
Techniques employées dans le contrôle acoustique

Chairman/ Président: H. REITHAUG, MacMillan Bloedel Ltd., Port Alberni, B.C.

1. Equipment Acoustics, D.J. WHICKER, Barron & Associates, Acoustical Consultants Ltd., Vancouver, B.C.

SESSION IV (Cont'd)

2. Vibration Isolators and Their Principles, D.L. ALLEN, Vibron Ltd., Mississauga, Ont.

3. Enclosures, J. KANE, Higgot-Kane Industrial Noise Control Ltd., Scarborough, Ont.

4. Noise Control of Control Valves and Regulators, J. NILES, Leslie Co., Parsippany, NJ, U.S.A.

5. Noise Source Diagnostic Techniques, G. RASMUSSEN, Bruel & Kjaer Canada Ltd., Toronto, Ont.

Tuesday, Sept. 11 1400 mardi 11 sept.

SESSION V:
The Noise Abatement Program/
Le programme d'atténuation du bruit

Chairman/
Président: To be announced

1. Noise Control Program For Your Mill (Why, How, Cost, Benefits), D.P.W. POUNDS, Paprican, Pointe Claire, Qué.

2. The Consultants Role in Noise Control, D.J. WHICKER, Barron & Associates, Acoustical Consultants Ltd., Vancouver, B.C.

3. Planning For Noise Control in the Paper Machine Room, J. CROUSE, Beloit Corp., Beloit, WI, U.S.A.

4. Noise Compliance Plans, S.H. EATON, Worker's Compensation Board of British Columbia, Richmond, B.C.

Tuesday, Sept. 11 1530 mardi 11 sept.

SESSION VI:
Equipment Noise Control and Case Histories
Equipement de contrôle acoustique
et exemples typiques

Chairman/
Président: E. PELLETIER, Fraser Inc., Edmundston, N.B.

1. Noise Control of Pneumatic Vibrators as Used in the Pulp and Paper Industry For Chip Car Unloading, A. G. DUBLE, Acoustical Consultant, Newberg, OR, U.S.A.

2. Noise Control of Cyclones as Related to Paperboard and Cardboard, L. KENDE, Ministry of the Environment, Toronto, Ont.

Wednesday, Sept. 12 0900 mercredi 12 sept.

SESSION VII:
Case Histories of Noise Abatement Solutions/
Exemples typiques de solutions relatives
à l'atténuation du bruit

Chairman/
Président: G. WAZNY, Manitoba Forest Resources Ltd., The Pas, Man.

1. Noise Control of a Vacuum Pump, H. REITHAUG, MacMillan Bloedel Ltd., Port Alberni, B.C.

2. Noise Control Solution of a Bale Press, D. JARDINE, St. Anne-Nackawic Pulp & Paper Co., Nackawic, N.B.

SESSION VII (Cont'd)

3. Saw Mill and Wood Room Noise, J. KANE, Higgot-Kane Industrial Noise Control Ltd., Scarborough, Ont.

4. Noise Control of a Displacement Blower, H. REITHAUG, MacMillan Bloedel Ltd., Port Alberni, B.C.

5. Vacuum Pump Noise Abatement, H. REITHAUG, MacMillan Bloedel Ltd., Port Alberni, B.C.

6. Noise Abatement Program at the Alma Mill, J. MOREL and P. DECOSTE, Abitibi-Price Inc., Québec, Qué.

7. Noise Problems of Chain Saws, D. MYLES, Canadian Forestry Service of Environment Canada, Hull, Qué.

8. Saw Mills & Planer Mills Noise Abatement, S.H. EATON, Worker's Compensation Board of British Columbia, Richmond, B.C.

9. Noise Emanation from Conical Refiners and Disc Refiners, G.W. PETTERSEN, Norwegian Pulp and Paper Research Institute, Oslo, Norway

10. Systems for Noise Control at the Norwegian Pulp and Paper Research Institute, Measurements and Analyses, Examples from Project Work, P. LANDMARK, Norwegian Pulp and Paper Research Institute, Oslo, Norway

Wednesday, Sept. 12 1400 mercredi 12 sept.

SESSION VIII
Problem Solving Workshop/
Atelier portant sur les solutions
à apporter aux problèmes

Chairman/
Président D. DMYTROW, E.B. Eddy Forest Products Ltd., Hull, Qué.

TABLE	TOPIC/ SUJETS DE DISCUSSION	MODERATOR/ MODÉRATEUR
1	Enclosures, Silencers	J. KANE, Higgot-Kane Industrial Noise Control Ltd., Scarborough, Ont.
2	Paper Machine Noise Control	J. CROUSE, Beloit Corp., Beloit, WI, U.S.A.
3	Measuring, Monitoring & Diagnosis of Noise	R. PEMBERTON, Bruel & Kjaer Canada Ltd., Ottawa, Ont.
4	Equipment Noise Abatement	D.J. WHICKER, Acoustical Consultants Ltd., Vancouver, B.C.
5	Noise Abatement in Valves and Pipelines	J. NILES, Leslie Co., Parsippany, NJ, U.S.A.
6	Government Standards & Regulations	C. SHERRY, Domtar Inc. Senneville, Qué.

Further information and registration forms may be obtained from:

W. Robert Wood
Assistant Manager, Technical Section,
Canadian Pulp and Paper Association
Sun Life Building, 23rd Floor
1155 Metcalfe St.
Montreal, Quebec
H3B 2X9

Pour de plus amples informations et des formules d'inscription, s'adresser à:

M. W. Robert Wood
Directeur adjoint, Section technique
Association canadienne des producteurs de pâtes et papiers
Immeuble Sun Life, 23e Étage
1155 rue Metcalfe
Montréal, Québec
H3B 2X9

SEMAINE CANADIENNE D'ACOUSTIQUE

La Semaine Canadienne d'Acoustique se tiendra cette année à **Québec** du **22 au 26 octobre 1984**.

Les journées des **22 et 23 octobre** sont d'ores et déjà réservées pour **deux séminaires** qui auront lieu à l'Université Laval:

- Séminaire **1** (en français) consacré à **l'acoustique en général et au contrôle du bruit**,
- Séminaire **2** (en anglais) consacré à **l'intensimétrie et ses applications**.

Le symposium et toutes les autres activités prévues pour les 24, 25 et 26 octobre se tiendront au **Château Frontenac** soit au coeur de la Vieille Capitale. Toute l'information nécessaire sera envoyée sous peu aux membres de l'Association et publiée dans le prochain numéro de la revue.

APPEL POUR LES CONFERENCES

Tous les conférenciers intéressés sont priés de faire parvenir **avant le 31 mai 1984 un résumé de moins de 200 mots** en indiquant le theme choisi. Tentativement, les themes retenus pour les conférences sont les suivants:

- techniques d'identification des sources de bruit,
- réduction du bruit à la source,
- bruit urbain et environnemental,
- écrans et enceintes antibruit,
- acoustique prévisionnelle des locaux industriels,
- acoustique architecturale,
- bruit et vibration,
- analyse de la parole,
- métrologie acoustique,
- ultrasons et hydroacoustique,
- physio et psycho-acoustique,
- divers.

Néanmoins, le comité organisateur se réserve la possibilité de reclasser les communications suivant les réponses obtenues.

Il est prévu de rassembler, sous forme d'un cahier à l'usage de tous les participants du Symposium une information plus détaillée sur les conférences. Aussi les conférenciers devront prévoir, **pour le 7 septembre 1984, remettre un article sommaire de 2 pages relatif à leurs exposés**. Chaque conférencier participant recevra l'information nécessaire au cours de l'été.

Pour tout renseignement complémentaire, prière de contacter:

- Jean-Gabriel Migneron (organisation)
  CRAD, 16e étage, Pav. F.-A. Savard
  Université Laval
  Québec, P.Q.
  G1K 7P4

- Jean Nicolas (conférences)
  Département de Génie mécanique
  Faculté des sciences appliquées
  Université de Sherbrooke
  Sherbrooke, P.Q.
  J1K 2R1

ACOUSTICS WEEK IN CANADA

Acoustics Week in Canada will be held this year in **Quebec City** from **October 22 to October 26**.

October 22 and 23 will be devoted to **two seminars** which will take place at Laval University:

- Seminar **1** (in French) entitled **General Acoustics and Noise Control**,
- Seminar **2** (in English) entitled **Intensity Measurement and its Applications**.

The symposium and other activities scheduled for October 24-26 will be held at the **Château Frontenac** in the heart of Old Quebec. All pertinent information will be sent to Association members shortly and published in the next issue.

CALL FOR PAPERS

Those interested in presenting papers are requested to forward **a summary of 200 words or less before May 31, 1984** with an indication of the selected topic. The list of possible topics has been tentatively proposed as follows:

- noise-source identification techniques,
- quieting the noise source,
- urban and environmental noise,
- barriers, screens and shielding,
- in-plant noise control and models,
- architectural acoustics and building noise control,
- noise emission and vibration,
- speech analysis,
- acoustical measurement techniques,
- ultrasonics and underwater acoustics,
- hearing conservation and psychoacoustics,
- miscellaneous

The organizing committee reserves the right, however, to reclassify papers according to the number of replies received.

For the future reference of symposium participants, more detailed summaries of each paper will be published in cahier form. Participants should therefore submit **a brief 2-page article summarizing their paper by September 7, 1984**. Those participating in the symposium will receive further information during the summer.

For further details please contact:

- Jean-Gabriel Migneron (organization)
  CRAD, 16e étage, Pav. F.-A. Savard
  Université Laval
  Québec, P.Q.
  G1K 7P4

- Jean Nicolas (papers)
  Département de Génie mécanique
  Faculté des sciences appliquées
  Université de Sherbrooke
  Sherbrooke, P.Q.
  J1K 2R1

NEW BOOKS

COMMUNITY NOISE RATING, SECOND EDITION
Theodore J. Schultz
Elsevier Science Publishing Co., Inc., 52 Vanderbilt Avenue, New York, NY 10017, 1982
xii + 385 pp., cloth, $74.00
The first edition of this book was published in 1972 with the same title. It represented an exhaustive and up-to-date account of the noise ratings in common use at that time. This required only 85 pages. The fact that the number of pages has increased in the second edition to 385 is a measure of the surprising magnitude of the virtual explosion of new noise ratings and evaluation schemes. The author points out that the 1970's may be called the "decade of regulation," while the 1980's, with respect to noise abatement, will be the "decade of the consumer." This book has seven chapters which cover all aspects of the rating of community noise. Following the introductory chapter is a description, analysis and evaluation of various rating schemes and procedures for assessing human reaction to noise. Comparisons of the ratings against each other and against subjective responses are then given. Then follows a chapter describing social surveys on noise annoyance. A chapter on special matters covers such topics as the rating of low noise environments, environmental impact statements, pure tones, night-time penalties and models of noise annoyance. The final two chapters cover current standards for community noise, such as those of HUD and other U.S. federal agencies, and proposals for future studies on community response to noise.

ENGINEERING ACOUSTICS AND NOISE CONTROL
Conrad J. Hemond, Jr.
Prentice-Hall, Inc., Englewood Cliffs, NJ 07632, 1983
xiv + 192 pp., cloth, $28.95
This book is intended as a text for use at the undergraduate level in an engineering curriculum. The use of mathematics is minimized in order that, in the author's words, "The student may better understand the art, the fundamental concepts, and the continuity of acoustics." There are 12 chapters in the book; the first seven cover fundamental topics while applications are discussed in the last five chapters. Chapter VIII presents a systematic approach to noise control. Chapter IX covers instrumentation; Chapter X is on community noise; Chapter XI discusses air distribution system noise. Finally, Chapter XII is devoted to architectural acoustics. The book uses English, S.I. and c.g.s. units ". . . as feasibility dictates."

ENGINE NOISE
R. Hickling and M. M. Camal, Editors
Plenum Publishing Corp., 233 Spring Street, New York, NY 10013, 1982
ix + 497 pp., cloth, $62.50
This book is the proceedings of a symposium on "Engine Noise: Excitation, Vibration and Radiation" which was held at the General Motors Research Laboratories on 1981 October 11-13. Although the specific topic of the symposium was control of automotive engine noise, the techniques and concepts discussed at the meeting are applicable to other fields of noise control engineering. There are four sections of the book dealing with excitation sources, transmission paths and structural vibrations in the engine, radiation of noise from engine surfaces and practical methods of reducing engine noise. In the first section, new work is presented on noise generated by cylinder pressure pulsations, piston slap, fuel-injection systems and gears. In the second section, the areas covered are transmission-path analysis, vibrations in linkages, and finite-element analyses of vibrations in the engine structure. In the third section, new experimental methods of measuring the acoustical radiation from engine surfaces are discussed, in particular acoustic intensity procedures. Methods of computing acoustical radiation from vibrating surfaces are also discussed. In the final section on practical methods of reducing engine noise, two general approaches are considered. One approach is to reduce noise through modifications to the engine based on understanding of the vibrations in the structure and of noise-generating mechanisms. The second is to reduce noise by means of acoustical enclosures. Oral discussions were recorded at the time of the symposium. In addition, written discussions were submitted. This book includes an edited version of the papers and the discussions.

HANDBOOK FOR INDUSTRIAL NOISE CONTROL
W. Graham Orr
National Technical Information Service, Springfield, VA 22161, 1981
v + 139 pp., paper, $7.50
This handbook was prepared by The Bionetics Corporation for NASA and is published as NASA Report SP-5108. This handbook gives basic information on the understanding, measurement, and control of noise in industrial environments. It is intended for engineers with or without acoustical experience; to this end, it presents sections on noise problem analysis, instrumentation, fundamental methods of noise control, and properties of acoustical materials. Means for identifying and characterizing a noise problem so that subsequent work may provide the most efficient and cost-effective solution are outlined. A methodology for choosing appropriate noise control materials and the proper implementation of control procedures is detailed. The most significant NASA-sponsored contributions to the state-of-the-art in developing optimum noise control technologies are described, including cases in which aeroacoustics and related research have shed some light on ways of reducing noise generation and its source. The material included in this handbook is limited to that which is clearly applicable to non-aerospace industrial noise control problems. The chapters near the end of the handbook include more advanced and source-specific noise control technology. Emphasis has been placed on fan noise reduction, noise transmission control techniques and jet noise suppression.

SOUND AND SOURCES OF SOUND
A. P. Dowling and J. E. Ffowcs Williams
Halstead Press, John Wiley & Sons, 605 Third Ave., New York, NY 10016, 1983
321 pp., cloth, $59.95
This book, addressed primarily to engineers, concentrates on the precise description of useful and practical idealizations in the science of sound. The source of sound and noise, par-

ticularly the noise of turbulent flow, a frequently neglected but growing area of interest and importance, is developed from first principles. It is described, analyzed and illustrated with materials selected for its interest and study value. Worked examples contain illustrations at a practical level. Questions and answers are provided, but separated in the text to encourage readers to learn for themselves the level of effort needed for a solution. Brief listings of facts, definitions and formulae are collated at the end of the book as a ready reference for the reader of the most commonly recurring points. This book is based on the lectures given to a final-year undergraduate course to engineers at Cambridge University.

NOISE EFFECTS HANDBOOK
Anonymous
National Association of Noise Control Officials, P. O. Box 2618, Fort Walton Beach, FL, 32549, 1981
Approx. 90 pp., paper, $6.95
This pamphlet is subtitled: "A Desk Reference to Health and Welfare Effects of Noise." It was prepared by the Office of Noise Abatement and Control, U. S. Environmental Protection Agency and was first published in 1979 and then revised in 1981. NANCO is making this publication available with EPA permission. The document contains current information on the levels and sources of noise, criteria pertaining to the effects of noise on people, and answers to common questions concerning various health and welfare consequences of noise exposure. The handbook consolidates information contained in various EPA health and welfare publications such as the Levels Document, the Criteria Document, the Urban Noise Survey, etc., as well as the pertinent scientific literature. A bibliography is included.

IAC NOISE CONTROL REFERENCE HANDBOOK
Martin Hirschorn
Industrial Acoustics Company, 1160 Commerce Avenue, Bronx, NY 10462, 1982
approx. 160 pp., paper, $10.00
This little book written by the president of the Industrial Acoustics Company is intended as a vest-pocket guide. The first part of the guide is devoted to noise control engineering data. This includes definitions, terminology, formulae, tables and nomograms on basic acoustical engineering, acoustic fields, sound paths, rooms, enclosures and partitions, silencers and noise level criteria. The second part of the guide is devoted to IAC products and services. The third part of the guide includes two indices. A great deal of information is included that is useful to the practicing noise control engineer.

PRINCIPLES AND APPLICATONS OF ROOM ACOUSTICS, VOLUME 1
L. Cramer and H. A. Mueller, translated by T. J. Schultz
Elsevier Science Publishing Co., Inc., 52 Vanderbilt Avenue, New York, NY 10017, 1983
xvi + 651 pp., cloth, $94.50
This book is a translation, by Theodore J. Schultz, of the second German edition which appeared in 1978. The study of room acoustics is divided into four parts, three of which appear in Volume 1. They deal with geometric room acoustics, statistical room acoustics and psychological room acoustics. Volume 1 will be of interest to those involved in building construction, architects as well as engineers. It will also be of interest to recording engineers and those who are concerned with room acoustics, whether as performers or listeners. The reader may be surprised at the large amount of cross-referencing between the parts of the work until it is recognized that a relatively small number of important acoustical phenomena are being examined from different viewpoints. The careful cross-referencing guides the reader back and forth between the alternative analyses. This scheme of presentation has the merit of making clear how certain analytical techniques are used over and over in different contexts. Taken together, this two volume work offers a systematic and comprehensive presentation of the fundamentals of room acoustics. It presents a carefully argued exposition of the basic scientific principles of room acoustics, provides insight into the history of acoustical invention, and serves as an important source of acoustical applications.

PRINCIPLES AND APPLICATIONS OF ROOM ACOUSTICS, VOLUME 2
L. Cramer and H. A. Mueller, translated by T. J. Schultz
Elsevier Science Publishing Co., Inc., 52 Vanderbilt Avenue, New York, NY 10017, 1983
xx + 434 pp., cloth, $69.75
Volume 2 deals with the wave-theoretical aspects of room acoustics. This is the fourth part of the two-volume work. Because of its greater mathematical content, this part is addressed primarily to the acoustician – who may be either a physicist or an engineer – though for him it can be regarded as an introduction to theoretical acoustics. Many of the 14 chapters of Volume 2 deal with subjects of considerable interest to the noise control engineer. The topics covered in this volume include: the sound field equations, reflection and transmission of normally-incident sound, wall impedance, measurement of absorption coefficients in a tube, experimental determination of wall impedance, sound propagation in tubes, oblique incidence, porous sheets, absorption by resonators, absorption by the use of stiff plates, wave-theoretical treatment of reverberation in rectangular rooms, forced vibration in rooms, statistical considerations and dissipation during propagation in a room.

ENERGY AND NOISE
Richard I. Miller

The Fairmont Press, Inc., P. O. Box 14227, Atlanta, GA 30324, 1981
iv + 134 pp., cloth, $36.00
This thin volume is sub-titled: "How to Incorporate Energy Conservation in Your Industrial Noise Program." The author's premise is that economic benefits derived from energy conservation present an excellent means to justify expenditures for noise control projects by showing an economic payback. He outlines technical approaches by which energy conservation may be incorporated into a noise control program. Set from typewriter-composed plates, the copy editing of this book is not up to the standard of a large publishing house. For example, page 4 is repeated with minor typographical errors as page 5. Many of the illustrations are taken from other publications.

DYNAMIC MECHANICAL DATA ON NON-REINFORCED PLASTICS
Kjell Lundin
Department of Technical Acoustics, Royal Institute of Technology, S-100 44 Stockholm, Sweden, 1982
ii + 137 pp., paper, free
This report presents a compilation of data taken from the literature on the dynamic mechanical properties of plastics. Engineering design problems that require consideration of the damping properties include: mechanical resonance and fatigue; acoustical response and fatigue; noise generation; vibration, shock and noise isolation, and heating under cyclic stress. The same formats for the data presentation are used for all materials included in the report. Separate figures are presented for the temperature and frequency dependencies. The range of modulus values presented are extended to large values in order to make it possible to compare data on high modulus fibers. The range of loss factors is made large enough to include both low loss metals and high loss elastomers. The data are presented in four sections: the first section is compiled data on all of the non-reinforced plastics which were included in the study. The second and third sections give the frequency- and temperature-dependence data on the plastics included in the study. The fourth section gives the results of dynamic measurements which were made on the samples.

SPEECH ENHANCEMENT
Jae S. Lim, Editor
Prentice-Hall, Inc., Englewood Cliffs, NJ 07632, 1983
xv + 363 pp., cloth, $34.95
This book is a collection of reprints of original articles which have appeared in the technical literature. The book is divided into four parts and for each part the editor has provided an overview. Speech enhancement is addressed in four different broad contexts. Part I considers the problems of enhancing speech which has been degraded by additive noise. Even though this problem has received considerable attention in recent literature and is rich with sophisticated signal processing, major unsolved problems offer considerable room for further research. Part II considers the problem of processing undegraded speech in anticipation of its degradation by additive noise. This problem typically arises when the speaker is in a noise-free environment but the listener is in a noisy environment. When the undegraded speech is available for processing, very simple processing methods lead to significant speech enhancement. Part III considers the problem of enhancing speech degraded by reverberation or echos. Systems that are successful in reducing room reverberation or telephone network echos have been developed and are discussed in this part. Part IV considers the problem of slowing down or speeding up the apparent rate of speech. Potential applications exist in which even undegraded original speech is enhanced by such processing. For example, people with impaired hearing or those who are learning a foreign language may prefer the slowed-down speech to the original undegraded speech. In all, 46 reprints from the technical literature are included in this volume.

OUR ACOUSTIC ENVIRONMENT
Frederick A. White
Krieger Publishing Co., Inc., P.O. Box 9542, Melbourne, FL 32901, 1975
xxi + 501 pp., cloth, $37.50
This book was originally published by John Wiley and is now distributed by a new publisher. It is intended for students in environmental studies, urban planning, musical and architectural acoustics, speech and hearing, the social and behaviorial sciences, pre-medical and pre-law programs. An overview of the diverse topics related to environmental acoustics is presented. Both the wanted and unwanted acoustic energy of our sonic environment is discussed. The book analyzes the physiological and psychological effects of speech, musical perception, and other deliberately produced expressions of sound, and demonstrates how noise control is an integral part of effective urban planning. Sound propagation is examined in both outdoor and indoor environments and the use of the decibel scale is explained for monitoring sound levels. Sound perception is examined in terms of the physiological and subjective aspects of hearing. Traffic, highway, aircraft and industrial noise and its control are studied as societal problems, and a survey of local, state, federal and international legislation is included. Other subjects discussed include an examination of speech sound parameters that affect speech intelligibility in the human environment, the application of musical acoustics to auditoriums, concert halls, and other special acoustic environments, and techniques for measuring the sound pressure level of traffic noise and the reverberation time of an auditorium. Material is presented to show how urban planners have reduced noise pollution in many communities and how future noise problems should be anticipated.

SOUND CONTROL AND THERMAL INSULATION OF BUILDINGS
Paul Dunham Close
Krieger Publishing Co., Inc., P.O. Box 9542, Melbourne, FL 32901, 1966
vii + 502 pp., cloth, $28.50
This book originally published by Reinhold in 1966 is now available from the Krieger Publishing Co. This volume is essentially two books in one as it deals with two subjects which are both of major importance in building design but which bear little relationship to one another insofar as the solution of building problems are concerned and are therefore treated separately. It is intended to be used as a general reference for architects, contractors and others interested in the subjects covered and as a textbook for schools and colleges. The book is intended primarily to cover the fundamentals of two major subjects and to give essential design data and product information, including application details. The sound control section deals with acoustical problems common to various types of buildings and includes 1) auditorium acoustics involving good hearing conditions for speech and music, 2) noise quieting in offices, industrial buildings, schools, hospitals, restaurants and other buildings, 3) noise control in buildings used for residential purposes such as homes, apartments, hotels, motels and institutions, and 4) machinery vibration and noise, a problem common to all types of buildings. Nine of the twenty chapters are devoted to acoustics and noise control.

GEARS AND THEIR VIBRATION
J. Derek Smith
Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016, 1983
ix + 170 pp., cloth, $29.50
This book is subtitled: "A Basic Approach to Understanding Gear Noise." The author's objective is to help engineers who encounter gear noise problems to understand the mechanisms of noise generation and to tackle gear vibration problems in an orderly manner. Direct production of noise by gears is rare; a point emphasized in the book is that vibration travels through the gearcase and surrounding structure and is eventually radiated as noise. This single-source reference offers practical guidelines for controlling vibration-generated noise. Providing analyses of errors and dynamics in both the design and manufacture of gears to reduce noise, this book serves as a primary source of information for particular problems. It is intended to be suitable for those who have little experience of either gears or vibration and will be of interest to mechanical engineers concerned with gearing, industrial gear inspectors, gear manufacturers, noise control engineers, designers of antivibration mounts, stress analysts, safety engineers and others. It contains material for graduate courses in vibration or gear drives as well as advanced undergraduate courses in mechanical engineering. The volume is divided into 15 chapters covering the following subjects: introduction, spur gears, helical gears, other gear drives, manufacturing methods, gear measurement, elastic deflections, noise generation, experimental investigations, gearbox modeling, development priorities, standards, gear failures, lightly loaded gears and gear systems. The S.I. system is used throughout the book with unit equivalents given in an appendix.

VIBRATION EFFECTS ON THE HAND AND ARM IN INDUSTRY
A. J. Brammer and W. Taylor, Eds.
John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158, 1982
xvii + 376 pp., cloth, $40.00
Habitual exposure of the hand and arm to vibration leads to damage of the peripheral blood vessels and nerves. Other systems, including the central nervous system and the musculosketal system, may also be involved. This collection of papers on the medical, acoustical, engineering and legal aspects of exposure of the arm and hand to industrial vibration examines various methods of measuring vibration exposure, the effects of such exposure, including the development of "white fingers" and "dead hands," and the resulting dose-response relationships. The book also includes papers on objective tests for diagnosis, methods for reducing vibration exposure, and the legal ramifications for workers who become disabled as a result of exposure. Written by an international group of specialists in the field, a discussion section at the end of each paper clarifies disputes that arose during the editorial process. An introduction to the volume by the editors integrates the various findings and highlights major areas of concern. This book is intended to serve both the novice and the expert in occupational health, industrial hygiene, vibration acoustics, mechanical engineering and the regulatory process. The book is divided into eight sections with a half-dozen papers in each. The sections are entitled: physiological effects, objective methods for diagnosis, measurement of vibration entering the hand, occupational exposure to vibration, tool and machine vibration, dose-effect relations, exposure limits and standards, methods for reducing vibration exposure and legal implications.

NOISE AND ITS EFFECTS ON COMMUNICATION, SECOND EDITION
Nelson M. Blackman
Krieger Publishing Co., Inc., P.O. Box 9542, Melbourne, FL 32901, 1982
xv + 259 pp., cloth, $26.50
This is the second edition of a text originally published in 1966 which presents the basic tools of statistical communication theory and some of their applications. The book is written for engineers, physicists, and mathematicians. The noise with which is deals is mainly the inevitable Gaussian noise that arises in every electrical circuit and limits the useful sensitivity of electronic equipment in which it may produce a hissing or roaring sound. The first part of the book describes noise and random signals. The second part deals with the effect of noise upon signals in various nonlinear devices, such as AM and FM demodulators, limiters, harmonic generators, and unintended nonlinearities. The third and last part of the book presents the fundamentals of information theory, generally following the lines of Shannon's original papers. In the second edition, several sections of the book have been lengthened and new problems have been added. The book's emphasis on physical and geometric interpretations of methods and results remains the same. It is intended to give the reader an intuitive appreciation of the fundamentals of statistical communication theory needed in any industrial or research environment involved with the development of new communication techniques.

DIGITAL FILTERS, SECOND EDITION
R. W. Hamming
Prentice-Hall, Inc., Englewood Cliffs, NJ 07632, 1983
xiv + 257 pp., cloth, $28.95
This revised edition is significantly larger than the first edition. Much of the expansion is in the form of a more careful presentation of the material and includes many more pictures of the ideas. This book is intended for the many people who need a basic knowledge of digital filters but are not mathematically sophisticated and do not have an elaborate electrical engineering background. Only a knowledge of the calculus and a smattering of statistics are required. The book is elementary but does not avoid the basic ideas of the field. It shows the unity of such diverse fields as digital filters, statistics, numerical analysis and econometrics. The subject of digital filters is the natural introduction to the broad, fundamental field of signal processing. The power and basic simplicity of digital signal processing over the older analog techniques are so great that whenever possible analog systems are being converted to their equivalent digital forms. The second edition has fourteen chapters which cover the following topics: introduction, the frequency approach, some classical applications, Fourier series: continuous case, windows, design of nonrecursive filters, smooth nonrecursive filters, the Fourier integral and the sampling theorem, Kaiser windows and optimization, the finite Fourier series, the spectrum, recursive filters, Chebyshev approximation and Chebyshev filters, and miscellaneous topics. The most significant change in the second edition is the presentation of the difficult topic of windows.

Dear Sir:

I refer to the letters by H. G. Pollard and R. A. Hewett in the January 1984 (Volume 12, Number 1) edition of "Canadian Acoustics." Mr. Pollard's observations and his concern are something which many of us have been aware of for many years. The general lack of concern for adequate noise control led to the publication of the 2 volumes "Noise in the Human Environment". In those volumes we addressed ourselves to the pressing needs of noise control in the hope that effective action would be taken, not only in Alberta but also in the other parts of Canada. The recommendation contained in Volume 2 of the work referred to is listed below:

"Chapter 5 reveals the serious inadequacy of the building codes. Most serious is the inadequacy of the national Building Code of Canada with respect to the acoustic insulation requirements for party floors and walls.

> "It is recommended that very urgent consideration be given to raising the Sound Transmission Class value to 55 for apartment party walls and floors and between bedrooms and other living areas in dwellings."

A further lack is the failure to specify impact sound insulation. Similarly, there is the failure to specify control of the noise from mechanical appliances and building services.

> "It is essential that a determined effort should be made to rectify these deficiencies in the National Building Code as quickly as possible, by resorting to interim recommendations if necessary."

No building code is adequate of itself; an educational program linked to enforcement procedures backed by field measurements is necessary. Otherwise, faulty building practices may negate the effects of changes in the code. A provincial (or inter-provincial) study of the enforcement problem is needed to design an effective and economically acceptable program."

To the best of my knowledge the analysis and recommendations have had no practical impact.

There is a crying need for some form of effective action to meet the needs of the public. The Canadian Acoustical Association needs to do more to influence the situation in Canada. Two activities are required. First, the association needs to conduct some sort of education programme which will lead to better recognition of the utility of Noise Control Engineering. The writing of the two Volumes referred to earlier in this letter could have provided a spring board for such action. Unfortunately other factors pre-empted the proper follow-up activity. I believe we have much to learn in this regard from our colleagues in the United States.

Second, the Canadian Acoustical Association needs to develop influence in the area of the decision making which is concerned with the awards of research fundings. On the national scene, practically the only organizations which receive any continuity in their funding are those of the National Research Council. This means that in Canada there is no major work in Universities which compares with that done in institutions such as the Institute of Sound and Vibration Research at the University of Southampton, for example. I believe that a sub-committee consisting of the past presidents of the organization, together with one or two individuals from NRC and one or two representatives from industry, should be convened to formulate a policy for the association on both of these points.

In the longer term it may be that the survival of the association could depend on it's ability to make some lasting impact in the areas which I have listed.

H.W. Jones
Professor, Engineering Physics
Technical University of Nova Scotia

Dr. Dale Ellis receives the directors' award for the best paper by an author under 35. His paper was titled, "Some Simple Formulae for Normal Mode Wave Numbers, Cutoff Frequencies and the Number of Modes Trapped by a Sound Channel." Shown from left to right are: Mr. F.A.A. Fergusson, Chief of DREA; Dr. Ellis; Dr. L.J. Leggat of DREA, Director of CAA and last year's recipient of the award, making the presentation; and Dr. L.T. Russel, Technical University of Nova Scotia, a Director of CAA.

Letter to the Editor:

LATERAL DIFFERENCE IN HEARING SENSITIVITY

by

David Y. Chung, Ph.D.
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ABSTRACT

A series of studies on the lateral difference in hearing sensitivity by gender, age, and hearing threshold level were done at the Workers' Compensation Board of British Columbia. Results confirm the right ear is statistically the 'better' ear. In addition this lateral difference is shown to be a function of hearing threshold level. The different factors that could contribute or affect the lateral difference are discussed.

SOMMAIRE

Une série d'études portant sur la différence latérale dans la sensibilité de l'ouie selon d'âge, le sexe et le niveau d'audition a été effectuée à la Commission des accidents du travail de la Colombie-Britannique. Les résultats confirment que, pour la moyenne des gens, l'oreille droite est plus sensible. De plus, cette différence latérale est représentée comme une fonction du niveau d'audition. Cette communication traite des différents facteurs qui pourraient influencer la différence latérale.

INTRODUCTION

Results from large-scale hearing surveys have demonstrated statistically that the right ear is more sensitive than the left ear, (Kannan & Lipscomb, 1974). This i found not only in adult male populations but also in children between the ages of 12 - 17 (Roberts & Ahuja, 1975). The lateral difference in sensitivity, however, is most prominent in the male adult population. This leads to the query that the latera difference may be a sequence of a systematic asymmetrical noise exposure such as the mode of driving and/or shooting. While these possibilities may seem reasonable they cannot account for all the lateral difference.

In a study done a few years ago at the WCB (Chung et al, 1981) we separated two factors which are related to the lateral difference. The factors are shooting and th ear effect. Both factors are related positively to the lateral difference as defined by threshold of the left ear minus the threshold of the right ear.

In shooting, if one is a right-handed shooter, the left ear is more likely to have worse hearing, (Taylor & Williams, 1966; Keim, 1969). This has been ascribed to the head shadow effect. The far ear receives less noise exposure due to the attenuation of the head, thus less hearing loss. Since most people are right-handed the average shooter has more hearing loss in the left ear, at the higher frequencies.

The ear effect is defined as the difference in hearing threshold between the two ears after asymmetrical noise exposure has been controlled for. This was done by two different approaches at the WCB.

In B.C. we have jurisdiction over hearing conservation in industry. The Industrial Health & Safety Regulations of the WCB require companies to have a hearing conservation program (HCP) consisting of engineering controls, personal hearing protection and audiometric surveillance when workers are exposed to a steady-state noise of 90 dBA (time-weighted average - TWA) for eight hours. When there is a HCP all workers exposed to a TWA of 85 dBA for eight hours must have a pure-tone, air-conduction audiogram taken annually. The WCB requires copies of all audiograms along with information or medical history, shooting history, smoking history, and use of hearing protectors. All data are stored on tape.

The first approach we took was to study all workers who had a history of shooting (Chung et al, 1981). At the time of the study there were 29,953 workers who had some kind of a shooting history but no apparent ear pathology other than possibly noise damage. Since the ear effect presumably is not affected by the handedness and the shooting effect is dependent on the handedness, it is possible to separate the two effects mathematically. By doing so it was found that the shooting effect increases with the years of shooting but the ear effect does not. However, both effects are most prominent between 3 to 6 kHz. The shooting effect is negligible at 0.5 and 1 kHz and the ear effect is slightly less than 1 dB at 0.5 and 1 kHz.

Another approach in obtaining the ear effect is to study a group of subjects, with no apparent asymmetrical noise exposure (Chung et al, 1983a). In that study we only used workers without shooting history and no apparent ear pathology other than noise exposure. Workers (shingle sawyers) with asymmetrical noise exposure in the workplace are also excluded (Chung et al, 1983b). Over 50,000 cases were analyzed. The ear effect by sex, age, and hearing loss was also studied.

When the ear effect was analyzed by gender it was found that male workers have approximately twice the ear effect that the female workers have at frequencies 2-8 kHz, but at 0.5 and 1 kHz the ear effect is about the same for the two groups. For example, at 4 kHz the female ear effect is about 1.25 dB and the male ear effect is about 2.45 dB.

Analysis of the ear effect by age also shows a difference between the male and the female groups. As age increases from 20 to 50 years the ear effect also increases significantly ($p < 0.001$) at the high frequencies for the male group but the increase is not significant in the female group. However, for the male group as age increases above 50 years the ear effect decreases again.

The most important relationship was found between the ear effect and hearing level. Overall the ear effect increases significantly ($p < 0.001$) with hearing level to about 40 dB HL and then decreases for individuals who have hearing losses of 40 dB or more. This trend is true for frequencies 2 kHz and above.

At 0.5 and 1 kHz, the ear effect as a function of age behaves quite differently from that at the higher frequencies. It decreases up to the age group 45-49, where hearing level is about 10 dB HL at both frequencies. Over 45-49 years, the ear effect at these two frequencies begins to increase slightly. When the ear effect is plotted against hearing level it can be seen that the ear effect at 0.5 and 1 kHz increases to a hearing level of 20-29 dB and then it decreases.

When hearing level is controlled, the ear effect is no longer related to age. This demonstrates that the ear effect is indirectly related to age because age is related to hearing level. This, together with the fact that the ear effect, being lower in the female workers than in the male workers, which can be explained by the better hearing threshold level of the female workers in the higher frequencies, suggests that hearing level is a major factor relating to the magnitude of the ear effect.

There are various possibilities which may cause or influence the ear effect. They are: (1) the order of testing, (2) systematic asymmetrical noise exposure, and (3) lateral difference in susceptibility to noise damage.

In our program the left ear is the ear tested first unless the worker indicates his right ear is the better ear. It is possible, therefore, that such bias could contribute to the ear effect. However, the fact that the ear effect changes with hearing level suggests that the order of ear testing is not a significant factor influencing the ear effect. Also, it has been shown that the ear effect persists despite the randomization of the order of presentation (Singer et al, 1982).

While lateral difference in hearing level could be caused by a systematic asymmetrical noise exposure, evidence from this study does not support this explanation. Since in this study shooters and shingle sawyers were eliminated, and right-handers of hand-tool users would more likely yield a right bias in noise exposure, it is unreasonable to ascribe the ear effect to a systematic left bias. The data also show that, generally, there is a decrease in the ear effect when hearing level is above 40 dB HL. This is inconsistent with the asymmetrical noise exposure explanation. Furthermore, a lateral difference has already been shown to be present in teenagers (Roberts & Ahuja, 1975).

The possibility that the ear effect is partly caused by a lateral difference in the susceptibility to noise damage should be considered. For a positive ear effect to occur as a consequence of a lateral difference in susceptibility there must be a left bias in the susceptibility. This is consistent with our clinical findings (Chung et al, 1983c) which showed that of the 69 workers who had the 2-kHz asymmetry 82.6% had worse hearing thresholds in the left ear at 2 kHz. Evidence of that study suggests the asymmetry at 2 kHz is a manifestation of a lateral difference in susceptibility to noise damage and that the left ear is the more susceptible one in most cases.

How can the theory of the lateral difference in the susceptibility to noise damage explain: (1) the finding that there is a decrease in the ear effect above 40 dB HL, (2) that there is already an ear effect existing in teenagers, and (3) that the ear effect at 0.5 and 1 kHz behaves quite differently from that at high frequencies?

At present there are no unequivocal answers to these questions. Nevertheless, speculations may be made. The decrease in the ear effect above 40 dB HL or over 55 years old can be explained by the presence of presbycusis in the older age group. Presbycusis may dilute the ear effect but if this is true then presbycusis must not be simply additive to noise-induced hearing loss.

The fact that a certain amount of the ear effect already present in teenagers and in normal-hearing people of all ages suggests that there is a basic statistical difference of about 1 dB in sensitivity between the left and the right ear, both in the male and the female adult. The difference is independent of asymmetrical noise exposure and susceptibility.

The finding that the ear effect at 0.5 and 1 kHz behaves quite differently from that at the high frequencies is consistent with the theory of the lateral difference in susceptibility because 0.5 kHz and 1 kHz are usually the least affected frequencies in noise-induced hearing loss. The ear effect remains relatively stable over the age groups at these two frequencies. It also peaks at 20-29 dB HL at these lower frequencies and not 30-39 dB HL as at the high frequencies. Presbycusis occurs at a lower hearing level and at an older age at these low frequencies.

CONCLUSION

There seem to be four factors which affect the lateral difference in hearing sensitivity: (1) a basic statistical difference of about 1 dB in sensitivity between the left and the right ear, right ear being the more sensitive one; (2) asymmetrical noise exposure, such as shooting and certain types of occupational noise; (3) asymmetrical susceptibility to noise damage, left ear being statistically the more susceptible one; (4) presbycusis which tends to dilute the effect of lateral difference in hearing sensitivity due to noise.

REFERENCES

1. Chung,D.Y., Gannon,R.P., Willson,G.N. & Mason,K.: Shooting, sensorineural hearing loss, and Workers' Compensation. J.Occup. Med. 23, 481-484 (1981).
2. Chung,D.Y., Mason,K., Gannon,R.P., & Willson,G.N.: The ear effect as a function of age and hearing loss. J. Acoust. Soc. Am. 73, 1277-1282 (1983a).
3. Chung,D.Y., Mason,K., Willson,G.N. & Gannon,R.P.: Asymmetrical noise exposure and hearing loss among shingle sawyers. J. Occup. Med. 25, 541-543 (1983b).
4. Chung,D.Y., Willson,G.N. & Gannon,R.P.: Lateral differences in susceptibility to noise damage. Audiology 22, 199-205 (1983c).
5. Kannan,P.M., & Lipscomb,R.M.: Bilateral hearing asymmetry in a large population. J. Acoust. Soc. Am. 55, 1092-1094 (1974).
6. Keim,R.J.: Sensorineural hearing loss associated with firearms. Archives Otolaryngol. 90, 65-68 (1969).
7. Roberts,J., & Ahuja,E.M.: Hearing levels of U.S. youths 12-17 years, United States, National Center for Health Statistics, HEW, Series 11, No.145 (U.S.GPO, Washington, DC) pp.84, (1975).
8. Schrier,A.J.: Analysis of noise-related auditory and associated health problems in the U.S. population (1971-1975). EPA Technical Report 55019-82/103A (1982).
9. Taylor,G.D., & Williams, E.: Acoustic trauma in the sports hunter. Laryngoscope 76, 863-879 (1966).

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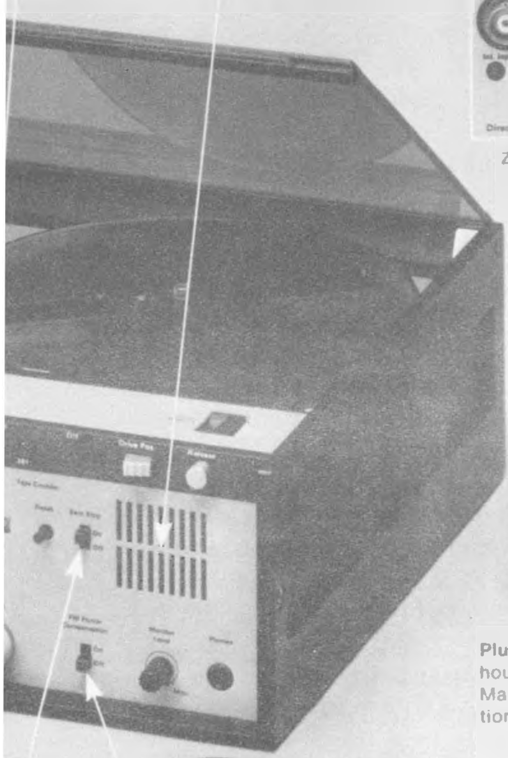

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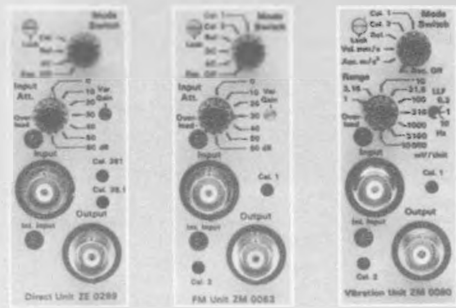

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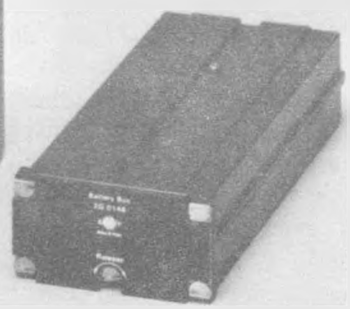

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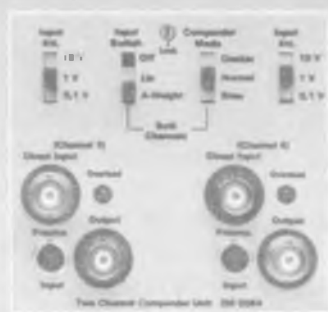

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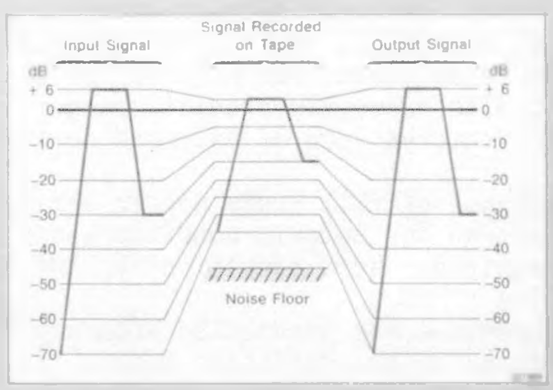

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THE ACCURACY OF HIGHWAY TRAFFIC NOISE PREDICTIONS

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ABSTRACT

The free-field prediction accuracies of four highway traffic noise prediction models (FHWA, CMHC, RDG, and ONTARIO) were compared over a wide range of the basic variables of traffic noise prediction. The average error, in terms of standard deviation of difference between the predicted and measured sound levels, was found to be about 2 dBA. A review of the free-field prediction accuracies of major North American models developed since 1971 revealed similar results. In order to improve prediction accuracy, effects such as ground conditions and atmospheric influences on the propagation of traffic sound must be better understood and incorporated into prediction models. Also, noise generated due to tire-pavement interaction and sound emission levels of various vehicle types must be better characterized in existing prediction procedures.

SOMMARIE

On compare la précision de la prédiction en champ libre de quatre modèles de prédiction des bruits routiers (FHWA, SCHL, RDG, et Ontario) sur une gamme très étendue des variables de base de la prédiction des bruits routiers. On a trouvé que l'erreur moyenne, on terme de déviation normalisée des différences entre les niveaux sonores prédits et les niveaux mesurés, est de 2 dBA. L'examen de la précision de la prédiction en champ libre des plus importants modèles nord-américains crées depuis 1971 donne des résultats similaires. Afin d'améliorer la précision des prédictions, il faut mieux comprende certains effets tels que l'état du sol et les influences atmosphériques sur la propagation des bruits routiers et les incorporer dans les modèles de prédiction. De plus, it faut mieux caractériser le bruit résultant de l'interaction entre les pneus et le revetement et le niveau d'émission sonore des divers types de véhicules dans les procédures existantes.

1/ INTRODUCTION

A reliable and accurate highway noise prediction method is a cornerstone for control of acoustical environment along highways. A reliable prediction method should be accurate, not only as far as overall results are concerned, but it should also correctly predict changes in sound levels due to specific highway design features such as pavement surface type and highway grade.

The purpose of this study was to verify the accuracy of a newly developed prediction method for Ontario conditions and to determine if any further improvements are required. More specifically, the objectives of the study were:

a) To compare the prediction accuracy of the new Federal Highway Administration highway noise prediction model [1], referred to subsequently as the FHWA model, with other prediction models, namely CMHC [2], RDG [3] and Ontario [4] models.

b) To determine the minimum standard deviation of differences between the predicted and measured sound levels which can be expected if only customary, basic variables are used for predictions.

c) To quantify prediction errors which may arise from variables not included in the current prediction models.

2/ METHODS

The prediction accuracies of the models were determined by comparing predicted and measured energy equivalent sound levels. The predicted levels were obtained by inputting the actual traffic, geometric, and other required parameters into the four models (FHWA, CMHC, RDG, ONTARIO) The measured levels were obtained at 27 sites specifically selected for the purposes of this study. The sites were selected with the objective to obtain a general data base for overall evaluation of the models. The sites encompassed a wide range of traffic flow conditions (traffic volume, composition, and speed) and highway facilities. Approximately one-half of the sites bordered on freeways and the rest on regional roads and arterial streets. The sequence of measurements on individual sites was randomized as much as possible.

All sites approximated free-field conditions. The subtended angles of at least 150° at the measurement locations were unobstructed by houses, barriers, or other shielding features. The ground between the roadway and the measurement locations was covered mainly by grass. Measurements were conducted using the procedures and techniques recommended in Reference 5. To minimize variation, the measurements were conducted only along straight roadway sections with asphalt pavement surfaces and with highway grades less than 2%.

The total traffic volume ranged from 40 to 8800 vehicles per hour with the mean of 2500. The total truck percentage, including both medium and heavy trucks, ranged from 2% to 45% with a mean of 15%. The medium trucks were defined as 2-axle trucks with four tires on the rear axle, the heavy trucks were defined as trucks with three or more axles. The percentage of the heavy trucks in the total truck flow ranged from 0 to about 90% with a mean of 70%. Sound level measurements were taken at a height of 1.2 m above roadway pavement elevation and at equivalent distances (equivalent distance is defined as a square root of the product of the perpendicular distance between the measurement location and the centrelines of the near and far traffic lanes, respectively) ranging from 10 to 115 m with a mean of 50 m.

The total number of observations was 85 indicating that, on the average, three sound level measurements were carried out at each site. These were not duplicate measurements but rather measurements done at different distances from the roadway. The maximum number of measurements performed at any one site was limited to four in order to minimize the influence of any site-specific features, such as ground cover or prevailing wind conditions, on the statistical evaluation of model accuracies.

3/ RESULTS OF MODEL COMPARISONS

The prediction accuracies obtained for the four models are compared and summarized in Table 1 in terms of means and standard deviations of differences between the predicted and measured sound levels.

Table 1/ Comparison of Prediction Accuracy

Prediction Model	Mean Difference Between Predicted and Measured Values, dBA	Standard Dev. of Differences dBA	Intercept of Regression Line dBA
A) Overall Comparison, All 85 Observations			
FHWA	0.78	1.59	8.01
CMHC	-0.10*	1.62	8.72
RDG	1.61	1.99	14.44
ONTARIO	0.23	1.68	6.43
Empirical	0.00	1.47	2.71
B) Comparison for Freeways, 46 Observations			
FHWA	0.71	1.77	14.32
CMHC	-0.75	1.36	7.46
RDG	0.97	2.07	21.00
ONTARIO	0.52	1.74	13.94
C) Comparison for Non-Freeways, 39 Observations			
FHWA	0.87	1.35	7.30
CMHC	0.68	1.57	7.76
RDG	2.36	1.60	6.77
ONTARIO	-0.11	1.54	12.05

* Negative values indicate underprediction.

The comparison was done separately for all 85 observations, 46 freeway observations, and 39 non-freeway observations. Also shown are results for an empirical model developed by multiple regression analysis which will be discussed later. The following conclusions are based on the statistical indicators given in Table 1.

1/ For all 85 observations, the prediction accuracy of the four models (FHWA, CHMC, RDG, ONTARIO) was quite similar. The standard deviation of the models was in a narrow range from 1.62 dBA, obtained for the CMHC model, to 1.99 dBA, obtained for the RDG model.

2/ For 46 freeway observations, all models tended to overpredict with the exception of the CHMC model which underpredicted by an average of 0.75 dBA. However, the CMHC model had the lowest standard deviation of 1.36 dBA.

3/ For 39 non-freeway observations, the RDG method overpredicted by an average of 2.36 dBA and should be considered deficient for these sites. The differences in prediction accuracies calculated for the other three models were only marginal.

4/ MODEL SELECTION

Since the accuracies of several prediction models were similar, the decision as to which model to use was based on additional considerations such as their analytical qualities, flexibility, and expected enhancement. In this respect, the FHWA model is clearly superior and was, for this reason, adopted by the Ontario Ministry of Transportation and Communications as the recommended model.

For illustration, let's examine how the traffic flow parameters are accounted for by different methods. The computerized version of the FHWA model, STAMINA 2.0 [6] accepts up to eight classes of highway vehicles which can be defined by the user in terms of the average emissions levels, for each octave band centre frequency, at the distance of 15 m from the vehicle centreline. This analytical approach enables the user to calculate sound levels along specialized facilities, for example, along busways and logging roads. On the other hand, the CMHC and ONTARIO models use only two fixed vehicle classes, namely cars and trucks, and tend to predict well only for average traffic conditions and for typical highway facilities. For example, correlation analyses performed on the CMHC model using the survey data indicated a negative linear dependence of the model accuracy on the percentage of heavy trucks. The model underpredicts, with the significance level of about 0.02, at higher percentages of heavy trucks (approximately 1 dBA for 15% of heavy trucks).

The four prediction models analysed use only the basic, customary variables of highway noise prediction -- distance from observer to source, traffic volume and composition, and average speed of traffic flow. To determine the potential accuracy attainable by employing only those variables, an empirical prediction equation was constructed and calibrated to fit the survey data for all 85 observations using multiple regression analysis. The empirical equation is given by:

$$L_{eq} = 21.5 + 11.1 \log(V_C + 10\, V_{MT} + 15\, V_{HT}) - 15.4 \log D + 15.0 \log C$$

where: L_{eq} = energy equivalent sound level, dBA

V_C = volume of cars, vehicles per hour
V_{MT} = volume of medium trucks, vehicles per hour
V_{HT} = volume of heavy trucks, vehicles per hour
D = equivalent distance, m
S = average operating speed of traffic flow during an hour, km/h

The multiplication factors of 10 and 15 for medium and heavy trucks, respectively, were obtained by substituting trial factors into the equation and selecting the factors which resulted in the smallest standard deviation of differences between predicted and measured sound levels. Further work would be required to optimize these factors and to determine their speed dependance.

The statistical indicators of the prediction accuracy of the empirical model are compared with those obtained for the four prediction models in Table 1. As expected, the empirical model outperformed the other models. It should be noted, however, that the improvement in terms of standard deviation was only marginal (1.47 dBA versus 1.62 dBA obtained for the CMHC model) and is not expected to change substantially even if the multiplication factors of the empirical model were adjusted for speed dependence. These results indicate that there is a "maximum" accuracy attainable using only the basic variables of highway noise prediction. To improve the accuracy of the current prediction methods, it is not sufficient just to characterize better the basic prediction variables and to improve their functional relationships, it is necessary to incorporate other factors and variables into the models.

5/ REVIEW OF PREDICTION ACCURACIES

In the past, a number of studies have been conducted to assess accuracies of highway traffic noise prediction models. The results of these studies, dealing with major North American prediction models, are presented in a summary form in Figure 1. The results obtained in this study are also included. Figure 1 shows a relationship between an approximate date a specific model was developed and its accuracy, in terms of standard deviation of differences between the predicted and measured values, as reported by the author of the model or by an independent evaluator. For completeness, two additional North American models, TSC model [16] developed in 1972, and Wyle Laboratories model [17] developed in 1974 should have also been included and compared in Figure 1 but appropriate data were not available.

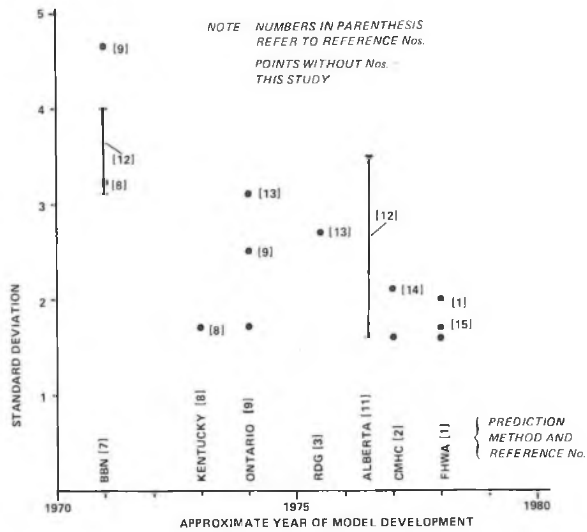

Figure 1/ Prediction Accuracy of Traffic Noise Prediction Models
Sites without artificial barriers only.

The relatively narrow range of errors reported by different investigators for the seven most recent highway noise prediction models evaluated in Figure 1 indicates that there is indeed a limit on the prediction accuracy which can be achieved by current models using only the basic, customary variables. This limit appears to be approximately 2 dBA in terms of standard deviation of differencies between the predicted and measured levels. It may be noted that the mean difference between predicted and measured sound levels was not used to compare model accuracies since it is easily influenced, in the case of empirical models, by model calibration, or in the case of analytical models, by adjustments to average vehicle emission levels.

According to Figure 1 data, there has not been any noticeable improvement in prediction accuracy since 1973. The spread of values reported for the different prediction methods and by different investigators can be attributed largely to differences between the studies (e.g., site selection criteria). The relatively low standard deviations obtained in this study are probably the result of the strict site selection criteria used (e.g., only asphalt concrete pavements, flat, grass-covered terrain between the roadway and the receiver).

It should be noted that the errors plotted in Figure 1 were obtained for generally unshielded locations, i.e., locations not shielded by houses or artificial barriers. For the sites shielded by houses, the error can increase by about 20% [14] and for sites shielded by artificial barriers the error can actually double [15, 18].

6/ NEW PREDICTION MODELS

To significantly improve prediction accuracies of the existing models, the effects of several specific factors (e.g., pavement texture and highway grade) must be better understood and additional factors related to sound propation over ground and weather-related influences must be incorporated into the models. The trend to increase the number of variables included in the prediction models, and incidentally their complexity, is shown in Table 2 which classifies the existing models and models under development into four categories as first, second, third and fourth generation models.

Table 2/ Traffic Noise Prediction Models

Model Class	Example and Date of Development	Selected Model Features
1st Generation	BBN [7], 1971 ONTARIO [9], 1974	Only two highway vehicle classes. Overall dBA level calculation. Only limited recognition of ground attenuation.
2nd Generation	FHWA STAMINA [6]* 1979	Several highway vehicle classes. Octave or third octave centre frequency calculation. Some recognition of ground impedance.
3rd Generation	FHWA-N [19], 1982 STOP-GO [20], 1982	Same as 2nd generation plus: Explicit recognition of ground impedance and its variation between the source and the receiver.
4th Generation	Under Development	Same as 3rd generation plus weather-related variables.

* This is a computerized version of the original model [1].

For example, the third generation models now under development account for coherence between direct and ground reflected sound propagation. The ground cover is modelled by several contiguous planes using 3-dimensional coordinates. Sound absorption properties of these planes are characterized by their complex ground impedance values given for each of 24 one-third octave band center frequencies spanning the 50 to 10 000 Hz range. This illustrates the increase in the model complexity which may be required to significantly improve the accuracy of the existing prediction methods.

7/ CAUSES OF ERRORS

Some of the major causes of errors associated with highway traffic noise prediction methods are quantified in the following.

7.1/ Emission Levels of Highway Vehicles

The assumptions regarding the noise emission levels of highway vehicles are paramount for prediction accuracy at all distances. Figure 2 shows that while the assumptions made by different agencies on the sound emission levels of passenger cars are quite similar, the assumptions on the sound emission levels of heavy trucks, made by the same agencies, can differ by up to 5 dBA. These differences can be attributed to variations within the class of heavy trucks which encompasses vehicles with gross weight ranging from about 12 000 to 65 000 kg and to the prevalence of certain types of heavy trucks in some localities. Since the contribution from heavy trucks often dominates highway traffic sound levels, better site-specific characterization of their emission level is required.

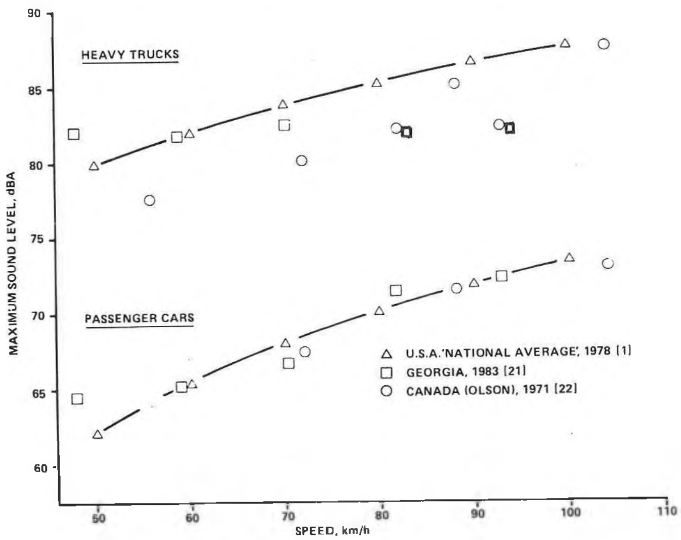

Figure 2/ Variation in Maximum Sound Level of Highway Vehicles
The standard deviation of individual points was approximately 2 dBA for passenger cars and 3 dBA for trucks.

7.2/ Sound Propagation

Sound propagation is influenced by a number of factors such as geometry between the source and the receiver, environmental weather-related effects, ground impedance and its variation, source frequency and source shape (or traffic volume) [23]. To quantify the influence of some of these factors we have conducted a series of long-duration 24-hour measurements along a six-lane freeway. The measurements were conducted at two locations on the opposite sides of the freeway, approximately 350 m from the centreline. Five 24-hour sound level measurements were conducted at each location before a barrier construction and eight to ten 24-hour measurements were conducted after the barrier construction during an eight-month period spanning virtually all four seasons. The dominant noise source at these locations was traffic noise.

Results given in Figure 3 show a considerable day-to-day variation in sound levels. The standard deviation of this variation was approximately 2.5 dBA and was not influenced by the barrier construction nor by measurement location (north side and south side in Figure 3a). The nighttime sound levels were about 6 dBA lower than the daytime levels (Figure 3b) both before and after barrier construction. The standard deviations of the daytime sound levels and night-time sound levels measured during the eight-month period were similar (2.38 and 2.47 dBA, respectively).

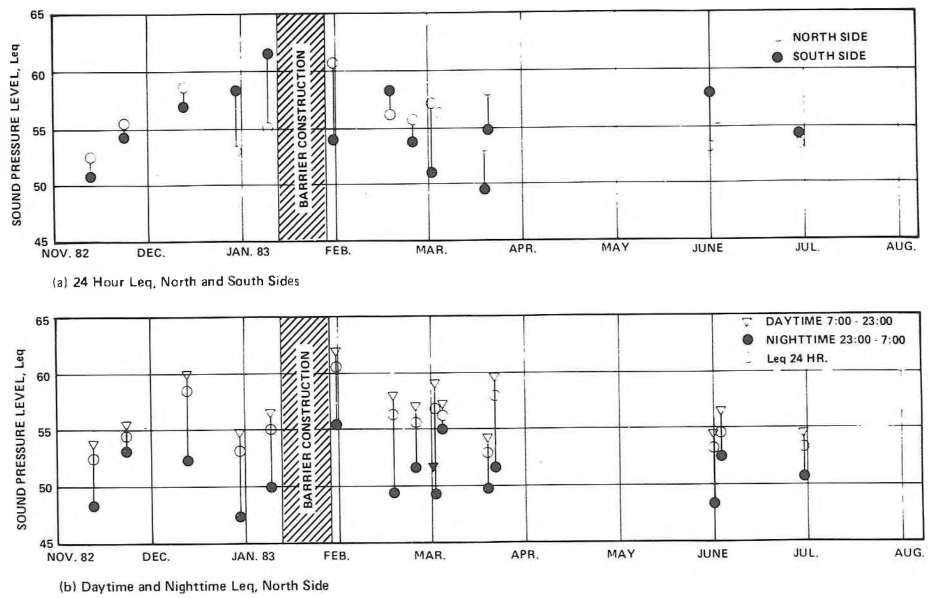

Figure 3/ Long-Term Changes in Sound Levels Along a Major Freeway Before and After Barrier Construction
Locations approximately 350 m from centerline.

The influence of weather-related variables (such as wind velocity and temperature which were also monitored) on the measured sound levels was also analysed, but it was difficult to quantify due to the transient nature of these variables. Thus, the observed variation in sound levels should be attributed to weather-related factors, the change in the ground cover during the seasons and to some extent, to the influence of community noise sources which could not be eliminated. The barrier erection may have also contributed to the variation in the measured sound levels but its influence was overshadowed by the aforementioned factors. It should be noted that the distance between the barrier and the measurement locations was more than 300 m.

7.3/ Pavement Surface Type

The contribution of tire-pavement interaction noise increases with vehicle speed and often dominates traffic noise in most highway situations where the average operating speed of traffic flow approaches or exceeds 80 km/h. The tire-pavement interaction noise generating mechanisms is rather complex and depends mainly on pavement surface characteristics, tire type, number of tires, vehicle speed and vehicle weight. Nevertheless, the relative noise generation potential of typical pavement surfaces has been established and is summarized in Table 3.

Table 3/ Relative Change in Overall Sound Levels Due to Pavement Texture, dBA*

Pavement Surface Type	dBA
ASHPALT CONCRETE PAVEMENTS	
Typical pavement (HL-1)	0
Open-graded friction course	-2
Surface treatment	+5
PORTLAND CONCRETE PAVEMENTS	
Used pavement	-1
New, wire-brushed finish	+5
New, plastic-grooved finish	+7

* For traffic flow containing about 10% of trucks with an average operating speed about 100 km/h. Pavements in good structural condition. Distance about 30 m from the centre-line. Results may vary by several decibels depending on actual pavement texture.

Data presented in Table 3 indicate that typical highway traffic travelling on an open-graded asphalt concrete pavement may be, on the average, about 9 dBA quieter than the same traffic travelling on a new plastic-grooved Portland cement concrete pavement. To reduce prediction errors, the influence of the pavement surface type on traffic noise generation should be explicitly included in highway noise predictions, preferably by modifying vehicular noise emission levels.

8/ SUMMARY AND CONCLUSIONS

1/ The prediction accuracy of the four highway noise prediction models evaluated in this study (FHWA, CMHC, RDG and ONTARIO) was relatively similar with the exception of the RDG model which was found deficient for non-freeway situations.

2/ Since the differences in prediction accuracies between the models are marginal, the model selection should be based on its analytical properties, flexibility and whether or not the model development will continue. On this basis, the FHWA method has been selected for the use of the Ontario Ministry of Transportation and Communications.

3/ The average prediction error which can be expected from the currently used highway traffic noise prediction methods employing only basic, customary variables is about 2 dBA in terms of standard deviation of differences between the predicted and actual sound levels.

4/ The prediction accuracy of the existing models can be improved by using vehicle emission levels reflecting actual vehicle population, by better characteriza- of the noise generation potential of different pavement surfaces and by inclusion of additional unconventional variables related to atmospheric propagation of sound over ground.

5/ Additional research is required to determine which parts of highway noise prediction methodology contribute most to the overall prediction error and thus are in greatest need of improvement.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Barry, T.M. and Reagan, J.A., "FHWA Highway Traffic Noise Prediction Model," U.S. Federal Highway Administration, Report. FHWA-RD-77-108, December 1978.

[2] Canada Mortgage and Housing Corporation, "Road and Rail Noise: Effects on Housing," Report NHA 5156, 1981.

[3] Kugler, B.A., Commins, D.E., and Galloway, W.J., Highway Noise -- A Design Guide for Prediction and Control, National Cooperative Highway Research Program Report 174, Transportation Research Board, Washington, D.C. 1976.

[4] Hajek, J.J., "L_{eq} Traffic Noise Prediction Method," Transportation Research Record No. 648, Transportation Research Board, Washington, D.C., USA, 1977, pp. 48-53

[5] "Sound Procedures for Measuring Highway Noise: Final Report", FHWA-DP-45-IR, Federal Highway Administration, Washington, D.C., August 1981.

[6] Bowlby et al, ed., "Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: Users Manual," U.S. Federal highway Administration, Report FHWA-DP-58-1, Arlington, VA. 22201, April 1982.

[7] Gordon, C.G. et al, Highway Noise, A Design Guide for Highway Engineers, NCHRP Report 117, Transportation Research Board, Washington, D.C., U.S.A., 1971, pp. 3-18.

[8] Agent, R.K., and Zegeer, C.V., "Evaluation of the Traffic Noise Prediction Procedure," Kentucky Department of Transportation, RR No. 379, Kentucky 40601, November 1973.

[9] Hajek, J.J., "Ontario Highway Noise Prediction Method," Transportation Research Circular No. 175, Transportation Research Board, Washington, D.C., U.S.A., January 1976, pp. 59-69

[10] Bradley J.S., "The Prediction of Urban Traffic Noise Levels Close to the Road," Research Report SV-75-3, Faculty of Engineering Science, The University of Western Ontario, London, Canada, November 1975, pp. 2-18.

[11] Anderson, G.S., et al, "Guidelines and Instruction Manual for the Assessment and Control of Surface Transportation Noise," Alberta Transportation, Edmonton, Alta, 1977.

[12] Jones, H.W., and Vermeulen, P.J., "The Assessment and Prediction of Traffic Noise," Inter-Noise 78 Proceedings, May 1978, pp. 801-808.

[13] Cohn, L.F., "Analysis of Approved and Recently Developed Prediction Methods," Transportation Research Circular No. 175, Transportation Research Board, Washington, D.C., U.S.A., January 1976, pp. 73-76.

[14] Halliwell, R.E., and Quirt, J.D., "Prediction Versus Reality: A Preliminary Evaluation of the NRC Traffic Noise Model", Noise Control Engineering, Vol. 13, No. 2, September-October 1979, p. 76-82.

[15] Hendriks, R.W., and Hatano, M., "Evaluation of Noise Barriers," California Department of Transportation, 5900 Folson Blvd., Sacramento, CA 95819, 1981.

[16] Transportation Systems Centre (TSC), "Manual for Highway Noise Prediction," Report DOT-TSC-FHWA-72-1 and 2, TSC, Cambridge, Mass, 1972.
[17] Plotkin, K.J., "A Model for the Prediction of Highway Noise and Assessment of Strategies for its Abatement Through Vehicle Noise Control," Wyle Research Report WR 74-5, Wyle Laboratories, Silver Spring, Maryland, U.S.A. September 1974.
[18] Hajek, J.J., "Noise Barrier Attenuation -- Highway 401 North Side East of Avenue Road, Toronto," Report 80-AE-03, Research and Development Branch, Ontario Ministry of Transportation and Communications, May 1980.
[19] Romano, F.M., "Prediction Modeling for the Assessment and Abatement of Highway Traffic Noise," Public Roads, Vol. 46, No. 3, pp. 85-91, January 1983.
[20] Slutsky, S., et al., "Stop-Go Urban Intersection Noise," Paper Presented at the 62nd Annual Meeting of TRB, Washington, D.C., January 1983.
[21] Harris, R.A., "Determination of the Reference Energy Mean Emission Level in Georgia," Georgia Department of Transportation Atlanta, Georgia 30336, August 1983.
[22] Olson, N. "Survey of Motor Vehicle Noise," The Journal of the Acoustical Society of America, Volume 52, No. 5, November 1972, pp. 1291-1306.
[23] Embleton, T.F.W., "Sound Progagation Outdoors -- Improved Prediction Schemes for the 80's," Proceedings, Inter-Noise 80, Miami, 1980, pp. 17-30.

IMPROVING SOUND-ABSORPTION PROPERTIES OF POROUS CONCRETE MATERIALS

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ABSTRACT

Different methods of improving sound-absorptive properties of porous concrete-based materials were investigated including:

a/ changing the material composition and thickness,

b/ incorporating resonator cavities in the form of resonator tubes or Helmholtz resonators, and

c/ sealing one face of homogeneous materials.

The investigation encompasses both analytical analyses and laboratory measurements using both the impedance tube and the reverberation room measurement methods. The results indicate that one of the most promising methods to improve sound-absorption quality of porous concrete-based material is sealing one face of the material.

SOMMARIE

On a étudié différentes méthodes pour améliorer les propriétés d'absorption acoustique de matériaux à base de béton poreux, dont:

a/ la modification de la composition et de l'épaisseur du matériau,

b/ l'incorporation de cavités résonnantes en forme de tube de résonnance ou de tube de Helmholtz, et

c/ le scellement d'une des faces des matériaux homogènes.

L'étude comprend des analyses analytiques et des mesures en laboratoire a l'aide des méthodes de tubes d'impédance et de mesures en chambre de réverbération Les résultats indiquent que l'une des méthodes les plus prometteuses pour améliorer les qualités d'absorption accoustique des matériaux à bàse de béton poreaux est de sceller une des faces du matériau.

1/ INTRODUCTION

There is an increasing need for sound-absorptive materials suitable for use as a highway noise barrier. The use of sound-absorptive materials can improve the performance of parallel highway noise barriers [1] and, in the case of single barriers, it can substantially reduce the amount of sound reflected by the barrier to the opposite side of the highway. Presently, all sound-absorptive barriers, that is, barriers which absorb more sound energy than they reflect, or partially sound-absorptive barriers built in Ontario, have utilized Portland cement-based materials. This may be attributed to the harshness of the highway environment and to the cost considerations.

The objective of this study was to evaluate and improve sound-absorptive properties of the Portland cement-based materials which are commercially available. Two generic types of these materials were investigated:

a) A two-layer system consisting of an absorptive layer, formed by wood fibres bonded together by Portland Cement, and a high-density concrete layer. The material selected for the study was Durisol-- produced by Durisol Materials Ltd. Durisol is a light-weight building material made of chemically mineralized and neutralized softwood shavings bonded together under pressure with Portland cement.

2) A single layer of homogeneous porous concrete using mineral aggregates bonded with Portland cement. The material selected for this study was obtained from Evercrete Ltd. This material contains sand and limestone screening aggregates and has the porosity of about 20%.

2/ SOUND ABSORPTION MEASUREMENTS

The sound-absorption measurements were performed using two methods, the impedance tube (IT) method and the reverberation room (RR) method as specified in References 2 and 3, respectively. The IT measurements were done at the Ontario Ministy of Transportation and Communications Research Laboratory using standard instrumentation manufactured by Bruel and Kjaer. The sample diameter was approximately 100 mm and the small gap between the sample and the impedance tube was sealed with a thin ring of plasticine. The RR measurements were performed at the Division of Building Research, NRC, Ottawa, and at the Domtar Research Centre, Senneville, Quebec.

All measurements should have been, preferably, performed at one facility using only the RR method since the use of different testing facilities can contribute to measurement errors [4] and, more importantly, the RR method is the most appropriate testing method for hard materials, such as those used in this study, which may exhibit a resonant sound-absorption [5]. The RR measurements at the two external facilities were necessitated by the availability of these facilities. The impedance tube measurements were used because of the considerable number of samples tested. The costs of producing and testing dozens of large samples required for the RR method would be prohibitive (the minimum recommended surface area for the RR method is about 4.5 m^2). Also, given the nature of the materials tested, it would be difficult to produce large samples with uniform properties, such as porosity or surface roughness.

3/ COMPARISON OF TESTING PROCEDURES

3.1/ Two-Layer Panels

The two-layer system consists of 7.5 cm thick Durisol material bonded to high density reinforced Portland cement concrete backing, approximately 1.9 cm thick. The sound-absorption coefficients of the 2-layer system measured by the RR and IT methods are compared jointly in Figure 1 even though the coefficients obtained by the IT method are normal incidence sound-absorption coefficients and the coefficients obtained by the RR method are random incidence absorption coefficients. The results of the RR measurements were obtained with the sample panels laying on the floor of the reverberation room and also standing in an upright position.

According to Figure 1, the two sample positions tested by the reverberation room method, as well as the impedance tube method, produced similar results which indicate that the sound-absorption of the two-layer panels occurs both in porous and resonant ways. The position of the panels in the RR is not critical. The IT measurements realistically resemble those obtained in the reverberation room allowing for the difference that occurs when the sound is only normally incident.

3.2/ One-Layer Homogeneous Panels

The results of sound-absorption measurements of homogeneous porous concrete panels, obtained by the two mesurement methods, are compared in Figure 2. The panels are self-supporting (without a rigid backing) and the presence of resonant absorption is evident only if the rigid backing is artificially created by the floor of the RR (when the panels are laying on it) or by the IT holder when the materials is measured in the tube. Thus, the proper testing procedure for this material is to have it in standing position in the RR. However, as indicated before, the IT method was also used for this material in order to evaluate relative performance of different material modifications with the intention to test the most promising ones later in the reverberation room.

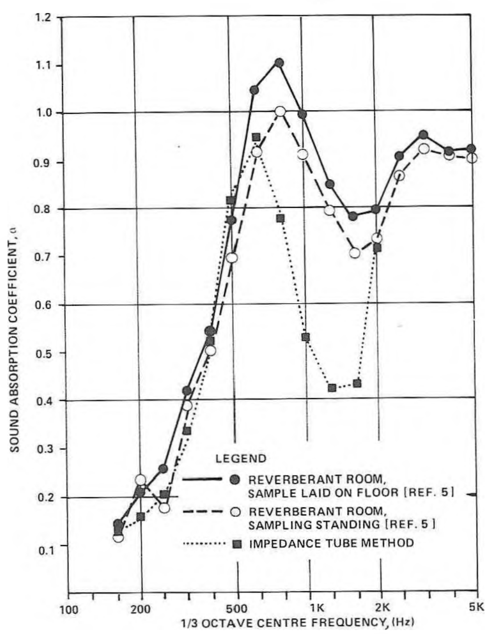

Figure 1/ Absorption Coefficient of Two-Layer Panels (Durisol) Measured by Different Testing Methods

Thickness of Durisol layer 7.5 cm, thickness of concrete backing 1.9 cm

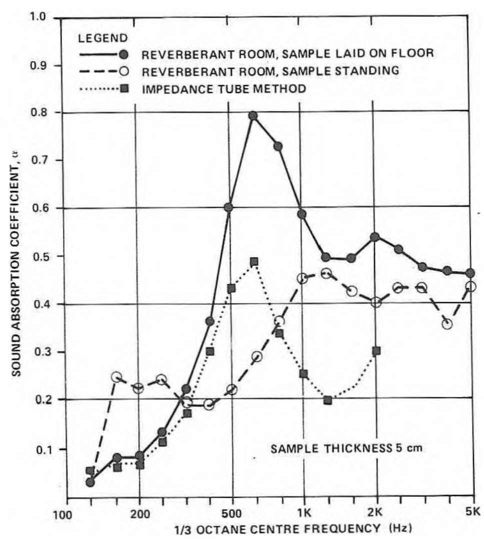

Figure 2/ Absorption Coefficient of One-Layer Porous Concrete Material (Evercrete) Obtained by Different Testing Methods

4/ METHODS FOR IMPROVING SOUND-ABSORPTION

The following methods for improving sound-absorption properties of the Portland cement concrete-based materials were investigated.

1/ changes in thickness of the sound-absorbing layer of the two-layer panels and in the mix composition of the single-layer panels;

2/ Use of resonator cavities - resonator tubes and Helmholtz resonators;

3/ Application of rigid backing to homogeneous single-layer panels.

Whenever possible, both analytical and experimental approaches were used. A brief description of the results achieved by these methods and their limitations is given below.

4.1/ Changes in Thickness and Material Composition

Since the presence of the sound-absorbing layer in the 2-layered panels is not required for structural support, the thickness of the layer can be changed. By varying the thickness of the absorptive layer, it is possible to influence both the amount of sound-absorption and the position of the resonance frequency (Figure 3). The relationship between the thickness of the absorptive layer and its overall sound-absorption, expressed in terms of A-weighted sound-absorption coefficient α_A, is shown in Figure 4. The coeffecient α_A, when multiplied by 100, gives the percentage of the A-weighted energy equivalent sound level which would be absorbed by the material assuming a typical highway traffic noise spectrum [6]. Thus, α_A provides a single-number index for an easy and accurate comparison of the sound-absorption effectiveness of the highway noise barrier materials.

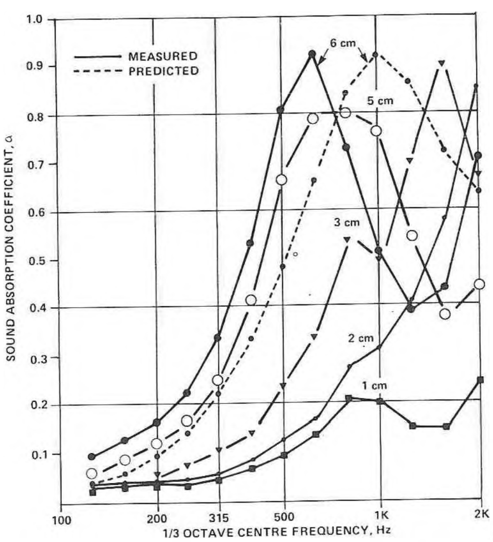

Figure 3/ Absorption Coefficient of Two-Layer Panels (Durisol) Measured by Impedance Tube Method

Complete panel with concrete backing. Thickness of Durisol layer as indicated. Values assumed for calculations : see Figure 4.

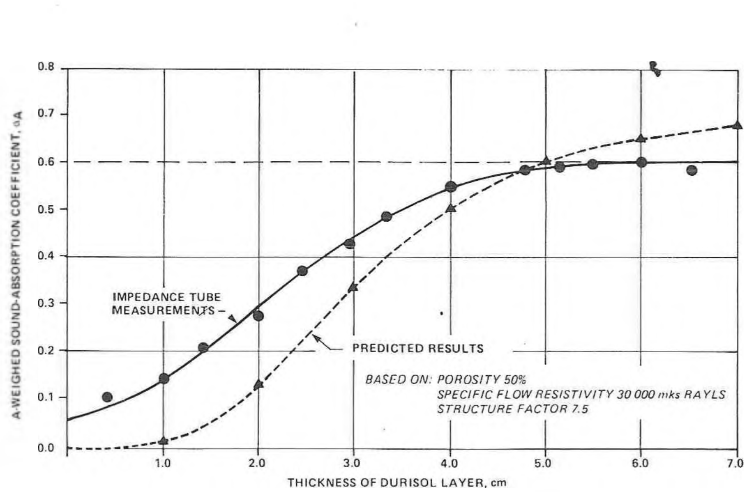

Figure 4/ Influence of Thickness of Durisol Layer on Sound-Absorption Coefficient, α_A

According to Figure 4, after the thickness of the absorptive layer reaches about 4.5 cm, any additional increase in its thickness results in only marginal improvement of α_A. Also shown in Figures 3 and 4 are calculated sound-absorption coefficients for specific assumptions of flow resistivity, porosity and structure factor of the Durisol material.

Using pressure and velocity equations for a sound wave travelling through a medium and appropriate boundary conditions, the absorption characteristics of the medium can be determined. Considering three media backed by a rigid wall (Figure 5), the following ratio of the reflected and incident pressures can be obtained:

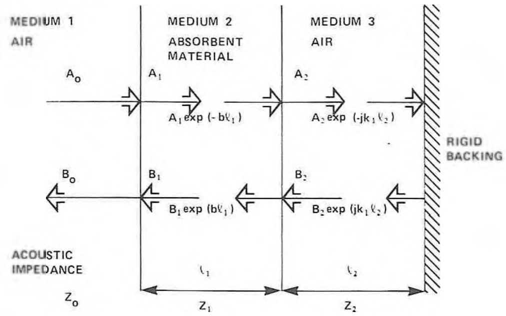

Figure 5/ Sound Wave Propagation

$$\frac{B_o}{A_o} = \frac{(B_1/A_1)Z_a - Z_b}{Z_a - (B_1/A_1)Z_b} \tag{1}$$

where: $$Z_a = Z_1 + Z_o \tag{2}$$

$$Z_b = Z_0 - Z_1 \tag{3}$$

$$\frac{B_1}{A_1} = \exp(-2b\ell_1) \; \frac{\exp(2jk_1\ell_2)(Z_2 - Z_1) + (Z_2 + Z_1)}{\exp(2jk_1\ell_2)(Z_2 + Z_1) + (Z_2 - Z_1)} \tag{4}$$

k_1 = wave number (angular frequency/speed of sound)
b = propagation constant [7] and other terms as defined in Figure 5.

The absorption coefficent is defined as

$$\alpha = 1 - \left| \frac{B_o}{A_o} \right|^2 \tag{5}$$

The similarity between the Equations 1 to 4 and Equation 1 in Reference 7 is recognized. However, the Equation 1 in Reference 7 contains several typographical errors.

The analytical approach based on the fundamental material properties, while promising (in view of the apparent agreement between the measured and calculated values given in Figures 3 and 4) could not be effectively pursued because of the unavailability of equipment for airflow resistance measurements [8] in Canada.

To improve sound-aborption properties of homogeneous concrete materials, a separate study was made which attempted to relate material characteristics, such as specific gravity and porosity, with sound-absorption. Data for the 10 samples included in the study are summarized in Table 1. The results were rather disappointing in that no significant correlation was obtained between the porosity and sound-absorption coefficent α_A even though some was expected. However, a statistically significant correlation was obtained between surface roughness, measured on a subjective scale, and absorption (Figure 6). The subjective scale was 1 to 10, where 1 was a smooth surface without visible openings or pores and 10 was a rough surface with about 30% of openings. This leads to suggest that the way in which the pores are connected to the surface is more important than the amount of pores i.e., porosity. Additional research is required to evaluate the effect of different aggregates (shape and size) and other factors, such as strength, which were not included in this study.

Table 1/ Properties of Porous Portland Cement Concrete Samples

Sample No.	Dry Density g/cm³ [1]	Water Absorption After Boiling, % [1]	Porosity, % of Space	Surface Roughness [2]	A-Weighted Sound-Absorption Coefficient, α_A [3]
1	1.96	15.38	30.1	2	0.17
2	2.02	13.74	27.8	3	0.20
3	2.08	12.30	25.6	4.5	0.21
4	2.01	13.79	27.8	3	0.23
5	2.01	14.19	28.5	4	0.28
6	2.07	12.34	25.6	6	0.28
7	2.03	13.38	27.2	5	0.29
8	2.14	10.92	23.3	7	0.30
9	2.01	13.82	27.8	6	0.31
10	2.15	10.37	22.3	7	0.32

[1] Based on ASTM C 642

[2] Based on a subjective scale 1 to 10.

[3] A-weighted sound-absorption coefficient based on impedance tube measurements.

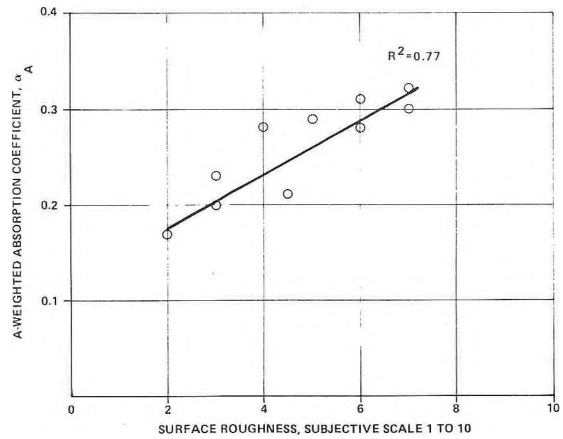

Figure 6/ Relationship Between Surface Roughness and α_A, Porous Concrete

4.2/ Use of Resonator Cavities

4.2.1/ Resonator Tubes

Sound-absorption of resonator tubes occurs primarily due the tube resonance when the sound wave leaving the tube cancels the incoming wave. For resonance to occur, the tube length (disregarding the end correction factor) must be an odd multiple of $\lambda/4$ where λ is the wavelength. The wave amplitude is also attenuated by the viscous friction between the wall of the tube and the air in the tube. However, this attenuation is considered negligible for tubes with radius greater than about 0.2 cm and length shorter than 6 cm [9].

As an example of many resonator tube arrangements evaluated, Figure 7 shows that a significant improvement in the sound-absorption of homogeneous layer of porous concrete can be achieved by creating holes acting as resonator tubes. The improvement is highest at the resonance frequency calculated at 1888 Hz. The calculation was based only on the resonant absorption [9]. The measured and calculated values agree quite well for frequencies near the resonance. For other frequencies, the characteristics of the material itself predominate and the increase in absorption may be attributed to the increase in the total effective area of the sample.

While the sound-absorption of porous concrete materials can be significantly improved by creating resonator tubes, the field application of the resonator tubes requires careful consideration of their impact on durability, strength and sound transmission of the weakened panel. Also, considering the predominant highway traffic noise frequency of about 550 Hz, the length of tubes to achieve resonance (and consequently the panel thickness) is relatively large, about 15 cm.

4.2.2/ Helmholtz Resonators

Unlike the tube resonators which absorb sound predominantly by radiation cancellation, Helmholtz resonators absorb sound also by frictional absorption due to the movement of air mass in the neck (aperture) of the resonator. Results obtained from two Helmholtz-type slot resonators incorporated into a layer of porous con-

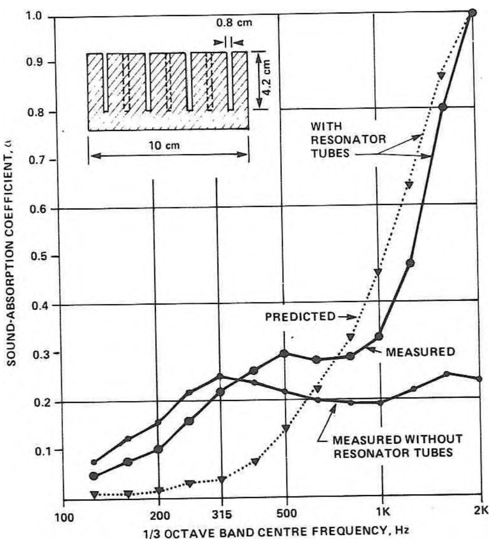

Figure 7/ Sound-Absorption Coefficient for Porous Concrete with 0.4 cm Radius Tube Resonators

Length of resonator tubes 4.2 cm, sample thickness 5.5 cm, 19 resonators in the sample (diameter=10 cm), measured by impedance tube method.

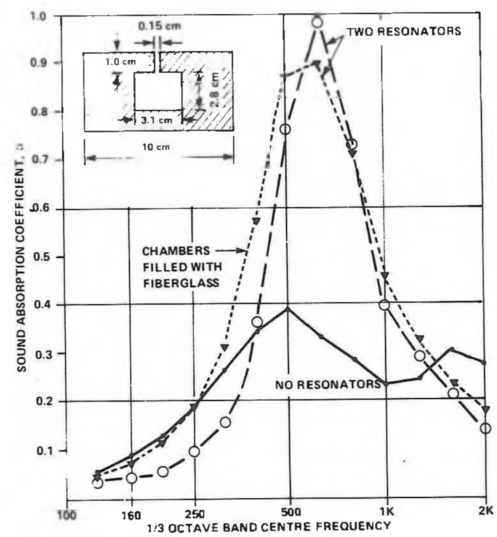

Figure 8/ Absorption Coefficient of Porous Concrete with Helmholtz Slot Resonators

Two slot resonators in a 5 cm radius sample. Calculated resonance frequency 630 Hz. Measured by impedance tube method.

crete material are shown in Figure 8. The advantage of this type of resonator is that it can be incorporated into a relatively thin panel and designed so that its resonance absorption coincides with the predominant component of the highway traffic noise frequency spectrum. Figure 8 also shows that the sharp resonant absorption peak may be somewhat blunted and spread out by filling the resonator chamber with fibreglass. As with the resonator tubes, use of this system for highway barriers would be conditional on the strength and durability characteristics of the weakened panels.

4.2.3/ Application of Rigid Backing

As discussed in Section 3.2 and shown in Figure 2, the addition of an apparent rigid backing, created by the reverberation room floor, to a porous homogeneous material induces resonant absorption. In order to verify this phenomenon and to utilize it in a practical way, a 3.8 m^2 sample of porous homogeneous concrete panel was tested by the reverberation room method in a standing position without any backing and with two types of backing -- a) 1.9 cm thick vinyl-coated gypsum wallboard attached to one side of the panels and b) a heavy coat of Betonite paint on one side of the panels (Betonite is an acrylic-silicone emulsion manufactured by Sternson Ltd.).

While the addition of the gypsum wallboard does not have any significant practical application for the outdoor noise barriers, it shows that it can substantially increase sound-absorption of the panels, particularly at the induced resonant frequency of 500 Hz (Figure 9). The sealing of one face of the panels (the face

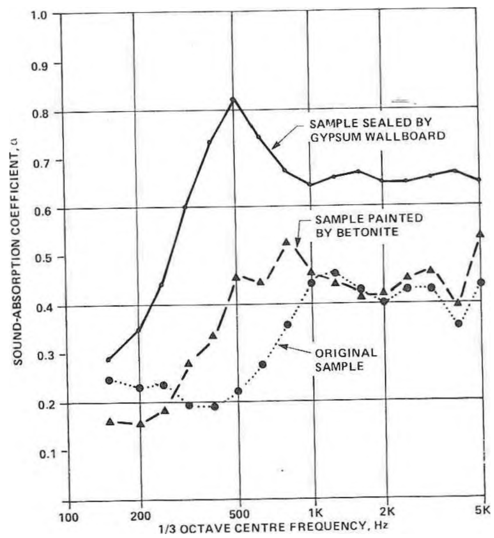

Figure 9/ Effect of Sealing Porous Concrete on Sound-Absorption

Results shown are for the sample face with highest overall absorption. Thickness of sample 5.0 cm. sample size 3.8 m² measured by reverberation room method.

away from the noise source) with a concrete paint or Portland cement concrete slurry may be inexpensive and a practical way to increase sound-absorption of the panels. Figure 9 shows that this method can approximately double the sound-absorption coefficient of the original sample at the frequency range of 400 to 630 Hz, which is the predominant frequency range of highway noise.

5/ CONCLUSIONS

1/ The thickness of the absorptive layer of the two-layer panels should be optimized for highway noise barrier application. For example, in the case of Durisol absorptive layer, the recommended thickness is about 5 cm.

2/ For the range of variables studied, no correlation was found between the porosity of porous concrete materials and their overall sound-absorption (of highway traffic noise).

3/ The use of resonator cavities significantly improves sound-absorption of porous concrete materials. However, their effect on durability, strength and sound transmission must also be considered.

4/ Sealing one face of the porous concrete panels, to achieve resonant absorption, appears to be the most promising method to improve their sound-absorption characteristics.

6/ ACKNOWLEDGEMENT

Thanks are due to Miss J. Neschokat and Mr E.J. McCarron who performed most of the analytical calculations and the impedance tube measurements. The help in providing material samples and product data by Mr. A.J. Stegmaier of Durisol Materials Ltd. and Mr M.E. Gabriel of Evercrete Ltd. is gratefully acknowledged. Thanks are also due to Dr A. Warnock of the National Research Council, Division of Building Research, Ottawa, and to Dr A. Kazakov of the Ontario MTC for many useful discussions.

REFERENCES

[1] Hajek, J.J., "The Effects of Parallel Highway Noise Barriers," Paper presented at the 1983 Transportation Research Board Meeting, Washington, D.C., January 1983.

[2] ANSI/ASTM C384-77, "Standard Test Method for Impedance and Absorption of Acoustical Materials by the Impedance Tube Method," American National Standards Institute, 1981.

[3] ANSI/ASTM C423-81, "Standard Test Method for Sound Absorption and Sound Absorption Coefficents by the Reverberation Room Method," American National Standards Institute, 1981.

[4] Halliwell, R.E., "Inter-Laboratory Variability of Sound Absorption Measurement," Journal of Acoust. Soc. Am, Vol. 3, No. 3, March 1983, pp. 880-886.

[5] Behar, A., "Limitations in the Measurement of the Sound Absorption Coefficient on Materials for Highway Noise Barriers," Acoustics and Noise Control in Canada, Vol. 8, No. 4, October 1980, pp. 20-28.

[6] Hajek, J.J., Jung, F.W., and Hunter, M.R., "Highway Noise Barrier Options: Q.E.W., East of Cawthra Road," Rept. AE-81-06, Research and Development Branch, Ontario Ministry of Transportation and Communications, Downsview, June 1981.

[7] Koketsu, M, and Koga, S., "Ceramic Sound Absorbers and Their Performance in Industrial Noise Control," Proceedings of Inter-Noise 80, pp. 641-644.

[8] ANSI/ASTM C-522-80, "Standard Test Method for Airflow Resistance of Acoustical Materials," American National Standards Institute, 1981.

[9] Beranek, L.L., Noise and Vibration Control, McGraw-Hill Book Co., New York, 1954.

SOUND FIELDS NEAR BUILDING FACADES

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ABSTRACT

Measurement of sound transmission through the exterior facade of a building requires a determination of the incident sound power. Direct measurement of the sound field near the relevant surface seems preferable to the use of a 'calibrated source' because of variability in outdoor propagation associated with ground reflections and atmospheric conditions. The interpretation of sound pressure level measurements in this environment is, however, complicated by the interference between incident sound waves and those reflected from building surfaces. This paper presents experimental results and a simple predictive model.

SOMMAIRE

La mesure de la transmission du son à travers l'enveloppe d'un bâtiment exige qu'on détermine la puissance acoustique incidente. La mesure directe du champ acoustique près de l'élément de surface considéré semble préférable à l'utilisation d'une 'source étalonnée' en raison de variations dans la propagation extérieure des ondes associées aux réflexions par le sol et aux conditions atmosphérique. L'interprétation des mesures du niveau de pression du son dans ces conditions est cependant rendue difficile en raison de l'interférence entre les ondes sonores incidentes et celles réfléchies par les surfaces de bâtiments. Cette communication présente les résultats expérimentaux et propose un modèle simplifié de prédiction.

This paper uses experimental data and a simple predictive model to examine systematic effects associated with reflections from a large flat facade and, subsequently, to investigate deviations from this ideal case. For an infinite reflecting plane, sound pressure level (SPL) at the surface should be 6 dB higher than that for the incident wave alone. At some distance from the surface, phase differences between direct and reflected waves range from 0 to 360 deg for a band of noise, and the average SPL approaches 3 dB above the incident wave SPL. The practical problem is to determine the cases where the limits apply or, if possible, to predict (and correct for) interference effects in intermediate cases.

The prediction model uses a plane wave approximation and assumes specular reflection, with no absorption or phase shift at the surface. Direct and reflected waves for a specific frequency and angle of incidence are treated as fully coherent. Contributions from different angles or frequencies are treated as independent, and are combined by adding weighted mean square pressures at the position of interest. Weighting was chosen to correspond to experimental conditions (e.g., 1/3 octave bands of white noise).

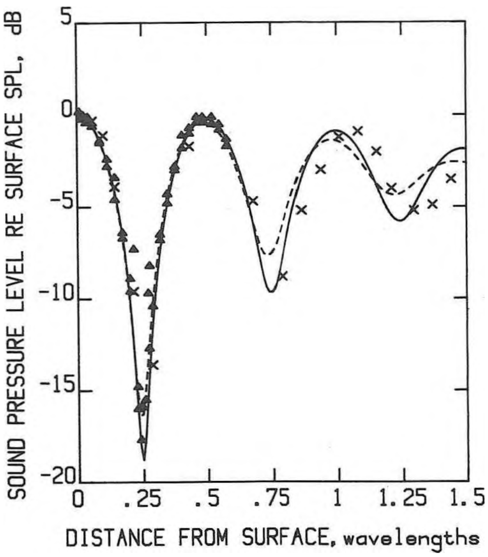

Figure 1

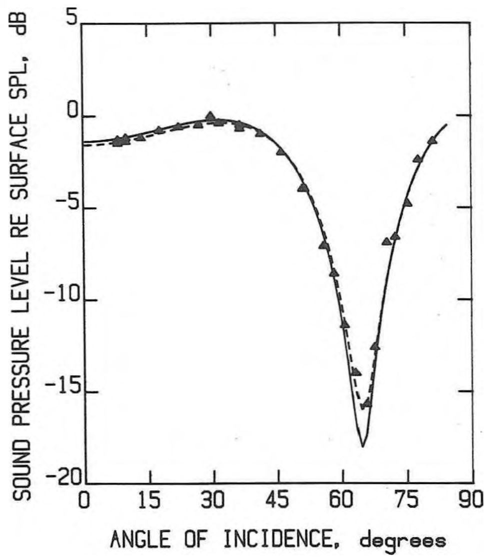

Figure 2

Figures 1 and 2 present 1/3 octave band data for SPL near a reflecting surface in an otherwise anechoic room. The reference microphone was mounted through the wall, its diaphragm flush with the surface. The source was a small loudspeaker 3 m from the reference microphone; white noise was used. Data for 2 kHz (Δ) and 5 kHz (X) bands were obtained using 6 mm condenser microphones with a conventional 1/3 octave measuring system by repeated careful repositioning of microphone or source. The solid line shows the calculated difference in SPL for a perfect 1/3 octave filter, and the dashed line the corresponding calculation for a filter with the minimum attenuation characteristic for an ANSI Class III filter; as expected, data fall between these limits. Figure 1 presents the data for perpendicular incidence, with the second microphone centred from 3 mm (touching surface) to 100 mm from the reflecting plane. The relation between incident sound power and measured SPL changes significantly in the region 0.1 - 1 wavelength from the surface, and quite small changes in microphone position can drastically alter the apparent spectral balance. Figure 2 illustrates the change in SPL at a fixed position (0.57 wavelength from surface) as angle of incidence changes. As the angle moves from 0 deg towards grazing incidence, path length difference between direct and reflected waves decreases; for a fixed microphone position the interference pattern shifts to higher frequencies.

A clear impression of the interference pattern can be obtained more easily by using frequency rather than source or microphone position as the independent variable. Figure 3 shows the difference between measured SPL at two microphones (○), obtained from rms-averaged spectral amplitude measurements with a two-channel FFT analyser. One microphone touched the surface; the other was 2 m from the exterior wall of a building. White noise came from a loudspeaker at an angle of incidence of 60 deg. The dashed line shows the calculated difference in SPL for the filter response associated with an individual frequency line of the FFT. Small discrepancies between experiment and calculation are believed to be due to physical complications (such as sound reflected from the ground surface) not accounted for in the calculation. The solid curve in Fig. 3 is the 1/3 octave response synthesized from the FFT; at high frequencies the results approach 3 dB below the surface SPL, but interference effects are appreciable for the lowest bands.

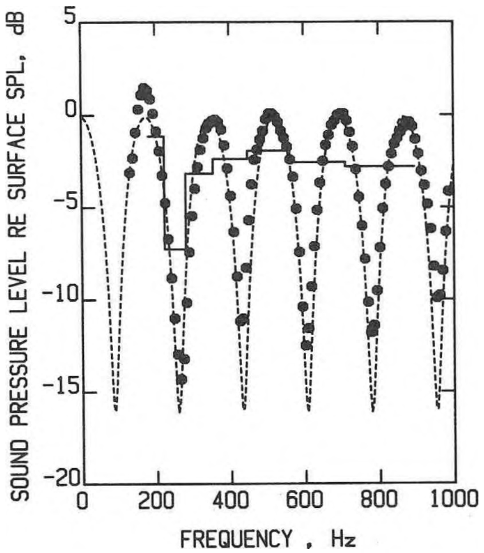

Figure 3

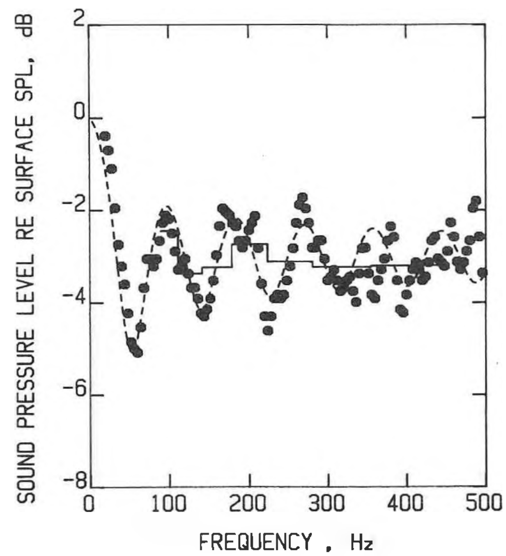

Figure 4

Reduced interference effects were observed with a line source. Figure 4 shows the predicted and measured SPL differences for microphones touching and 2 m from a large flat wall facing a major highway. The different interference patterns for different angles of incidence average out much of the variation in SPL versus frequency or distance from the surface. For the 2 m position the 1/3 octave SPL (solid curve) approaches surface SPL minus 3 dB for the bands above 100 Hz. Measuring closer to the surface would shift interference effects to higher frequencies.

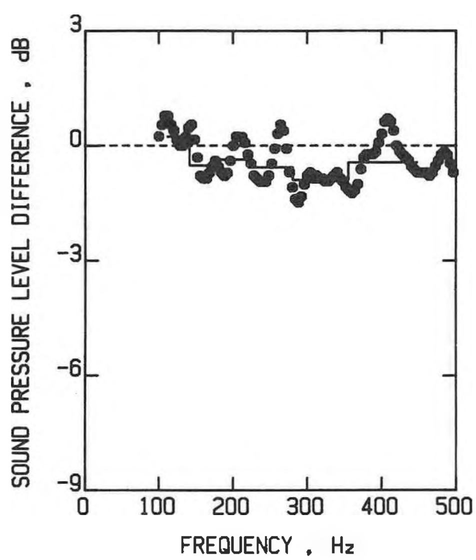

Figure 5

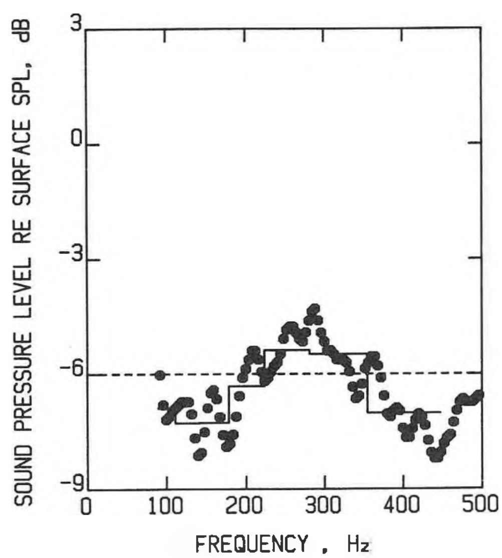

Figure 6

Standards for measuring facade sound transmission commonly assume that SPL at building surfaces is 6 dB higher than the SPL for the incident wave. Scattering, diffraction, and response of surface elements to the sound field could introduce deviations from this. Figures 5 and 6 show the difference in SPL measured with the FFT analyser for two microphones near a house wall (3 m high x 9 m wide). The data in Fig. 5 were obtained with microphones touching the wall at mid-point and 1 m from the corner. Similar results were obtained for other positions. Although systematic variation with frequency is evident, the 1/3 octave SPL (solid curve) is nearly uniform over the surface. The data in Fig. 6 were obtained with one microphone touching the wall surface (1 m from the corner) and the second microphone 2 m beyond the corner. Variations in SPL differences with frequency are consistent with expected diffraction fringes, but detailed calculations to confirm this mechanism are beyond the scope of this work. Variations in reflections from the rather uneven ground surface might also contribute. The average difference in SPL is close to 6 dB; for 1/3 octave bands, assumed pressure doubling at the wall is reasonably accurate.

At high frequencies the pressure doubling assumption fails if microphone diameter is comparable to wavelength. Figure 7 shows the difference, for a point source at normal incidence, between surface SPL (measured with flush-mounted microphone) and that measured with a 25 mm microphone touching the surface. The dashed line shows the calculation (as in Fig. 3) for expected SPL at the microphone mid-point; a sharp minimum is predicted near 7 kHz. The lumped response of the microphone to pressure distribution over the entire diaphragm limits the measured minimum; diffraction and microphone response also affect the results above 6 kHz. Measurements with smaller microphones centred at the same location should approach the calculated result more closely. The preceding analysis is concerned with SPL adjacent to essentially flat surfaces, but actual doors and windows are seldom flush. Because these elements often dominate sound transmission, sound power reaching them is of particular interest. Figure 8 shows the measured difference between SPL at a door surface (recessed 150 mm) and the reference SPL at an adjoining flat surface. Microphone location on the door surface alters the observed maxima and minima, which are apparently due to interference of sound wave components parallel to the surface: the high impedance of the 40 mm solid wood door should ensure negligible panel response. These effects should average out for higher 1/3 octave bands, but as shown by the solid curve in Fig. 8, they may affect the lower bands appreciably.

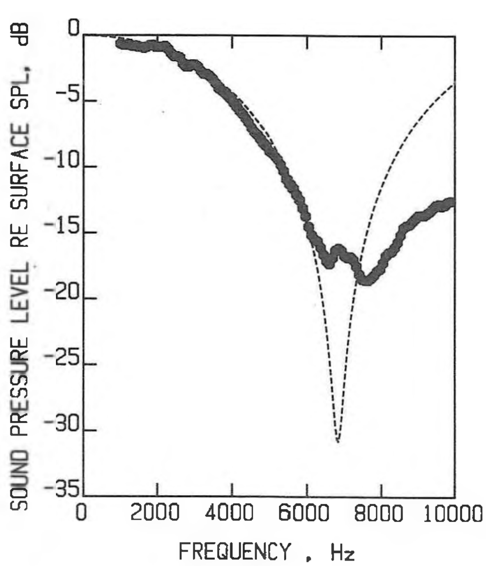

Figure 7

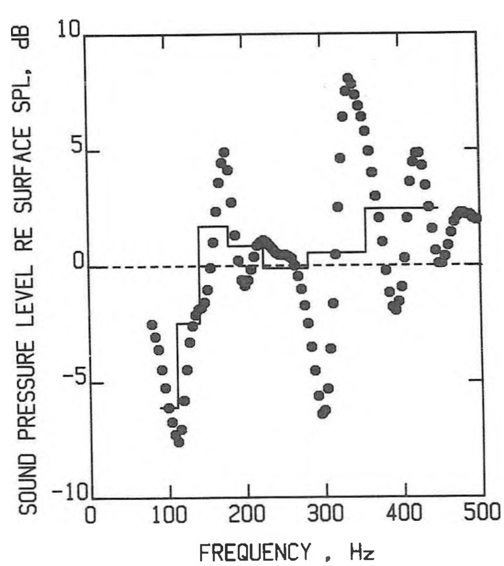

Figure 8

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