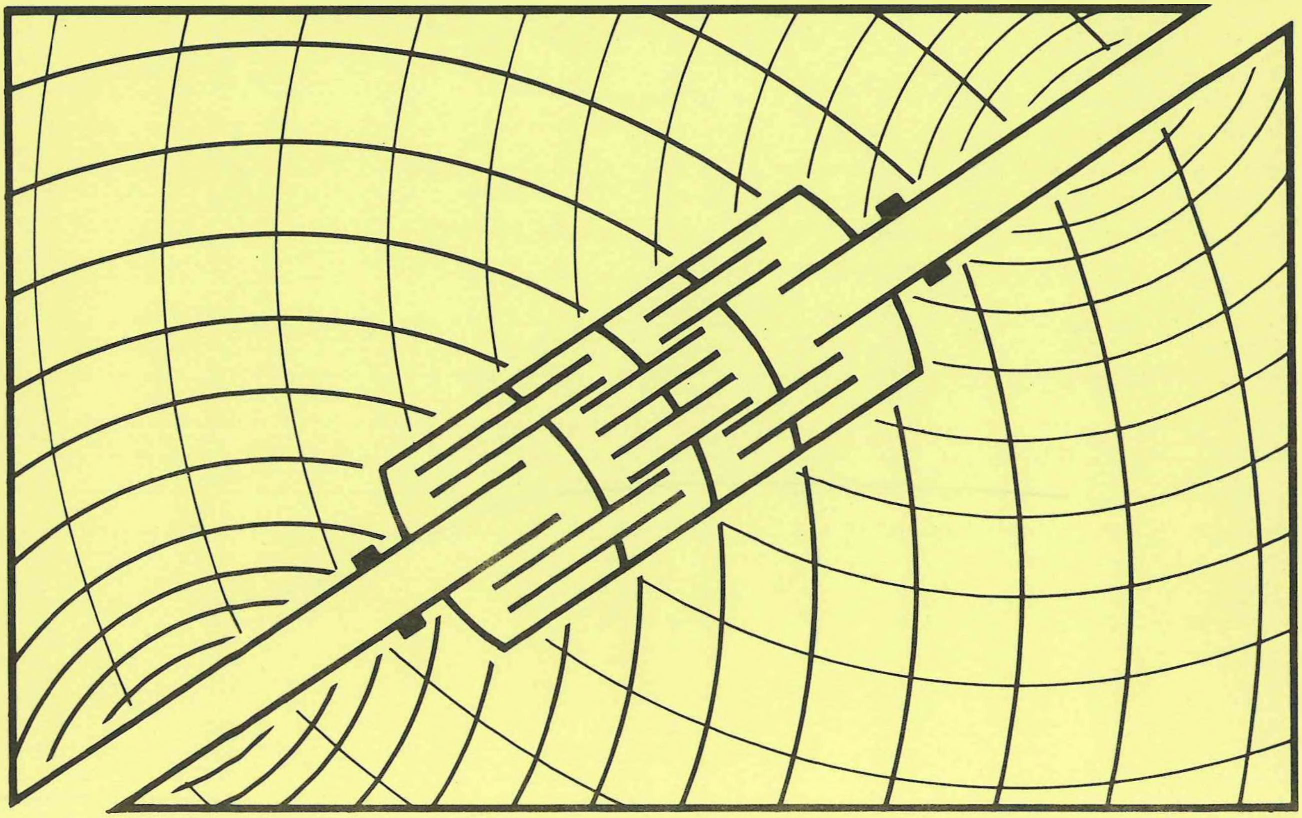
ISSN 0711-6659

canadian acoustics
acoustique canadienne

JANUARY, 1983 - Volume 11, Number 1 *JANVIER, 1983 - Volume 11, Numéro 1*



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EDITORIAL

The annual meeting and symposium of the CAA in Toronto, and the associated acoustical activities were a great success. Details of the various events are given in this volume. At the annual meeting of the CAA Cameron Sherry was elected the new president. We hope to present his picture and a short biography in the next issue. Other directors and officers of the CAA are listed on the inside back cover of CANADIAN ACOUSTICS.

A highlight of this year's acoustics week was a reception and tour of the Roy Thompson Hall in Toronto, the tour being conducted by Ted Shultz, the acoustical consultant for the Hall.

The next symposium and annual meeting of the CAA is scheduled for the week of October 17, 1983, in Vancouver, B.C.

We are pleased to announce that our Past President, Tom Northwood, recently received an Acoustical Society of America award, also described in this volume. Our thanks to Tom for his services to CAA and our congratulations.

EDITORIAL

Nous voudrions partager avec tous nos lecteurs, et surtout avec ceux qui n'ont pas eu l'occasion de se rendre à notre réunion annuelle à Toronto, le 18 au 22 octobre 1982, quelques nouvelles sur ce meeting.

Les activités ont commencé par trois séminaires intitulés: Vibrations, Contrôle du Bruit au lieu de Travail, et Contrôle du Bruit lié à l'Aménagement du Territoire. D'après le nombre de participants, ce séminaires ont été un succès. Concernant le Symposium, le programme a reflété à la fois la richesse et la diversité actuelles de l'acoustique au Canada - ceci malgré le nombre un peu décevant d'environ 100 participants pour une agglomération telle que Toronto. Trois sessions parallèles ont eu lieu, et le nombre total de présentations a dépassé 55. Une des nouvelles importantes de la Réunion Annuelle est que nous avons maintenant un nouveau président de l'ACA, c'est Cameron Sherry. Nous présenterons son portrait dans un des prochains numéros. A part çela, il a été décidé de tenir notre prochaine réunion en 1983 à Vancouver, B.C.

En plus de nos activités habituelles, une visite et une réception ont eu lieu le 20 octobre dans la nouvelle salle de concert Roy Thompson au centre-ville de Toronto. Les participants avaient la bonne occasion d'avoir le meilleur guide possible pour présenter l'acoustique de cette salle, à savoir Ted Shultz. Ses commentaires et ses explications, et surtout son sens d'humour, ont marqués cette soirée inoubliable.

POSITION WANTED

M. Atwal is looking for a position in noise control, sound transmission, or a related area. He is willing to locate anywhere in Canada or the U.S. He has a B.Sc. in Physics, and has spent the last 4 years conducting research into transmission of sound through porous materials at Leicester Polytechnic where he received his M.Phil. and Ph.D.

For further information please contact Mr. Atwal directly:

M. Atwal
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Erith, Kent, U.K.
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CAA TORONTO CHAPTER

The first meeting of the 1982/83 season was held at the Mount Sinai Hospital Auditorium on September 13,

1982. The subject of the meeting was "Music and Acoustics". The meeting was chaired by the co-convenors, Mr. Alberto Behar and Mr. Winston Sydenborgh. Three guest speakers provided excellent topics.

The first speaker was Mr. Len A. Blizzard from the Department of Electronics Engineering, George Brown College. A comparison demonstration of recorded music was played using various instruments with synthesizer. The music sounded very realistic and a brief explanation of the equipment required was presented.

Mr. John LeBerg, Director of Operations of the Canadian Opera Company spoke to us on the formation and set-up of opera. Cast, frequency of rehearsals, and costs as well as funding were discussed. By coincidence, this was also the gala opening night of the Roy Thompson Hall and Mr. LeBerg had just come from this opening. On the question of future use of the Hall by the opera company, the answer was "no", since the Hall is not compatible with opera performances and also, rehearsal times would interfere with present bookings.

Mr. Leslie Doelle's topic "Music and Hall Acoustics" was a slide show of many famous halls in Europe and North America, with their good and bad points as well as many historical anecdotes. Many questions were asked of each of the speakers and lively discussions followed.

The meeting closed with a word of thanks to the speakers. The projectionist and the coffee was provided by Mount Sinai Hospital. Donuts were courtesy of Bruel and Kjaer.

Future meetings: (1) Monday, January 10, 1983, 7:00 p.m., Technical Visit to George Brown College, Sharon Abel and Len Blizzard, convenors; (2) Monday, April 11, 1983, 7:00 p.m., "Environmental Acoustics", Ontario Hydro Auditorium, 700 University Avenue, Toronto, Chris Krajewski, John Swallow, convenors.

For the Chapter
Steering Committee

W.V. Sydenborgh

ASTM E-33 TORONTO MEETING

The American Society for Testing and Materials (ASTM) Committee E-33 on Environmental Acoustics, met in Toronto, 25-27 October, 1982. For further information regarding the outcome of the meeting contact: Richard M. Guernsey, Cedar Knolls, New Jersey 07929, USA. Tel: (201) 539-6261.

ULTRASONICS INTERNATIONAL MOVES TO NOVA SCOTIA

In line with the policies of Ultrasonics International of alternating venues between the UK and overseas, it has now been arranged to hold the 14th meeting, UI 83, in Halifax, Nova Scotia. All previous arrangements to hold UI 83 at the University of Surrey, UK, are therefore postponed but it is intended that the next event will be held there in 1985. The dates contained in previous announcements have not been changed; UI 83 will still be held 12-14 July 1983, the week before the start of the Paris ICA. Canadian inquiries should be directed to Hugh Jones, Dept. of Physics, Dalhousie University, Halifax, Nova Scotia, B3H 3J5.

PROCEEDINGS OF MUSICAL PERCEPTION

The proceedings of the Queen's Symposium on Musical Perception held July 14-16, 1981 at Queen's University, Kingston, Ontario will be published in the 1982 (No. 3) issue of the Canadian University Music Review. Orders at $10.00 (Canadian) per copy may be placed with the Business Manager, Elaine Keillor, Department of Music, Carleton University, Ottawa, Ontario, K1S 5B6.

The papers are:

"Beginnings and endings in Western Art Music" by Jonathan Kramer, University of Cincinnati.

"Exploring sensitivity to structure in music" by Annabel Cohen, University of Toronto.

"Analyzing spectra that won't sit still" by A.S. Bregman, McGill University.

"Acoustical factors in subjective tests" by Floyd Toole, National Research Council of Canada.

"The musical control of sound color" by Wayne Slawson, University of Pittsburgh.

"Some perceptual aspects of timbre" by C.L. Searle, Massachusetts Institute of Technology.

"Factors of musical perception: three points of view" -- comments by Ireneus Zuk, David Keane and Lola Cuddy of Queen's University following a piano concert performed by Ireneus Zuk.

NEW RESEARCH CONTRACTS

To Ogmundson Marine Consultants, Chilliwack, B.C., $5,250, for "Hydro acoustic study of Sockeye salmon stock in Rivers Inlet." Awarded by the Dept. of Fisheries and Oceans.

To S.L. White, Vancouver, B.C., $4,686, for "Determination of fish size and species using echo location equipment in King Point area, Yukon." Awarded by the Dept. of Fisheries and Oceans.

To D.G.O. Martens, Electrical Engineering, University of Manitoba, Winnipeg, Manitoba, $30,000, for "Voice input/output study for videotex system." Awarded by the Dept. of Communications.

To S. Morissette, Faculty of Applied Science, Dept. of Electrical Engineering, University of Sherbrooke, Sherbrooke, Que., $35,489, for "Study of a new principle of instantaneous dynamic compression of speech signals as applied to mobile ratio."

To G.E. Beachell, Beaconsfield, Que., $1,875, to "Set up and run an underwater sound listening system for a study of white whales and ship traffic." Awarded by the Dept. of Fisheries and Oceans.

To Ontario Research Foundation, Mississauga, Ont., $281,998, for "Study of the detection of critical surface flaws in ceramics by surface acoustic waves." Awarded by the Dept. of National Defence.

To Dr. K.M. Wong, Dept. of Electrical Engineering, McMaster University, Hamilton, Ont., $45,097, for "Median filter data normalization of 2-dimensional acoustic data displays." Awarded by the Dept. of National Defence.

Dr. F.L. Hall, Dept. of Geography, Dr. S.M. Taylor, Dept. of Civil Engineering, McMaster University, Hamilton, Ont., $52,705, for "Development of a model from an existing data bank to predict the effects of environmental noise on residential communities." Awarded by the Ministry of Transport.

To Seakem Oceanography Limited, Sidney, B.C., $9,500, for "Development of a prototype inexpensive acoustic release." Awarded by the Dept. of Fisheries and Oceans.

To Nova Scotia Research Foundation Corporation, Dartmouth, N.S., $5,007, for "Nearshore seismic reflection survey near Pte. Sapin, New Brunswick." Awarded by the Dept. of Energy, Mines and Resources.

To Dr. G. West, Dept. of Physics, University of Toronto, $58,500, for "Continuation of further development and testing of the piezoelectric source - detector transducer system for borehole-to-borehole seismic logging over distances up to approximately one

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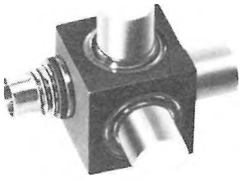

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kilometer." Awarded by the Dept. of Energy, Mines and Resources.

To Dr. S.G. Hutton, Dept. of Mechanical Engineering, University of British Columbia, Vancouver, B.C., for $32,526, for "Study of vibration sources affecting mine workers." Awarded by the Dept. of Energy, Mines and Resources.

To Supratec Incorporée, Trois-Rivieres, Que., $40,495, for "Ultrasonic holographic camera - phase II." Awarded by the National Research Council.

To Bolt, Berenak and Newman Incorporated, Cambridge, Mass., $76,366, for "Research ship radiated noise, evaluation and control." Awarded by the Dept. of National Defence.

To Ontario Research Foundation, Mississauga, Ont., $57,387, for "Development of a computer code for the prediction of failure of solid walls subjected to blast over-pressure." Awarded by the Dept. of National Defence.

To Netherlands Ship Model Basin, Wageningen, The Netherlands, $130,018, to "Conduct performance, cavitation, and noise tests for a new propeller design for the DDH 280 class of destroyers." Awarded by the Dept. of National Defence.

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CANADIAN ACOUSTICAL ASSOCIATION

"ACOUSTICS WEEK 1982"

The Canadian Acoustical Association (CAA) "Acoustics Week 1982" activities in Toronto opened with three two-day seminars on vibration, noise in the workplace, and noise control in land use planning. Fifty acoustical specialists, mainly from the Toronto area, presented the well-attended technical sessions and participated in the panel discussions.

During the week several meetings were held to discuss organization of the 12th International Congress of Acoustics to be held in Toronto in the summer of 1986. The CAA membership, at their annual general meeting, ratified the appointment of the 12th ICA Canada 1982 executive committee as follows: Edgar Shaw, President; Tony Embleton, Vice-President and Technical Program Committee Chairman; John Manuel, Secretary-General; and Aubrey Edwards, Congress Planning Committee, Toronto, Chairman. The CAA membership also expressed their support for Ultrasonics International '83 which will be held at Dalhousie University, Halifax, Nova Scotia on July 12-14, 1983.

"Acoustics Week" was highlighted by a tour of the newly opened Roy Thomson Hall in Toronto. This tour was conducted by Ted Schultz of BBN, the Acoustical Consultant for the Hall. Ted explained in detail many of the acoustical features of the Hall. The reception that followed was a pleasant introduction to the 21st Canadian Acoustical Association Annual Symposium which followed.

The Annual Symposium took the form of several parallel structured sessions on the following topics - hearing, architectural acoustics, environmental noise, instrumentation, ultrasonics, sound propagation, noise reduction, acoustic intensity and vibration. In all some 60 papers were presented.

Anita Lawrence, the President of the Australian Acoustical Society, was the after-dinner speaker at the CAA annual dinner in Toronto which marked the retirement of CAA President, Tom Northwood the founder of the original Canadian Committee on Acoustics in 1960.

J. Hemingway

CSA ACOUSTICS AND NOISE CONTROL COMMITTEE REPORT

The Canadian Standards Association Technical Committee Z107 on Acoustics and Noise Control held its annual meeting at the Westbury Hotel, Toronto on October 19, 1982. Some 25 members of the committee and about 3 guests attended.

During the year the work of the committee is advanced through activities and meetings of some ten subcommittees and task forces. Through their chairmen these groups report to the Executive Committee of Z107, which met for this purpose in January and July 1982. Progress during the year was made on almost all draft standards under consideration, in particular one notes that:

a) IEC 651 (1979) Sound Level Meters has been endorsed by Z107 for use in Canada - similar action is anticipated on ANSI S1.4 Sound Level Meters after this standard is issued next year, and a guideline is being prepared to indicate which standard is to be preferred in various measurement situations;

b) CSA Z107.53 - M1982 Procedure for Performing a Survey of Sound due to Industrial, Institutional or Commercial Activities has been issued and is available from CSA (178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3) at a price of $10;

c) draft standard CSA Z107.25 Procedure for the Measurement of the Exhaust Sound level of Stationary Motorcycles has been approved by Technical Committee Z107 and now requires approval of the Standards Steering Committee;

d) the Task Force on Occupational Noise has completed its report, in which it recommends "national guidelines on occupational noise and hearing conservation regulations" (to be prepared by some national regulatory body) and a "CSA standard on methods of conducting noise exposure surveys for the purpose of occupational noise exposure standards".

T. Embleton

1983 CAA SYMPOSIUM AND ANNUAL MEETING

The Vancouver delegation is pleased to invite all members of the Canadian Acoustical Association to participate in the 1983 Symposium and Annual Meeting.

When: Week of October 17, 1983 Where: Vancouver

Topics: All aspects of acoustics with emphasis on the following: Speech and Voice Synthesis and Analysis; Noise and Vibration; Architectural Acoustics; Underwater Acoustics; Transportation Noise; Psychoacoustics and Physiological Acoustics.

In addition to the symposium it is tentatively proposed to hold the following seminars: Vibration Measurement and Analysis for Machine Health Monitoring; Vibration Isolation and Seismic Restraints for Building Mechanical Equipment in Earthquake Zones; and Electro-acoustics for the Performing Arts.

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Minutes of the Annual General Meeting of the Canadian Acoustical Association Held at the Loew's Westbury Hotel, Toronto, on October 20, 1982

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1. The meeting was called to order by President T. D. Northwood at 2:00 p.m. on October 20, 1982.

2. The minutes of the previous annual meeting held in Edmonton on October 8, 1981 were read by the Executive Secretary, J. Manuel. On a motion by J. Hemingway, seconded by A. Edwards, the minutes were accepted as read.

3. The Treasurer, J. Nicolas, in presenting his report, noted that CAA financial affairs were in good shape. He noted that the main difference between the financial statements of last year and this year was that this year's statement is bilingual.

4. The Treasurer noted that the $2,000 cash advance to the Convenor of the 1981 Edmonton CAA meeting had been re-imbursed but had arrived too late to be included in the 1982 Financial Statement. He also noted that the proceeds of the 1982 CAA/MOE courses given in Toronto were also not included in his Financial Statement and would be reported separately. On a motion by H. Jones, seconded by C. Sherry, the Treasurer's report was accepted.

5. Since an Auditor's report was not available, T. Embleton moved and S. Abel seconded a motion that "C. W. Bradley be appointed Auditor for 1982 and that he examine the CAA financial records and report at the next annual meeting". Carried.

6. The Executive Secretary, J. Manuel, in dealing with correspondence received during the past year noted it was all of a routine nature. He noted that two students had written to request complimentary CAA membership which had been granted.

7. The Editor, D. Benwell, in presenting her report noted that the new Journal masthead "Canadian Acoustics/Acoustique Canadienne" had been well received. She felt that it had been quite a successful year even though there was a small loss of $1067.45 in the year's operations. The French content of the Journal continued to be steady. D. Benwell closed by saying that consideration was being given to adjusting the ad rates and that she planned to step down at the end of the current year. On a motion by L. Russell, seconded by T. Embleton, the report was accepted. Acclamation.

8. In presenting the report of the Nominating Committee, C.W.Bradley, noted that only one new position on the Executive had to be filled this year and he, therefore, proposed the following slate:

Executive:	President:	C. Sherry	(replacing T.D. Northwood)
	Exec. Secretary:	J. Manuel	(continuing)
	Treasurer:	J. Nicolas	(continuing)
	Editor:	D. Benwell	(continuing)
Directors:		D. Quirt	(replacing J. Piercy)
		R. Hétu	(replacing D. Whicker)

9. A nomination received in the meeting required that a secret ballot be held for the position of President. As a result of the ballot, C. Sherry was duly elected President of CAA. Acclamation.

10. The Chairman confirmed the results by congratulating the Executives and Directors on their election. Acclamation.

11. The 1982/83 CAA Directors are listed below.

R. Hétu - 4 year term (Quebec)
D. Quirt - 4 year term (Ontario)
L. Russell - 3 year term (Nova Scotia)
S. Abel - 3 year term (Ontario)
S. Eaton - 2 year term (British Columbia)
M. Osman - 2 year term (Ontario)
R. Cyr - 1 year term (Nova Scotia)
J. Hemingway - 1 year term (Ontario)

12. J. Hemingway moved, seconded by T. Kelsall, that "the CAA membership fee for 1983 remain at $15.00 for members and $0.00 for students. The subscription fee is $20.00".

13. On an amending motion, T. Embleton moved, seconded by D. Benwell, that "the annual student membership fee is $5.00". By a show of hands, the motion carried 18 to 10.

14. The original motion, as amended, that "the CAA 1983 fee for members is $15.00, and for students is $5.00 with subscriptions $20.00", was then carried unanimously.

15. The Chairman then broached the status of sustaining subscribers. It was confirmed that sustaining subscribers are entitled to all the privileges of membership except voting. Only individual CAA members, in good standing, are entitled to participate and vote at business meetings of the Association.

16. The Chairman announced that the 1982 Directors Award had been won by L. J. Leggat. He said that the award, the CAA Scroll, would be presented by L. T. Russell on behalf of the CAA Directors and membership at an appropriate ceremony in Halifax.
T. Embleton moved, seconded by J. Piercy, that "L. J. Leggat be congratulated on being the recipient of the 1982 Directors Award". Acclamation.

17. J. Manuel reported on the 1982 joint CAA/MOE training program in Toronto, previously authorized by the membership at the Edmonton 1981 meeting. He stated that the training courses were successfully presented and recommended that the arrangement continue for one more year. A motion by J. Manuel, seconded by J. Hemingway, that "A small group headed by J. Manuel is appointed to report at the next annual meeting on the policy CAA should adopt in this regard". Carried.

18. H. Jones then reported on the preparations for Ultrasonics International '83 in Halifax, NS. He said that a considerable turnout is expected from all parts of the world. While CAA is not sharing the financial responsibility, CAA is, however, co-sponsoring an application for an NSERC grant in Ottawa.

19. The Chairman noted that CAA had been invited to meet in Vancouver in 1983. It was also noted that although the invitation had been accepted, a Convenor had not been appointed for 1983. A motion by L. Russell, seconded by F. Hall, that "The CAA Executive shall appoint the 1983 Convenor" was proposed. In the discussion that followed it was suggested that because of the economy, Vancouver was perhaps not the most suitable site for the 1983 meeting. A meeting in central Canada was preferable. However, since a decision had been made in 1981 to hold the 1983 meeting in Vancouver, CAA was morally bound to proceed as agreed and not change course in mid-stream. The poor financial result of the 1981 Edmonton meeting was also discussed at length. It was stressed that future CAA meetings must be planned in a way to optimise the financial return, at least at the level achieved at earlier meetings.

20. It was agreed that, for future CAA meetings, the convening group should take total responsibility for the meeting and not use external professional help. In general, the CAA annual general meeting should be held within the two-day symposium period to ensure good attendance by the membership on both occasions.

21. In anticipation of the 1986 CAA meeting being held in Toronto concurrently with the 12 ICA Congress in July, 1986, it was suggested that the 1984 meeting be held in Quebec City/Montreal and the 1985 meeting in Ottawa. The motion (19) proposed earlier was then put to the vote and carried.

22. H. Jones then reported on recent meetings of International INCE. The report was accepted without further discussion.

23. The Chairman, under the agenda heading "Other business", then opened the discussion on the planning for the 12 ICA Congress and coordinated meetings being organized for 1986 in Canada. He noted that the two new CAA Directors elected today would be included in the CAA Congress Advisory Committee membership. He also stressed that the Toronto Local Committee is a creature of the 12 ICA Executive Committee and its continuing role would be defined by the 12 ICA Executive Committee.

24. A resolution moved by S. Abel, seconded by J. Piercy, that "the seven recommendations of the 12 ICA Planning Committee passed in their earlier meeting on October 20, 1982 in Toronto be adopted, specifically:

    (1) That an Executive Committee, responsible to the Board of Directors of the CAA, be formed to plan and carry out all tasks related to the Congress, including meeting arrangements, handling of technical papers, coordination of associated meetings, fund raising, publication of proceedings, and such other business as may arise;

    (2) That an Advisory Committee be formed to advise both the CAA and the Executive Committee on matters of long-term planning and policy;

    (3) That the initial memberships of the two Committees be as stated in the attached Appendix 1, and that they be authorized to add or replace members as deemed necessary for the business in hand;

(4) That the two Committees consult with each other from time to time as appropriate, and in any case during each annual meeting of the CAA;

(5) That the Executive Committee be authorized to delegate specific responsibilities as it sees fit. A written report to the Board of Directors of CAA shall be presented semi-annually by the Executive Committee;

(6) That a Congress bank account be opened and all cheques bear the signatures of persons authorized by the Executive Committee;

(7) That the Executive Committee shall have the authority to appoint or, for cause, remove from office any Committee Chairman. In the latter instance, a written report giving the reasons for the action taken shall be given to the Board of Directors of CAA".

Carried Unanimously.

25. The Chairman then called on selected ICA Committee Chairmen to present short reports, as follows:

- A. Warnock, Chairman, CAA Advisory Committee.
- E. Shaw, Chairman, 12 ICA Executive Committee.
- T. Embleton, Chairman, Technical Program Committee.
- J. Piercy, Coordinator, Associated Meetings.
- J. Manuel, Secretariat.
- A. Edwards, Chairman, Toronto Local Planning Committee.
- F. Hall, Chairman, Finance Committee.

26. Moved by C. Sherry, seconded by T. Brammer, that "Up to $10,000.00 in CAA funds be transferred to the Congress bank account, as required". Carried Unanimously.

27. Moved by J. Piercy, seconded by S. Abel, that "the 12 ICA Executive Committee delegates to the Secretary-General the administration of all Congress affairs at the National and International level". Carried Unanimously.

28. Moved by F. Hall, seconded by T. Embleton, that "the CAA approves funding the 12 ICA 1986 meeting by the institution of a voluntary contribution of $20.00 from CAA members for each of the next four years, or $75.00 for the first year". Carried Unanimously.

29. The Chairman then called on Anita Lawrence, President of the Australian Acoustical Society, to address the membership on the planning of the 10 ICA in Sydney in 1980. Her comments and advice were received with acclamation.

30. The Chairman then called on the Treasurer, J. Nicolas, to present his views on developing a competition leading to a CAA Scholarship Prize in Acoustics open to students in Canadian Universities. A motion by L. Russell, seconded by T. Embleton, that "the CAA Executive take appropriate action to institute a Scholarship Prize in Acoustics". Carried.

31. A motion by J. Manuel, seconded by C. W. Bradley, that "In recognition and appreciation of the services rendered during their respective terms of office, the CAA membership, Executives and Directors, thank the outgoing members for their support in furthering the interests of the Association, as follows:

T. D. Northwood - retiring President and
- new Chairman of the Nominating Committee
J. E. Piercy - retiring Director
D. Whicker - retiring Director"

32. There being no further business, the Chairman adjourned the meeting at 4:45 p.m.

J. Manuel
Executive Secretary

Note: Appendix I appears overleaf.

Report of the Convenor
1982 "Acoustics Week" in Toronto

On behalf of the CAA membership, I would like to thank the fifty or so dedicated CAA members and other friends who voluntarily organized, developed, chaired, and presented the three seminars given on October 18-19. By all accounts, the seminars; 'Vibration', 'Noise in the Workplace', and 'Noise Control in Land Use Planning', all achieved their planned objectives for the transfer of new technology to those from the private and public sectors participating in the seminars.

To the organizers and supporters of the CAA reception and "walk-through" of the new Roy Thompson in Toronto, my thanks for a very special evening. My thanks also to Ted Schultz for his presence in Toronto, and for his willingness to discuss features of the Hall acoustics design with his colleagues during the "walk-through" of the Hall.

The 1982 CAA Symposium was considered by many to be the best effort yet by the Association. My special thanks to the dedicated dozen or so colleagues who organized the structured sessions, and who chaired the various sessions and panel discussions, and also to those who actively participated. Your efforts were very much appreciated. I would be remiss if I did not also acknowledge the valuable assistance provided, courtesy of Ray Dodds and Len Blizzard, by students in acoustics at George Brown College in Toronto. I particularly commend Don Purser, Ken Emig and Bradley Basnett for their technical support and for sticking it out to the bitter end. Well done.

I am confident that the success of the 1982 "Acoustics Week" in Toronto reflects growing Canadian interest and support for the upcoming Ultrasonics International '83 meeting in Halifax, NS., as well as for the 12 ICA to be held in Canada in July, 1986.

J. Manuel
Convenor

APPENDIX I

12 ICA 1986 CANADA

EXECUTIVE COMMITTEE

INITIAL MEMBERS

Chairman, 12 ICA	E. A. G. Shaw National Research Council of Canada Ottawa, Canada, K1A 0R6	(613) 993-2840
Vice-Chairman and Chairman Technical Program Committee	T. F. W. Embleton National Research Council of Canada Ottawa, Canada, K1A 0R6	(613) 993-2840
Secretary-General	J. Manuel Ontario Ministry of Environment, Toronto	(416) 965-6343
Secretariat Address:	12 ICA Executive Committee 5007 - 44 Charles Street West Toronto, Canada, M4Y 1R8	
President, Canadian Acoustical Assoc.	C. Sherry Domtar Construction Materials Montreal, Canada, H3A 2A6	(514) 282-5306
CAA Treasurer	J. Nicolas Universite de Sherbrooke, Genie mecanique Sherbrooke, Canada, J1K 2R1	(819) 565-4490
Chairman, Congress Advisory Committee	A. C. C. Warnock National Research Council Canada Ottawa, Canada, K1A 0R6	(613) 993-2305
Chairman, Local Planning Committee, Toronto	A. T. Edwards Ontario Hydro Research Laboratories Toronto, Canada, M8Z 5S4	(416) 231-4111/6674
Chairman, Committee on Coordinated Meetings	J. E. Piercy National Research Council of Canada Ottawa, Canada, K1A 0R6	(613) 993-2840
Chairman, Finance Committee	F. L. Hall McMaster University, Geography Dept. Hamilton, Canada, L8S 4K1	(416) 525-9140
Chairman, Funds Raising Comm.	R. B. Johnston International Hearing Aids Limited Oakville, Canada, L6J 5E8	(416) 845-8900
Chairman, Congress Facilities & Accommodation Committee, University of Toronto	W. Richarz Institute for Aerospace Studies, U of T. Toronto, Canada, M3H 5T6	(416) 667-7707/4334

ADVISORY COMMITTEE

INITIAL MEMBERS

The Chairman of the Advisory Committee is Alf Warnock. The initial list of members is as follows: S. Abel, P. Alberti, E. Bolstad, C.W. Bradley, A. Brammer, D. Cheek, L. Cuddy, R. Cyr, S. Eaton, A. Edwards, T. Embleton, G. Faulkner, F. Hall, J. Hemingway, R. Hétu, D. Hill, H. Jones, H. Lof-green, J. Manuel, J. Migneron, J. Nicolas, T. Northwood, M. Osman, J. Piercy, J.D. Quirt, W. Richarz, L. Russell, E. Shaw, C. Sherry, D. Whicker.

CAA ANNUAL MEETING - TREASURER'S REPORT

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS FOR PERIOD SEPT. 1, 1981, TO AUG. 31, 1982
ETATS DES REVENUS ET DEPENSES POUR LA PERIODE DU 1er SEPT. 1981 au 31 AOUT 1982.

Receipts - Revenus

Membership, advertising, contributions Cotisation des membres, publicité, dons	$7,042.66
Interest - Intérêt	221.27
TOTAL:	$7,263.93

Disbursements - Dépenses

I/INCE	$ 206.23
Printing of C.A. - Imprimerie de l'A.C.	3,776.56
Postage-Expedition - Poste-Expédition	592.72
Miscellaneous - Divers	252.50
TOTAL:	$4,828.01

Excess receipts over disbursements - Excédant revenus versus dépenses	$2,435.92

BALANCE SHEET - ETATS FINANCIERS

31-08-1982

Assets - Actif

Cash on hand - Solde	$ 6,791.89
Bank term deposit - Dépôt à terme	5,000.00
	$11,791.89

Liabilities - Passif

(Balance - Solde) 31-08-81	$ 9,355.97
(Excess - Surplus) 31-08-81 - 31-08-82	2,435.92
	$11,791.89

J. Nicolas

AUDITOR'S REPORT

I have audited the books and reviewed the supporting documentation of the Canadian Acoustical Association for the year ending August 31, 1982. I find that the statement presented by the Treasurer at the Annual Meeting on October 22, 1982 is correct.

C.W. Bradley, Eng.

LE TRAITEMENT NUMÉRIQUE DES SIGNAUX ACOUSTIQUES: L'ANALYSE BI-CANAL

Jean Nicolas, Gilles Lemire, Blaise Gosselin*
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SOMMAIRE

L'analyse bi-canal des signaux acoustiques est scrutée de façon à proposer des solutions aux difficultés provenant d'erreurs de manipulation et d'interprétation. Une attention spéciale est accordée aux problèmes de déphasage, d'erreurs de troncatures, et de délai temporel. Les possibilités et les limites de la fonction de cohérence sont étudiées. La conversation bidirectionnelle instrument-ordinateur est présentée de façon systématique avec des exemples d'application.

SUMMARY

Dual channel analysis of acoustic signals is examined in order to propose solutions to the problems resulting from manipulation and interpretation errors. Special attention is given to phase shift problems, truncation error and time delay. The possibilities and limits of the coherence function are studied. Two-way conversation between instrument and computer is presented in a systematic way, with applications.

INTRODUCTION

Si la décennie 70-80 a été celle de l'avènement du traitement numérique des signaux acoustiques[1], celle des années 80-90 sera marquée par la mesure et l'analyse simultanée de plusieurs canaux d'informations. Le passage d'un traitement mono-canal à une manipulation bi ou multi-canal est beaucoup plus complexe qu'il n'y paraît de prime abord. En effet, il faut d'une part prévoir l'acquisition d'un grand nombre de données et ce de façon parfaitement synchrone[2] et d'autre part, faire face aux difficultés d'un calcul qui est alors vectoriel et non scalaire. Les instruments bi-canaux permettent l'obtention d'une multitude incroyable de fonctions. Cependant ils ne peuvent distinguer si les signaux d'entrée sont entachés d'erreurs (calibration, effet de troncature, désynchronisation, etc.) et surtout ils ne font pas l'analyse des résultats. C'est pourquoi nous nous proposons de mettre à jour un certain nombre de facteurs qui, selon notre expérience, se sont révélés être les plus susceptibles de fausser les données et l'interprétation des résultats.

Partant du problème-clef que représente l'information de phase, nous étudierons ensuite les erreurs de troncature, l'influence du délai temporel, l'interprétation des valeurs de cohérence, pour terminer par les possibilités de conversation bidirectionnelle instrument-ordinateur.

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* travaille maintenant pour la firme SILENTEC de Montréal.

Phase

Dès que l'on traite numériquement l'information obtenue de deux signaux ou plus, il devient évident que l'élément phase apporte une dimension supplémentaire en autant que cette information soit valide. Il faut donc d'emblée envisager un système de calibration de phase (et parfois d'amplitude) de ces deux canaux de mesure. Pour ce faire, nous avons utilisé une source de bruit blanc qui débite dans un cône exponentiel à sortie quasi ponctuelle ($\sim$ 1 cm) et munie d'un adapteur d'impédance. Les deux micros peuvent alors être placés nez-à-nez ou côte-à-côte dans l'axe principal et ils sont donc soumis au même champ acoustique. L'ensemble des circuits de mesure sont ainsi calibrés et une fonction de transfert complexe est mémorisée pour fins de correction éventuelle. La figure (1) montre le déphasage qu'il peut exister entre deux canaux d'un analyseur (1a) et entre deux microphones pris au hasard (1b). Il est bien évident que de tels déphasages doivent être corrigés puisqu'ils entraînent dans le cas de la mesure de l'intensité, par exemple, des erreurs de plusieurs dB en basses fréquences. Il est important de noter que cette méthode est beaucoup plus simple que d'autres proposées dans la littérature. De plus, elle possède l'avantage de mesurer une fonction de calibration avec les micros placés exactement dans la configuration géométrique qui sera utilisée pour les mesures, ce qui est très important en intensimétrie, par exemple.

Erreur de troncatures

Ces erreurs sont dues au fait que les analyseurs ou acquisiteurs travaillent normalement avec des mots de 2 octets (16 bits), alors qu'un ordinateur travaillera généralement avec des mots de 8 octets (64 bits). Ainsi lorsqu'on s'approche des valeurs limites, exemple pour une fonction de cohérence (les valeurs 0 ou 1), on constate que le calcul tronqué fait par un analyseur T.R.F. peut amener à des valeurs supérieures à 1.0 et qu'on procède généralement à l'intérieur de l'appareil à une normalisation quelconque (par rapport à la valeur maxi par exemple). Au départ donc, la valeur est entachée d'une erreur qui peut aller dans certains cas jusqu'à 10%, ce qui explique en outre la difficulté du calcul précis des fonctions de cohérences partielles[2].

Délai temporel et cohérence

Parce qu'on traite deux canaux, il est très important de tenir compte du délai qui peut exister entre le moment où une onde donnée est captée par le premier microphone et le moment où elle est captée par le deuxième microphone, si on veut comparer une onde progressive issue d'une ou plusieurs sources. L'erreur de biais ainsi provoquée sur le calcul d'une fonction de cohérence est donnée[2] par:

$$\gamma_{ij}^{2}(f) \simeq \left(1 - \frac{\Delta t}{T}\right)^{2} \gamma_{ij}^{2}(f)$$

où $\gamma_{ij}^{2}(f)$ est la cohérence estimée entre les micros i et j, Δt est le temps mis par l'onde pour aller de i vers j, et T est le temps total d'échantillonnage.

L'effet de ce délai[3] est visualisé aux figures 2a, 2b et 3a: on constate combien l'absence d'un délai programmé peut détruire la signification d'une fonction de cohérence; (i.e. laisser croire que la cohérence est faible alors que ce n'est pas physiquement le cas). Ce délai peut prendre toutes les valeurs possibles et c'est pourquoi les délais de T/10 ou T/100 proposés sur la plupart des analyseurs T.R.F. sont nettement insuffisants. Nos études ont montré qu'il est important pour obtenir des résultats précis que le délai soit ajustable à l'échantillon près (T/1024). Ce délai peut d'ailleurs prendre la forme d'ondes réfléchies qui arrivent "en retard" par rapport à l'onde incidente: la figure (3) montre certains de nos résultats obtenus pour un milieu semi-réverbérant (b) pour un milieu très réverbérant (d) et l'effet du bruit de fond sur la valeur de la cohérence (c) et ceci pour des ondes parfaitement cohérentes.

Avec l'analyse bi-canal, la fonction de cohérence est sans doute l'une des fonctions les plus difficiles à interpréter. Physiquement ce paramètre témoigne du degré de linéarité d'amplitude et de phase qui peut exister entre deux signaux. Cependant, il existe de nombreux cas pour lesquels cette fonction est inférieure à 1.0 sans pour cela qu'on puisse conclure à une non-linéarité. Les causes principales sont:

- Erreur de biais dans l'estimation des spectres
- Autres entrées $x_i(t)$ que celle considérée
- Présence d'un bruit provenant de l'instrumentation
- Bruit de fond élevé
- Contamination sur le cheminement.

Dans les quatre derniers cas il faut alors utiliser les cohérences partielles[3,4]. De plus, bien que la cohérence témoigne de la linéarité possible de deux signaux au niveau de la phase, elle demeure un paramètre scalaire, donc pour lequel le déphasage inter-microphone n'a aucune importance. Pour l'intensité, au contraire, la phase est un paramètre ultra crucial. Il est donc loisible d'en tirer un double avantage: primo, aucune calibration inter-micro n'est nécessaire, secundo, on pourra utiliser deux capteurs de natures différentes, par exemple microphone et accéléromètre. Cet outil s'avère d'ailleurs très puissant pour l'identification des sources. La figure (4) nous montre deux signaux (pression et accélération) provenant d'une source de type impulsionnel quasi-continu:

a) fréquentiellement ceux-ci semblent être sans relation (surtout entre 1 k et 2,5 kHz) (figure 4);

b) pourtant la cohérence est très forte, ce qui indique nettement que des différences au niveau de l'amplitude des spectres de puissance ne sont pas forcément la preuve d'une non-interrelation entre deux signaux (figure 5).

Conversation bidirectionnelle instrument-ordinateur

Comme nous l'avons dit précédemment, lorsqu'on interface convenablement un analyseur T.R.F. à un ordinateur ou un calculateur, les possibilités du système deviennent alors presque illimitées, et on acquiert une versatilité très utile[2]. Actuellement, deux types d'interface sont couramment disponibles

RS 232 et IEEE-488. Il est bon de se rappeler que l'interface RS 232 peut être utilisé pour les longues distances de transmission mais que la vitesse de transfert est généralement de 120 caractères par seconde (1200 bauds). Au contraire, avec l'interface IEEE, on parle de plusieurs dizaines de milliers de caractères par seconde mais pour des distances très courtes (quelques mètres), à moins d'utiliser des câbles à fibres optiques qui sont excessivement onéreux. Examinons maintenant de façon systématique les paramètres à connaître pour effectuer avec succès des transferts bidirectionnels:

a) Position, format et code de données

Position

L'organisation de la mémoire d'un analyseur T.R.F. doit être bien connue. A chaque fonction correspond une adresse décimale qu'il faut utiliser dans le but d'extraire la bonne information (voir tableau I).

Format

Le format dans lequel les données sont connues doit être précisé comme il est montré au tableau II.

Code

Ce code est un des éléments délicats lors de la manipulation. Généralement, il peut s'agir d'un code ASCII, de données codées en binaire, et en binaire complément de deux. Le tableau III donne un exemple de la traduction possible de différentes données.

b) Communications - instructions

L'analyseur et l'ordinateur sont tour à tour "parleur" et/ou "écouteur". Il est très important de bien définir avant chaque transfert lequel des deux va être "parleur" (envoyé des données) ou "écouteur" (recevoir des données). A ceci, on peut ajouter que l'utilisation de "drapeaux" levés ou baissés permet de multiplier les combinaisons et d'assurer la logique des instructions.

c) Modes d'interface

Ces modes permettent aux instructions et/ou aux données d'entrer ou de sortir de l'analyseur selon que celui-ci a été défini comme "écouteur" ou comme "parleur". Le tableau IV nous indique quels sont les modes standards et leurs fonctions pour un analyseur T.R.F. du type 2031 de Bruël et Kjaër (tableau IV).

d) Mémoire tampon

Cette mémoire tampon est une nécessité puisqu'elle permet en quelque sorte de régulariser le débit des transferts de données. En effet, les analyseurs et/ou acquisiteurs peuvent en général transférer les données plus vite que le calculateur ou l'ordinateur n'est capable de les recevoir.

Dès lors cet espace tampon devient un réservoir temporaire dans lequel on peut stocker rapidement des données qui seront ensuite extraites au rythme désiré.

e) Exemples d'utilisation

- Transformée complexe de Fourier convenablement référencée en phase

Afin de synthétiser les informations dont nous avons parlé jusqu'ici au sujet de la conversation bidirectionnelle, nous présentons ici le texte (tableau V) d'un programme permettant d'obtenir la T.R.F., dans le domaine complexe et ce, après avoir réorganisé la fonction de temps[1]. On constatera que cette manoeuvre simple nécessite cependant quelques 48 instructions, ce qui donne une idée des précautions que l'on doit prendre pour que la conversation bidirectionnelle se fasse convenablement.

- Réalisation d'un analyseur bi-canal à l'aide de deux analyseurs mono-canal[6]

La figure (6) montre le montage nécessaire à une telle réalisation. On notera la présence d'une boîte dite de synchronisation permettant d'assurer une acquisition parfaitement simultanée des données et ce, bien que chacun des analyseurs est un temps de conversion A/D et un temps de programmation du déclenchement légèrement différent. Bien que ce système soit hors temps réel, il offre des facilités non disponibles sur les deux canaux T.R.F. commerciaux: délai ajustable à l'échantillon près, gestion automatique, analyse de signaux ayant 10 k/par canal de données au lieu de 1 k.

Conclusion

L'analyse numérique des signaux, via un processus bi-canal, permet et permettra des analyses de plus en plus sophistiquées et puissantes (voir récemment l'intensité acoustique). Cependant elle ouvre la porte à des erreurs tant sur le plan de l'expérimentation que sur celui de l'interprétation. Nous avons vu que:

- le déphasage inter canal doit être parfaitement quantifié et calibré lors de l'utilisation de fonctions vectorielles;
- les erreurs de troncature peuvent être cruciales dans les cas limites. C'est souvent par là que la gamme dynamique des mesures va se trouver limitée;
- les simples délais temporels doivent être parfaitement corrigés, même pour des fonctions de type scalaire (telle la cohérence);
- la fonction de cohérence est souvent biaisée. C'est sans doute une des fonctions la plus difficile à maîtriser et même si les fonctions de cohérence partielle peuvent aider, elles demeurent délicates d'emplois;
- le fait d'interfacer convenablement un calculateur ou un ordinateur avec tout instrument en décuple les capacités.

Les perspectives intéressantes se situent évidemment au niveau du traitement multi-canal: il serait en effet très instructif par exemple, d'obtenir plus d'informations sur la radiation acoustique en développant une cohérence entre la vélocité acoustique (2 canaux) et la vélocité vibrationnelle (1 canal). L'analyse multi-canal nécessite et nécessitera le traitement d'un très grand volume de données; mais les problèmes de bases demeureront les mêmes que ceux vécus pour l'analyse bi-canal.

Remerciements

Les auteurs tiennent à remercier le Conseil national de la recherche en sciences et en génie et l'Institut de recherche en santé et sécurité du travail au Québec qui, par leurs subventions, ont rendu possible les travaux qui ont été présentés dans cet article.

Bibliographie

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3. B. Gosselin, "Méthode et utilisation des fonctions de cohérence pour l'identification des sources de bruit", Thèse de maîtrise, Université de Sherbrooke, 1982.
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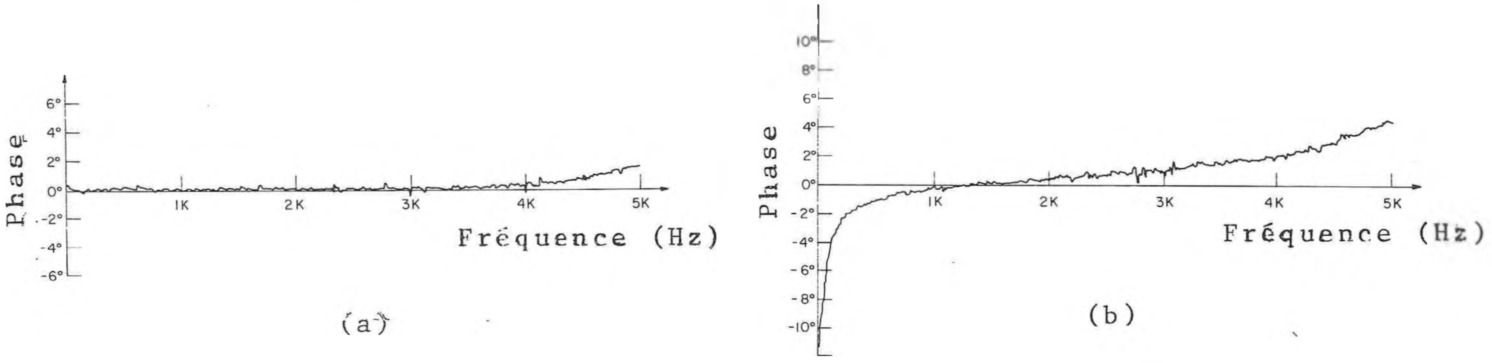
6. J. Nicolas, B. Gosselin, G. Lemire, "Duan channel analysis via two single channels", Inter Noise 82, San Francisco.



(a)

(b)

Figure 1. Déphasage a) entre deux canaux
b) entre deux microphones

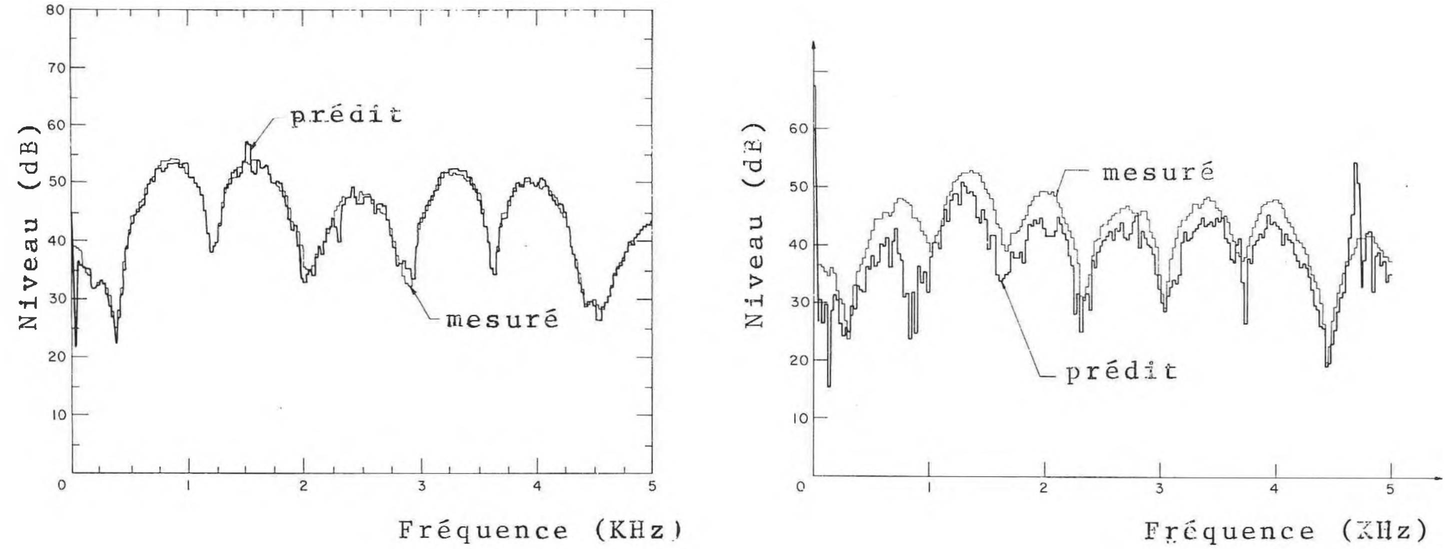
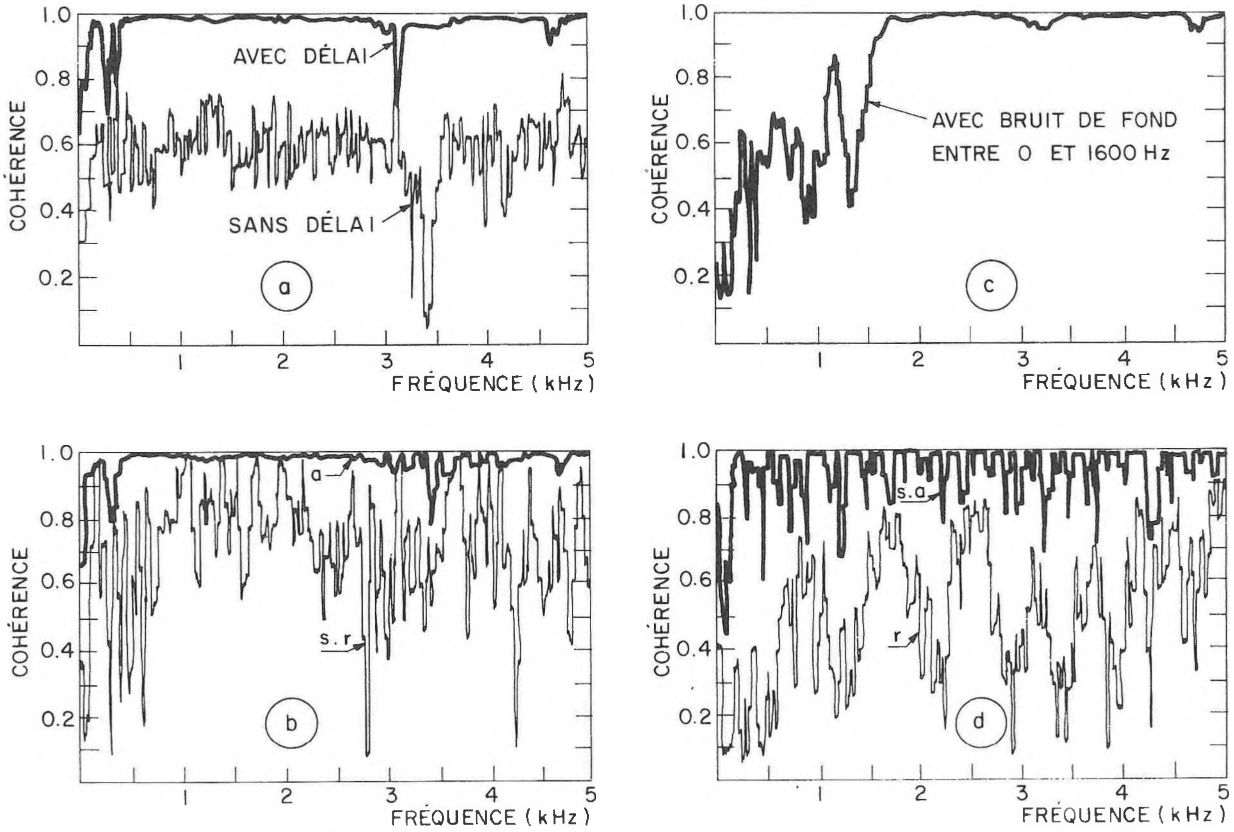


Figure 2. Effet du délai
a) sans programmation du délai
b) avec programmation du délai



a=anéchoique ; s.r = semi-réverbérant

s.a = semi-anéchoique ; réverbérant

Figure 3. Conditions influençant la cohérence.

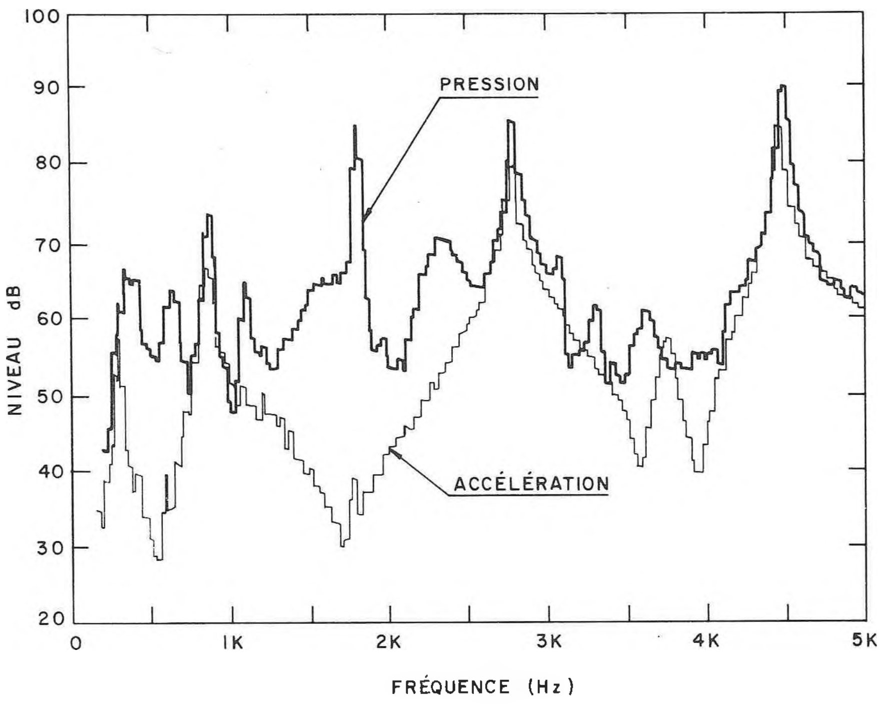


Figure 4. Spectres comparatifs bruit/vibration.

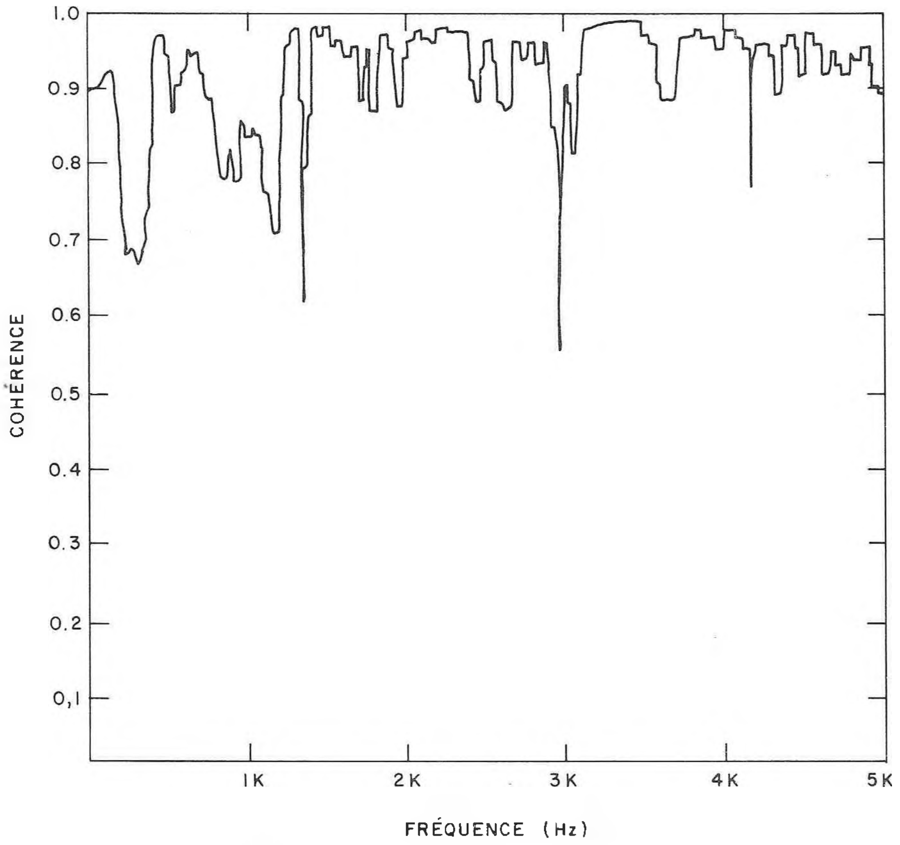


Figure 5. Cohérence entre signaux bruit/vibration.

Adresse décimale	Contenus de la mémoire
0 1023	- Fonction du temps. Spectre complexe ou spectre instantané.
1024 2047	- Fonction du temps. Spectre complexe ou spectre instantané.
2050 2849	- Spectre intégré.
2872 3071	- Registre d'affichage de spectre.
3073 3476	- Mémoire de référence.
3584 4095	- Fonction temporelle 8 bits

TABLEAU I : Organisation de la mémoire (modèle 2031 de B & K)

Place en mémoire	Contenu
2 ou 1026	Mantisse ligne 1
3 ou 1027	Exposant ligne 1
4 ou 1028	Mantisse ligne 2
5 ou 1029	Exposant ligne 2
etc.	etc.

a) Format du spectre de puissance instantané

Place en mémoire	Contenu
0 ou 1024	Partie réelle ligne 0
1 ou 1025	Partie imaginaire ligne 0
2 ou 1026	Partie réelle ligne 0
3 ou 1027	Partie imaginaire ligne 1
etc.	etc.

b) Format du spectre complexe

TABLEAU II : Formats dans la mémoire de l'analyseur

Traduction Données codées	Code ASCII	Code binaire Mots de 16 bits	Code binaire Mots de 8 bits	Code binaire Complément à deux mots de 16 bits
0100000100110111	A7	16695	65 et 55	-
1000000000000001	-	32769	128 et 1	-32767

TABLEAU III : Interprétation des données

Code de commande	Réponse de l'appareil	
	adressé écouteur	adressé parleur
#0	Entrée numérique du spectre en ASCII dans la mémoire	Sortie numérique du spectre en ASCII.
#1	Réglage ASCII des touches	Sortie de tous les réglages de touches en ASCII
#2	Entrée numérique et transformation de la fonction temporelle	Sortie numérique de la fonction du temps
#3	Transfert de blocs MSBY-LSBY vers le 2031	Transfert de blocs MSBY-LSBY à partir du 2031
#4	Adressage en ASCII de la touche à actionner	Sortie ASCII de sélection de touches
#5	-	Sortie numérique du spectre codé complément à 2.
#6	Transfert de blocs LSBY vers l'analyseur	Transfert de blocs LSBY à partir de l'analyseur
#7	Transfert de blocs MSBY vers l'analyseur	Transfert de blocs LSBY à partir de l'analyseur
#8	Poursuite des opérations	

où MSBY = "Most significant byte" ou octet le plus significatif
LSBY = "Least significant byte" ou octet le moins significatif.

TABLEAU IV : Modes de l'interface

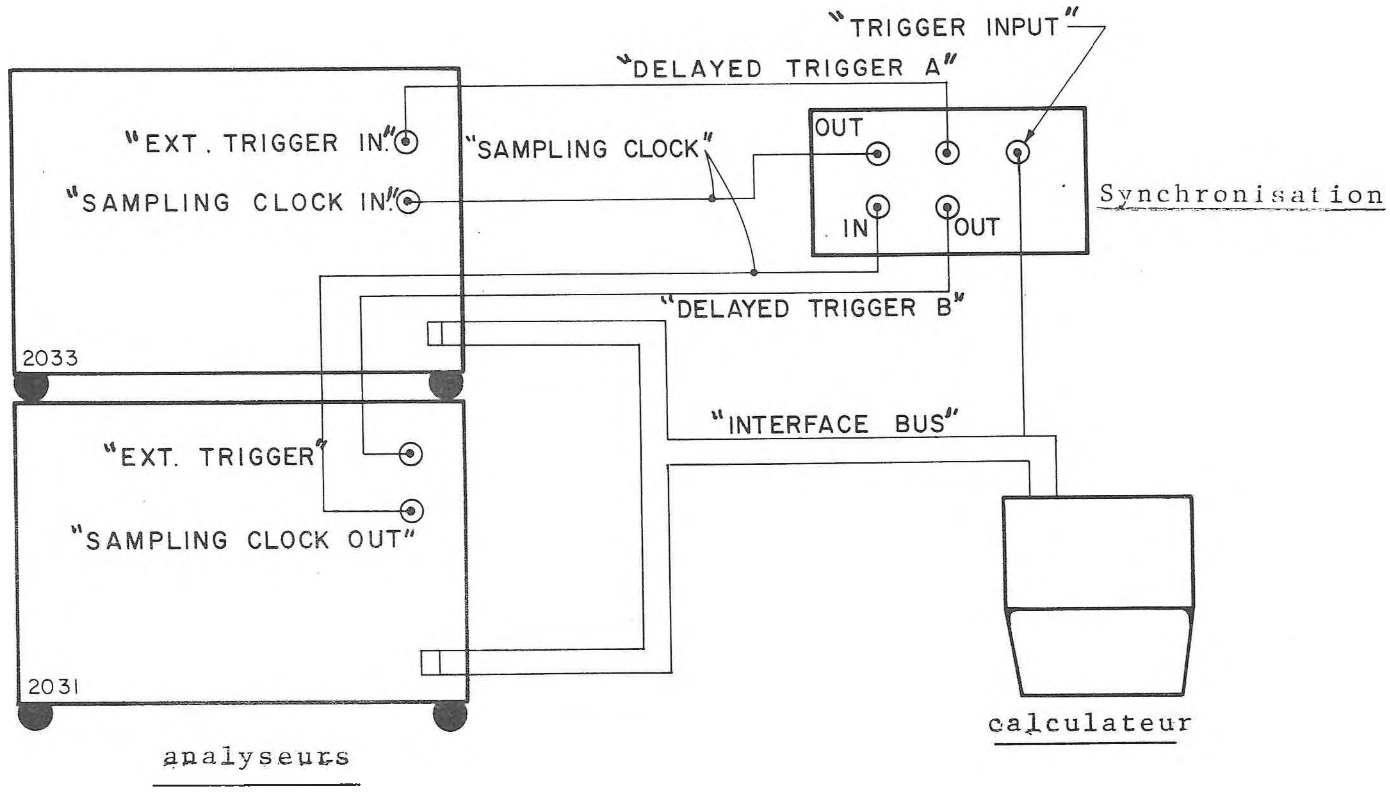
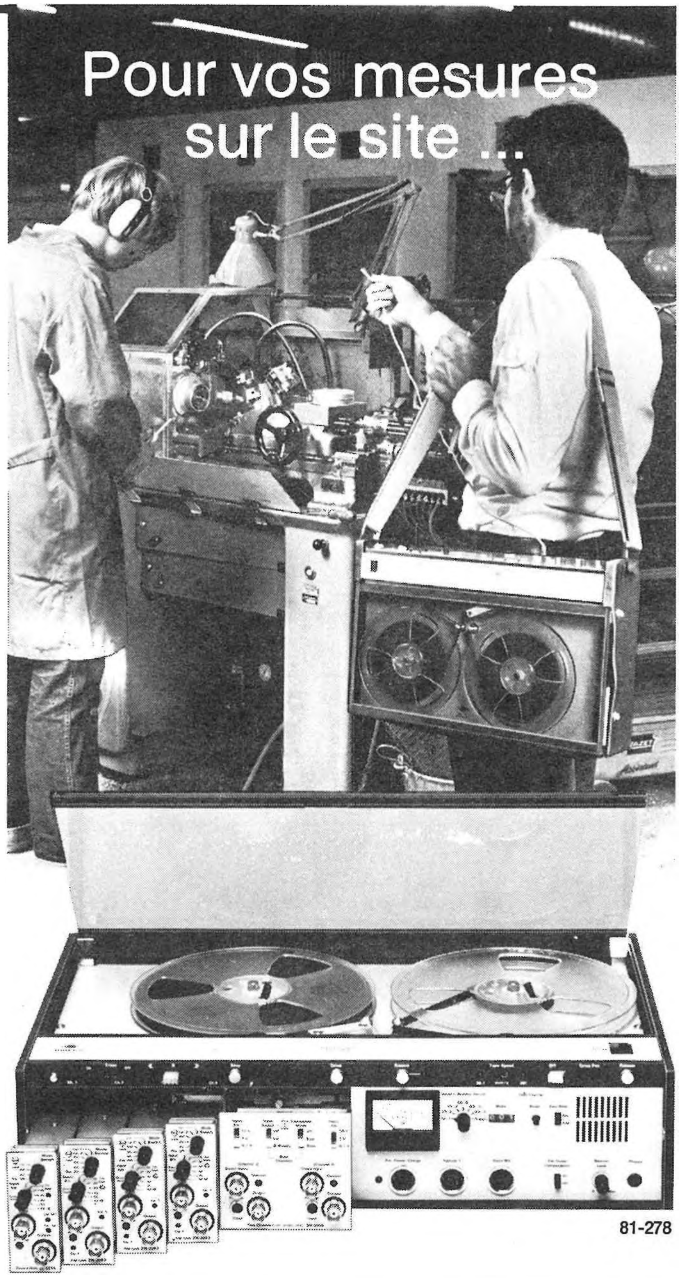
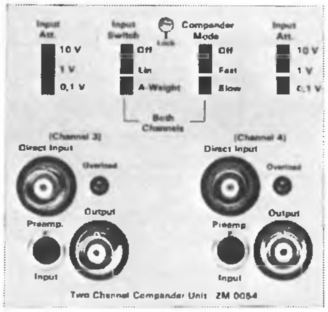


Figure 6. Montage assurant la synchronisation entre deux anlyseurs T.R.F.


Pour vos mesures
sur le site ...


Input Att.
10 V
1 V
0,1 V
Input Switch
Off
Lin
A-Weight
Lock
Compander Mode
Off
Fast
Slow
Input Att.
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1 V
0,1 V
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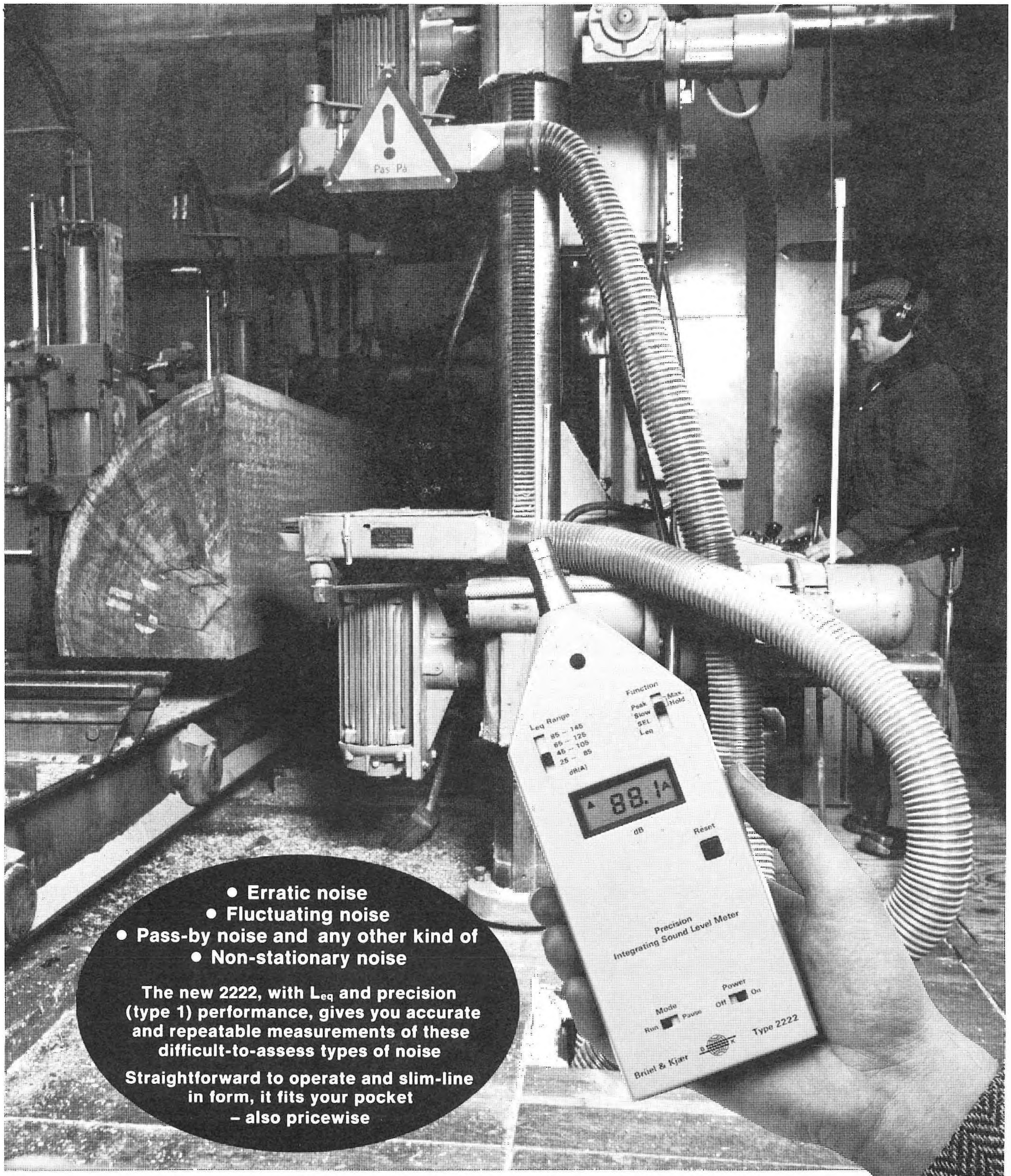

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```
0: cli 7;clr 7;cmd 7,"?"
1: dim A$[2065]
2: buf "FFT",A$,3
3: dim B$[20]
4: buf "EXP",B$,3
5: dsp "AJUSTEZ LES TOUCHES DU 2031";stp
6: "ON MET L'ANALYSEUR SUR STOP":
7: wtb 725,"#1,X1;"
8: "ECRITURE DU MASQUE":
9: wtb 725,"#6,2855,1,",1
10: spc 1
11: prt "POUR PRENDRE UN SPECTRE, IL SUFFIT DE PRESSER LA TOUCHE SINGLE"
12: prt "SUR LE 2031"
13: spc 2
14: dsp "PRENDRE UN SPECTRE/C.";stp
15: prt "PRESSEZ 'CONT' LORSQUE LE VO-  YANT TRIG'D DU"
16: prt "2031 EST ETEINT";spc 2;stp
17: "SORTIE DE LA FONCTION DE TEMPS":
18: wtb 725,"#2;"
19: tfr 725,"FFT",2049
20: jmp rds("FFT")#-1
21: "POURSUITE DES OPERATIONS":
22: wtb 725,"#8;"
23: prt "PRESSEZ 'CONT' LORSQUE LE 2031 EST EN POSITION"
24: prt "RECORD STOP";spc 2;stp
25: "ECRITURE DU MASQUE":
26: wtb 725,"#6,2855,1,",4
27: "ENTREE DE LA FONCTION DE TEMPS":
28: wtb 725,"#2,",A$
29: "LECTURE DE L'ADRESSE DE DEPART DU FFT":
30: wtb 725,"#3,3511,1;"
31: tfr 725,"EXP",3
32: jmp rds("EXP")#-1
33: itf(B$[1,2])→B
34: "LECTURE DU FFT":
35: if B=0;wtb 725,"#3,0,1024;"
36: if B=1024;wtb 725,"#3,1024,1024;"
37: "ON VIDE L'ESPACE TAMPON":
38: buf "FFT"
39: tfr 725,"FFT",2049
40: jmp rds("FFT")#-1
41: "ON VIDE LA MÉMOIRE TAMPON":
42: buf "EXP"
43: "LECTURE DE L'EXPOSANT":
44: wtb 725,"#3,3582,1;"
45: tfr 725,"EXP",2
46: itf(B$[1,2])→E
47: "ANNULATION DU MASQUE":
48: wtb 725,"#6,2855,1,",0
```

TABLEAU V : Programme pour l'obtention de transformée (complexe) de Fourier.

EFFECT OF MEAN FLOW AND DAMPING ON THE PERFORMANCE OF REACTIVE MUFFLERS

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ABSTRACT

Inclusion of mean flow effects in the mathematical modeling of exhaust mufflers has been found to be essential for achieving realistic results. Two mathematical models are presented which apply to plane wave propagation through a pipe or an expansion chamber including the effect of mean flow and damping. The solutions of the governing equations are represented by 2X2 transfer matrices. In evaluating the performance of exhaust mufflers, noise reduction (NR) is calculated using an open end termination. The measured NR characteristics of the tested laboratory mufflers are in excellent agreement with those predicted by the transfer matrix approach. The method of NR calculation is quite general in its application and can be extended further to optimize muffler configuration at the design stage.

SOMMAIRE

Il est apparu essentiel de tenir compte des effets de l'écoulement moyen dans la modélisation mathématique des silencieux afin d'obtenir des données réalistes. Dans cette communication, on présente deux modèles mathématiques qui décrivent la propagation d'ondes planes dans une conduite ou un détendeur en tenant compte de l'effet de l'écoulement moyen et de l'amortissement. Les solutions des équations du mouvement sont représentées par des matrices de transfert 2 x 2. Dans l'évaluation du rendement de silencieux, on calcule la réduction du bruit (RB) pour un silencieux à extrémité ouverte. Les valeurs de RB mesurées en laboratoire sur des silencieux concordent très bien avec les valeurs prévues par les matrices de transfert. La méthode de calcul de la RB se prêtre à des applications de caractère assez général, et il est possible d'étendre son utilisation à l'optimisation de la configuration des silencieux, lors de la conception.

---

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NOMENCLATURE

A11, A12, A21, A22	Transfer Matrix terms
A,B	Pressure amplitudes
c	Speed of wave propagation
f	Frequency of wave propagation
i	Imaginary quantity $(=\sqrt{-1})$
k	Wave number
ℓ	Length of element
M	Mach number
N	Area ratio
NR	Noise reduction
S	Cross section area of element
t	Time variable
[T]	Transfer Matrix notation
U	Steady mean flow velocity
v	Acoustic mass velocity
x	Space variable in axial direction
Y	Characteristic impedance
Z_L	Load impedance
Z_S	Source impedance
ω	Circular frequency $(=2\pi f)$
ζ	Friction coefficient
Subscript r	Refers to rth element or at point r

1. Introduction

Muffler manufacturers are being confronted with the problem of designing mufflers with low restriction as well as low radiated exhaust noise. Imposed noise regulations for the eighties have intensified the need for development of both experimental and theoretical modeling techniques to assist in the overall design effort. The analytical methods developed to predict the performance of exhaust mufflers in the past have been seriously handicapped due to the difficulties involved in the accurate measurement and proper modeling of the exhaust source impedance [1-3]. Apart from the lack of proper characterization of the source impedance, neglect of mean flow effects has been found to cause a considerable discrepancy between experiments and analytical predictions. Effect of damping due to friction and shear flow on the internal surfaces of the mufflers also has been neglected, which often has a considerable effect around resonant or antiresonant frequencies. The sources of energy loss in an acoustical system may be divided into two categories: those due to dissipation of acoustic energy in the transmitting medium and those associated with the boundaries of the medium [6].

In this paper two simple mathematical models have been suggested for the inclusion of damping along with the effect of mean flow in the system. The first model takes into account the damping due to the friction between the flowing medium and the walls of the system. The second model accounts for the shear viscosity effects between the layers of the medium. The solutions to these mathematical models are then transformed into the familiar two-by-two transfer matrix form which can be conveniently used in the evaluation of the performance of mufflers. The computed predictions using these transfer matrices have been compared with those measured experimentally by simulating a mean flow of air and a pure tone in the systems tested. Agreement appears to be very good.

2. Mathematical Modeling for Sound Propagation Through a Uniform Duct.

The transfer matrix formulation of a uniform pipe or expansion chamber of certain length with/without mean flow is presented here briefly in Sections 2.1 and 2.2. Thereafter, the models including the damping effects are presented in Sections 2.3 and 2.4.

2.1 No Flow or Stationary Medium

In the classical theory of sound transmission [6] the plane wave equation is given as

$$\frac{\partial^2 p}{\partial t^2} = c^2 \frac{\partial^2 p}{\partial x^2} \tag{1}$$

The steady state harmonic solution to (1) in terms of acoustic pressure p and acoustic mass velocity v can be expressed as

$$\left.\begin{aligned} p(x) &= A\exp(-ikx) + B\exp(ikx) \\ \text{and } v(x) &= \frac{A}{Y}\exp(-ikx) - \frac{B}{Y}\exp(ikx) \end{aligned}\right] \tag{2}$$

where $k=\omega/c$ is the wave number,
$\omega=2\pi f$; f is the frequency of wave propagation,
c=speed of wave propagation,
$Y=c/S$ is the characteristic impedance,
and S=cross sectional area of the pipe.
A and B are the amplitudes of the forward and backward waves.

Substituting the boundary conditions at $x=0$ and $x=\ell$ for a uniform pipe [7], (2) can be transformed into a transfer matrix form

$$\begin{bmatrix} p \\ v \end{bmatrix}_0 = \underbrace{\begin{bmatrix} \cos(k\ell) & iY\sin(k\ell) \\ \frac{i}{Y}\sin(k\ell) & \cos(k\ell) \end{bmatrix}}_{\text{T.M.}} \begin{bmatrix} p \\ v \end{bmatrix}_\ell \tag{3}$$

Expression (3) gives the desired transfer matrix (T.M.) for the plane wave sound propagation through a pipe of uniform cross section without mean flow in the medium. The subscripted column matrices with subscripts 0 and ℓ represent the acoustic pressure p and the mass velocity v at $x=0$ and $x=\ell$ respectively.

2.2 Mean Flow or Moving Flow

Replacing the time derivative '$\frac{\partial}{\partial t}$' in (1) by its substantial derivative '$\frac{D}{Dt}$' $= \frac{\partial}{\partial t} + U\frac{\partial}{\partial x}$, mean flow is introduced in the plane wave equation resulting in [7]:

$$\frac{\partial^2 p}{\partial t^2} + 2U\frac{\partial^2 p}{\partial x \partial t} + (U^2 - c^2)\frac{\partial^2 p}{\partial x^2} = 0 \tag{4}$$

The corresponding solution to (4) will be

$$p(x) = A\exp\left[-i\frac{\omega}{c+U}x\right] + B\exp\left[i\frac{\omega}{c-U}x\right] \tag{5}$$

Applying the boundary conditions the transfer matrix form is

$$\begin{bmatrix} p_f \\ v_f \end{bmatrix}_0 = e^{-iM(k_f\ell)} \underbrace{\begin{bmatrix} \cos(k_f\ell) & iY\sin(k_f\ell) \\ \frac{i}{Y}\sin(k_f\ell) & \cos(k_f\ell) \end{bmatrix}}_{\text{T.M.}} \begin{bmatrix} p_f \\ v_f \end{bmatrix}_\ell \tag{6}$$

where $k_f = \frac{k}{1-M^2}$ and the subscript f stands for the variables with mean flow included.

2.3 Mean Flow With Damping Due to Friction

The governing equation for this case can be written [8] as

$$\frac{\partial^2 p}{\partial t^2} + 2U\frac{\partial^2 p}{\partial x \partial t} + (U^2 - c^2)\frac{\partial^2 p}{\partial x^2} + 2\zeta U\frac{\partial p}{\partial t} + 2\zeta U^2\frac{\partial p}{\partial x} = 0 \tag{7}$$

where ζ is the friction coefficient. It should be recognized that in (7) there are now two additional terms, $2\zeta U\frac{\partial p}{\partial t}$ and $2\zeta U^2\frac{\partial p}{\partial x}$. These terms represent the damping due to friction on the walls of the system. The approximate solution to equation (7) can be written in the following form:

$$p(x) = A\exp\frac{-(is+r/\omega)\omega x}{c+U} + B\exp\frac{(is+r/\omega)\omega x}{c-U} \tag{8}$$

where $r = \zeta U$ and $s \simeq 1$.

Applying the boundary conditions for (8),

$$\begin{bmatrix} p_d \\ v_d \end{bmatrix}_0 = e^{-\gamma M \ell} \underbrace{\begin{bmatrix} \cosh(\gamma\ell) & Y\sinh(\gamma\ell) \\ \frac{1}{Y}\sinh(\gamma\ell) & \cosh(\gamma\ell) \end{bmatrix}}_{\text{T.M.}} \begin{bmatrix} p_d \\ v_d \end{bmatrix}_\ell \tag{9}$$

where $\gamma = (is + r/\omega)k_f$, $k_f = \frac{k}{1-M^2}$, $s \simeq 1$, and $r = \zeta U$.

2.4 Mean Flow With Damping Due to Shear Viscosity

The governing equation for wave propagation for the case of no flow but with shear viscosity present in the system [9, 10] is

$$\frac{\partial^2 p}{\partial t^2} = c'^2 \frac{\partial^2 p}{\partial x^2} \tag{10}$$

where c' = complex velocity of wave propagation defined as
$\equiv c(1 - i\alpha/k)$
$\alpha \equiv [(c+U)/(c-U)]^2 [\eta_e \omega/(2\rho)]^{1/2}/(c r_1)$
$\eta_e \equiv$ is the effective shear viscosity, and
$r_1 \equiv$ the radius of the pipe.

Now, replacing the derivative $\frac{\partial}{\partial t}$ by its substantial derivative $\frac{D}{Dt} = \frac{\partial}{\partial t} + U\frac{\partial}{\partial x}$, mean flow can be introduced in the system and the resulting transfer matrix form is,

$$\begin{bmatrix} p_s \\ v_s \end{bmatrix}_0 = e^{-iM'k_c'\ell} \underbrace{\begin{bmatrix} \cos(k_c'\ell) & iY'\sin(k_c'\ell) \\ \frac{i}{Y'}\sin(k_c'\ell) & \cos(k_c'\ell) \end{bmatrix}}_{\text{T.M.}} \begin{bmatrix} p_s \\ v_s \end{bmatrix}_\ell \tag{11}$$

where $k_c' = \frac{\omega/c'}{1-(U/c')^2}$ and $Y' = \frac{c'}{S}$. S is the cross sectional area of the uniform pipe.

The transfer matrices derived in the above four cases are quite general in their application and should be used depending on the physical medium of propagation existing in the system. Friction damping should be considered when higher mean flow is present or when friction losses for the pipe surface are considerable. Similarly, damping due to shear viscosity should be considered when viscosity of the propagating medium is significant.

3. Noise Reduction

There are several performance criteria that have been suggested by many researchers in the past. However, some authors use them with different meanings. There are three most commonly used terms: insertion loss, transmission loss, and noise reduction. Insertion loss (IL) is mostly preferred by manufacturers because it is easier to measure; however, its prediction also requires the knowledge of the source impedance. Transmission loss (TL) is easier to calculate and, therefore, is used by researchers. Noise reduction (NR), on the other hand, can be easily predicted as well as measured. By definition NR is defined as the difference between the sound pressure levels measured at the input of a muffler and its output [11]. Experimentally, NR is measured simply by the difference in pressure levels of two microphones - one at the inlet and the other at the outlet of the muffler, whereas the expression for NR can be easily derived starting from the open outlet end. This criterion of muffler performance has been used quite frequently by many investigators presenting experimental work [12-16].

4. Analytical Expression for NR by the Transfer Matrix Approach

Consider a muffler system as shown in Figure 1a. Stations I and II contain the muffler which is terminated by the source and load impedance respectively. Figure 1b shows the equivalent block diagram with source and load impedances connected as lumped elements. The product of transfer matrices from the load end L to station I can be written as follows:

$$\begin{bmatrix} p_I \\ v_I \end{bmatrix} = \begin{bmatrix} & & \\ & T & \\ & & \end{bmatrix}_n \begin{bmatrix} & & \\ & T & \\ & & \end{bmatrix}_{n-1} \cdots \begin{bmatrix} & & \\ & T & \\ & & \end{bmatrix}_1 \begin{bmatrix} 1 & Z_L \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ v_L \end{bmatrix} \qquad (12)$$

where subscripted [T]'s represent the transfer matrices corresponding to the number of elements n present in the muffler system and Z_L represents the load impedance of an unflanged open end. Also in the above equation, p_L has been taken to be zero because of the load end being open to the atmosphere [1].

Equation (12) can also be written as

$$\begin{bmatrix} p_I \\ v_I \end{bmatrix} = \underbrace{\begin{bmatrix} A11 & A12 \\ A21 & A22 \end{bmatrix}}_{A} \begin{bmatrix} 0 \\ v_L \end{bmatrix} \qquad \text{A is the overall product matrix} \qquad (13)$$

giving,

$$p_I = A12 \cdot v_L \tag{14}$$

Similarly, considering the tail pipe, as shown in Figure 1c, one can write,

$$\begin{bmatrix} p_{II} \\ v_{II} \end{bmatrix} = \begin{bmatrix} & & \\ & T & \\ & & \end{bmatrix}_{\ell} \begin{bmatrix} 1 & Z_L \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ v_L \end{bmatrix} \tag{15}$$

where $[T]_\ell$ stands for the transfer matrix of a pipe corresponding to the tailpipe of length ℓ.

Equation (15) can be rewritten in a product matrix form:

$$\begin{bmatrix} p_{II} \\ v_{II} \end{bmatrix} = \underbrace{\begin{bmatrix} A11' & A12' \\ A21' & A22' \end{bmatrix}}_{A'} \begin{bmatrix} 0 \\ v_L \end{bmatrix} ; \quad \text{A' is the product matrix} \tag{16}$$

giving,

$$p_{II} = A12' \cdot v_L \tag{17}$$

From relations (14) and (17) one can define noise reduction (NR) as,

$$NR = 20\log_{10} \left| \frac{p_I}{p_{II}} \right|$$

or

$$NR = 20\log_{10} \left| \frac{A12}{A12'} \right| \text{dB} \tag{18}$$

It should be recognized here that the two product matrix terms A12 and A12' are functions of the physical parameters of the muffler system, the load impedance, and also the frequency of wave propagation. The source impedance does not appear in the expression (18) for noise reduction.

A computer program incorporating the transfer matrices for various muffler elements shown in Figure 2 has been written to predict noise reduction for a particular muffler system consisting of these elements. Recognizing the various elements in a given muffler, one can quite readily predict the noise reduction characteristics. Various transfer matrices with no flow and including flow effects [5,15] have been given in Appendix A.

5. Experimental Set-Up and Measurement Procedure

The schematic diagram of the experimental set-up is shown in Figure 3. The noise reduction due to the muffler system 'I II' can be found by measuring the difference in sound pressure levels at stations I and II.

A sinusoidal acoustic signal was fed into the system by means of a horn driver connected to a power amplifier and the B & K (1022) beat frequency oscillator. The frequency range was controlled by the oscillator between 150 and 1000 Hz. Mean flow in the system was simulated by introducing an air flow of the order of 0.15 Mach number. The velocity of the mean flow was measured at the open end of the system by means of a Pitot tube.

To reduce the inherent fluctuating flow noise due to air turbulence, a silencing tank was connected in-line with the pipe introducing air into the system. A pressure regulator was connected before the silencing tank to maintain a steady pressure and flow of air. Two heterodyne slave filters were used along with measuring amplifiers to filter the signals from the two condenser microphones measuring the sound pressure levels at the input and output of the muffler. A level recorder was mechanically connected to the oscillator to get a continuous record of the sound level variation at sections I and II. All the muffler models were made from 4 mm thick mild steel pipes to avoid any significant vibrations or yielding of the walls.

The five basic types of laboratory mufflers that were tested experimentally are shown in Figure 4. It should be noted that these mufflers are essentially made up of the basic reactive muffler elements shown in Figure 2. Wooden supports were used to hold the mufflers rigidly on the test table.

6. Discussion of Results

6.1 Expansion Chamber Mufflers

The expansion chamber muffler is the simplest possible muffler configuration. Basically, it is made up an an inlet tail pipe, a sudden expansion, an expansion chamber, a sudden contraction, and an outlet tail pipe connected in series. Two expansions chamber type mufflers were fabricated: one with a small expansion chamber of 79.8 mm diameter and 500 mm length and the other with a large expansion chamber of 142.8 mm diameter but of the same length. The two sizes were chosen to determine how well the mathematical model represents a range of diameters.

Before introducing flow into the system, it was decided to verify experimentally the performance of these mufflers without mean flow. The solid line in Figures 5 and 6 shows the NR versus frequency plot for the small and large expansion chamber mufflers respectively, with the effect of viscous damping included. Experimentally measured values of noise reduction have been shown by small circles, whereas triangles represent the predicted NR when there was no damping in the system. These triangles have been shown only at the resonant and antiresonant frequencies where the effect of damping is most pronounced, since for other frequencies the NR remains essentially the same as those represented by the solid line. Generally, the experimental results are in very good agreement with the predicted results except at sharp peaks and valleys. The small discrepancies may be in part due to the inability of the measuring system to record accurately the suddenly changing pressure levels as the frequency of the input is swept over the frequency range. It may be observed that in the NR spectra there are none of the usual expansion chamber humps as are observed in the case of typical TL spectra. The main reason for this characteristic of NR curves is that both the inlet and the outlet tail pipes are also taken into account when predicting the NR of a muffler system.

By the introduction of mean flow into the system, the sharp resonant and antiresonant peaks were dramatically flattened, although the general shape of the attenuation curves still remained the same. Figures 7 and 8 show the predicted and measured results. The general observation in these cases is that damping flattens the peaks. The experimental results are in closer agreement with the case of friction damping with mean flow than with the case of only mean flow. The overall conclusion is that analytical and experimental results agree consistently.

6.2 Muffler With Extended Inlet and Outlet

Extended inlet and extended outlet are, in general, branched types of elements. Figure 9 shows the predicted and measured performance of a muffler using an extended inlet and an extended outlet. The configuration of this muffler has been shown in Figure 4c. Again, the agreement between theory and experiment is reasonably good even though there was a mean flow of 0.15 M through the system. The sharp NR peak observed around 700 Hz is due to the extended outlet elements with a length of 125 mm. The cavity in the extended outlet element acts as a resonator and produces the sharp peak of attenuation at a frequency dependent on the length of the cavity.

6.3 Muffler With a Hole-Cavity Resonator

Hole-cavity type of resonators are meant to generate a high noise reduction peak corresponding to their resonating frequency. This resonating frequency is proportional to the impedance of the holes and volume of the cavity. Unfortunately, by introducing flow into the system, the sharp peak due to the resonant frequency of the resonator disappears. This behavior is verified by the comparison of predicted and measured results for a hole-cavity type of muffler (Figure 4d) presented in Figure 10. Nevertheless, it is a common practice of muffler manufacturers to use fully perforated resonator elements in mufflers to cut down the high frequency content flow noise generated due to various other elements, without excessively restricting the flow of exhaust gases.

6.4 Muffler With Two Flow Reversals

Flow reversal elements form an integral part of present day mufflers used in most North American cars. The usual practice is to use a combination of flow reversals along with expansion chambers, resonators, and branched elements to arrive at the desired muffler configuration. The only disadvantage of reversal elements is that they cause heavy back pressure in the system [7]. Therefore, they attenuate noise at the cost of engine performance. Nevertheless, their high attenuation characteristics are made use of in many automobile mufflers. Figure 11 shows the predicted and measured performance of a muffler using two reversals - an expansion reversal and a contraction reversal (Figure 4e). In general, the agreement is very good except at the resonant peak around 350 Hz.

7. Conclusions

The following conclusions can be drawn from the results presented:

1) Including damping in the no flow case, very good agreement can be obtained between theory and experiment. Damping does not have much effect in the case of mean flow except at the resonant and antiresonant frequencies.

2) Knowledge or characterization of the source impedance is not a prerequisite in determining noise reduction using the transfer matrix approach.

3) Due to the absence of flow in complex elements like extended inlets, extended outlets, hole cavity resonators, and flow reversals, there would not be any additional terms due to friction damping accompanied with the mean flow. Therefore, the transfer matrices developed and used for these elements for the no flow case are satisfactory for the analysis of exhaust mufflers when flow is considered.

4) Perforated tube elements can be successfully modeled as a lumped hole-cavity element only if all holes are located in a single grouping along the tube.

5) Flow reversal elements, which are commonly used in most commercial exhaust mufflers, are effective in generating a large noise reduction in the lower frequency range, but the

fact that they can produce considerable back pressure on the engine should not be overlooked. Instead, extended outlet elements could be introduced in the mufflers to get a similar effect if space permits.

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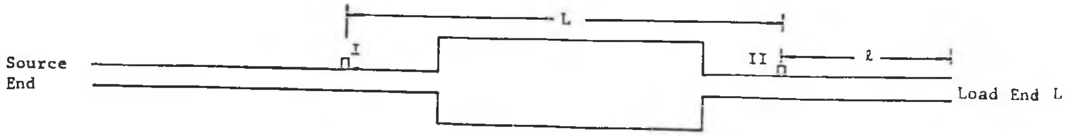
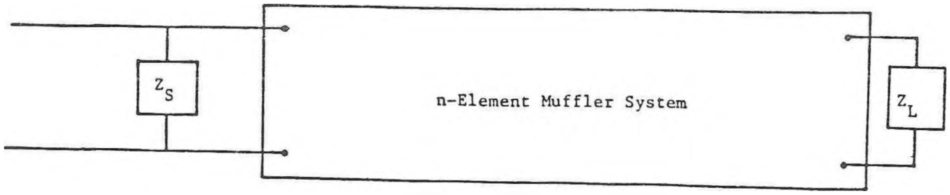
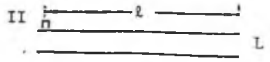


a) Muffler System

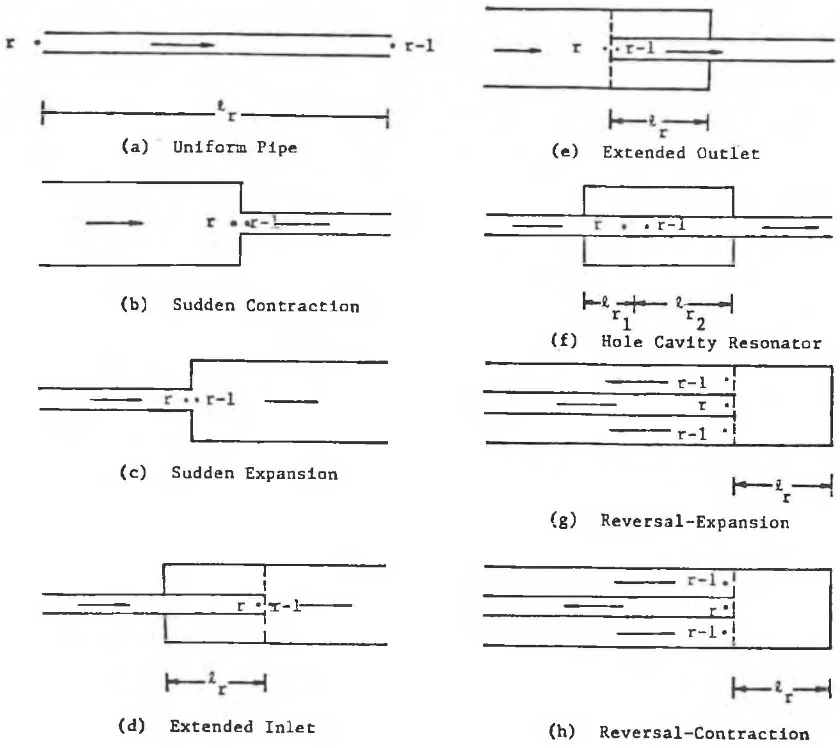


b) Equivalent Block Diagram



c) End Tail Pipe

Figure 1. ANALOGOUS MUFFLER SYSTEM TO PREDICT NOISE REDUCTION.



(a) Uniform Pipe
(b) Sudden Contraction
(c) Sudden Expansion
(d) Extended Inlet
(e) Extended Outlet
(f) Hole Cavity Resonator
(g) Reversal-Expansion
(h) Reversal-Contraction

Figure 2. VARIOUS ELEMENTS CONSTITUTING A REACTIVE MUFFLER.

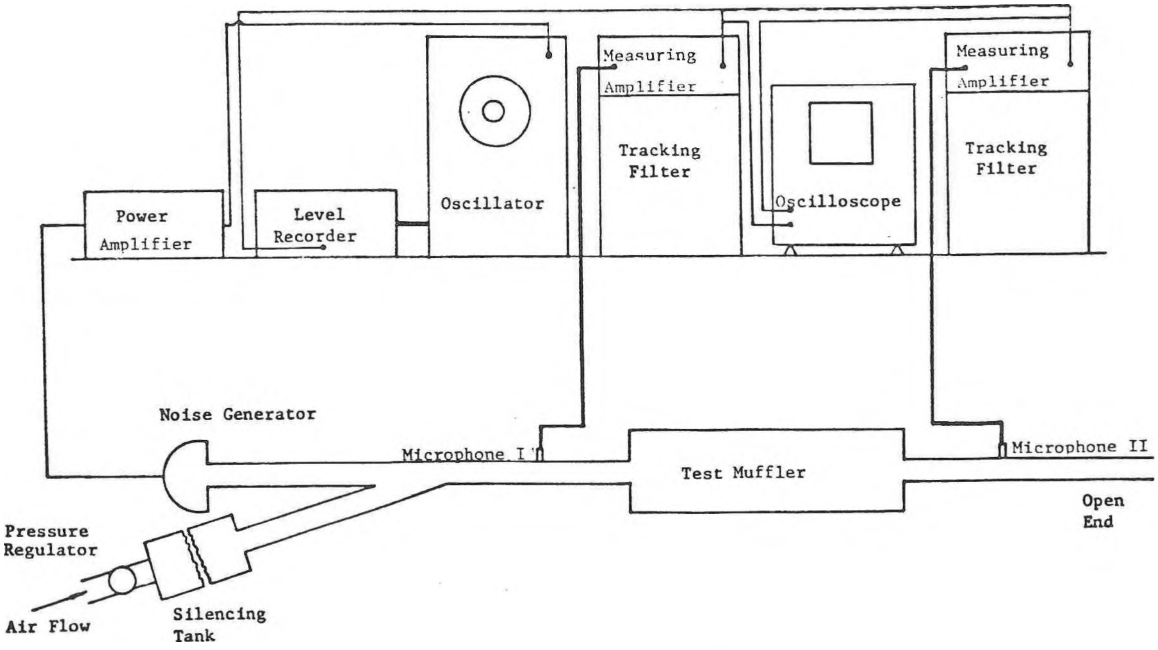
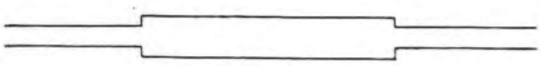


Figure 3. SCHEMATIC DIAGRAM OF EXPERIMENTAL APPARATUS FOR NOISE REDUCTION MEASUREMENTS.



a) Small Expansion Chamber

b) Large Expansion Chamber

c) Small Expansion Chamber with Extended Inlet and Outlet

d) Resonator with Centered Rows of Holes

e) Muffler with Reversal-Expansion and Reversal-Contraction Elements

Figure 4. LABORATORY MUFFLERS TESTED

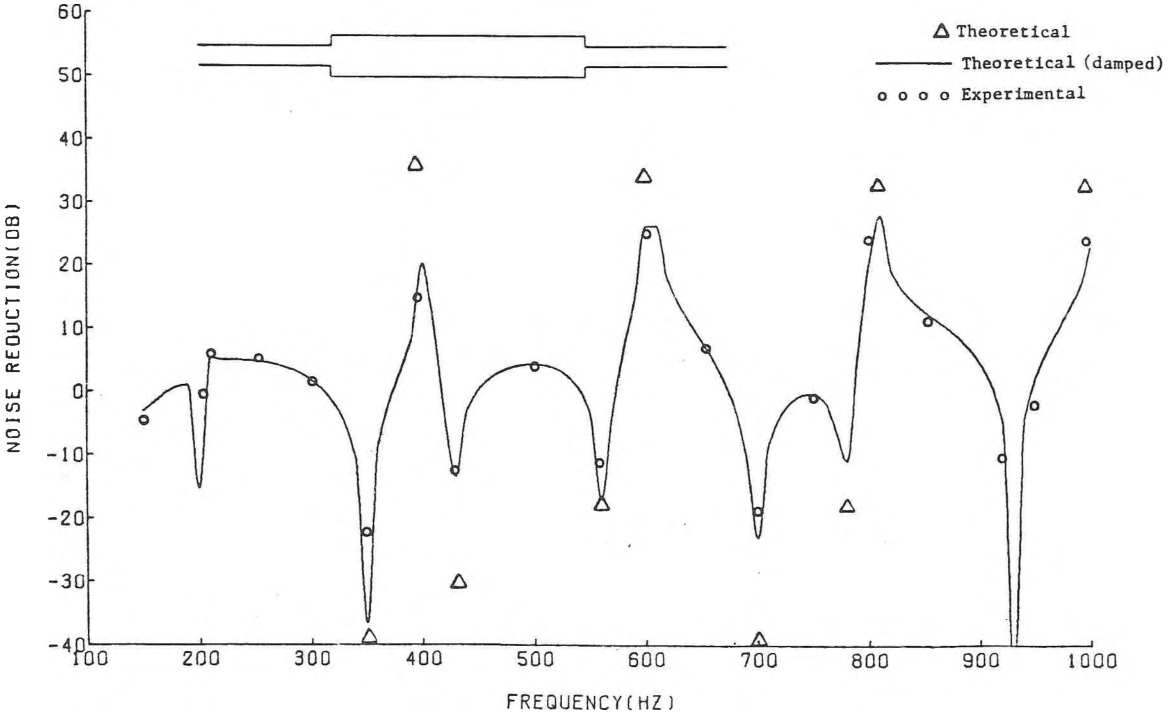


Figure 5. NOISE REDUCTION CHARACTERISTICS OF SMALL EXPANSION CHAMBER MUFFLER WITH NO FLOW.

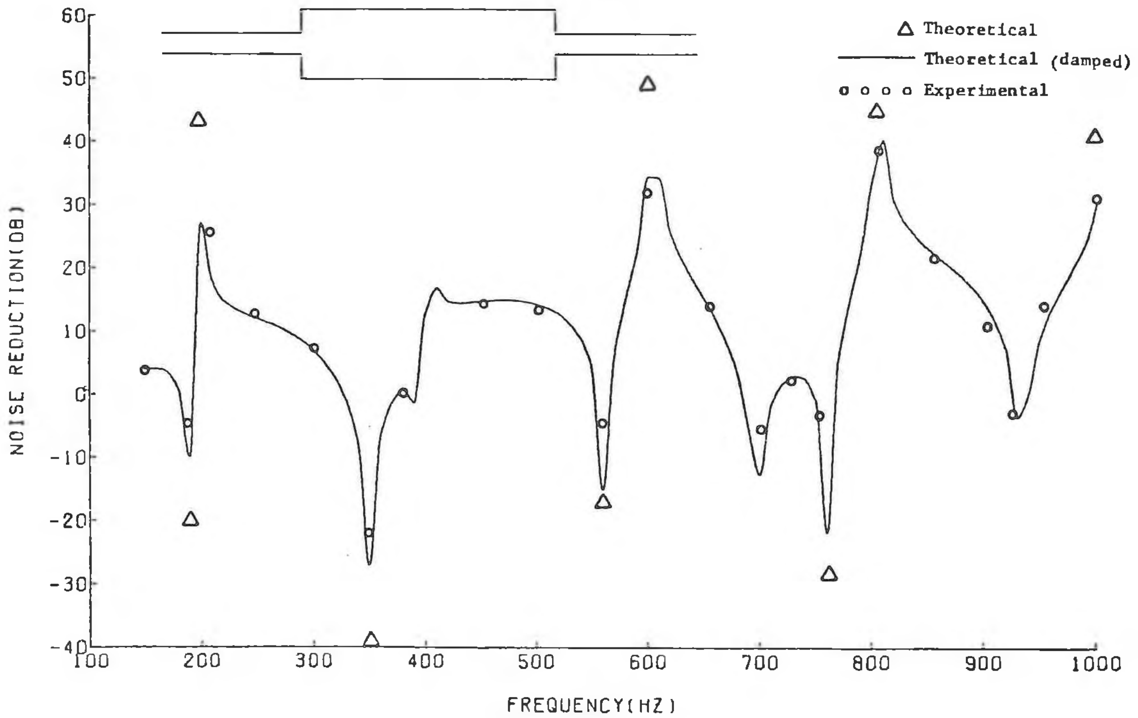


Figure 6. NOISE REDUCTION CHARACTERISTICS OF LARGE EXPANSION CHAMBER MUFFLER WITH NO FLOW.

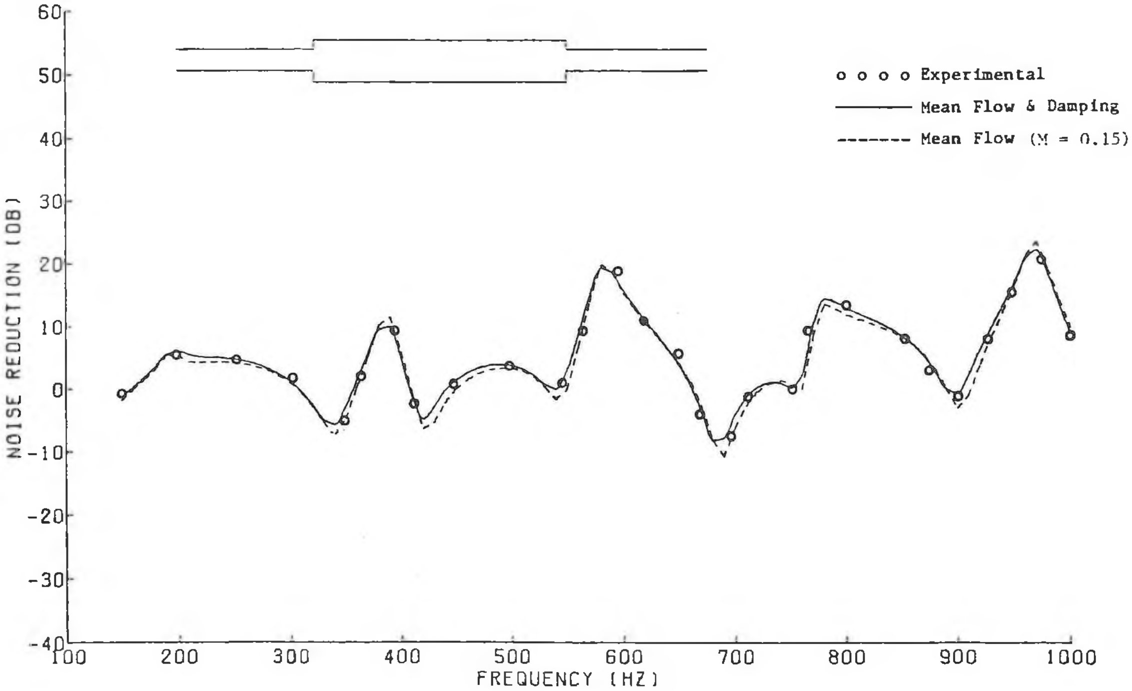


Figure 7. NOISE REDUCTION CHARACTERISTICS OF SMALL EXPANSION CHAMBER MUFFLER

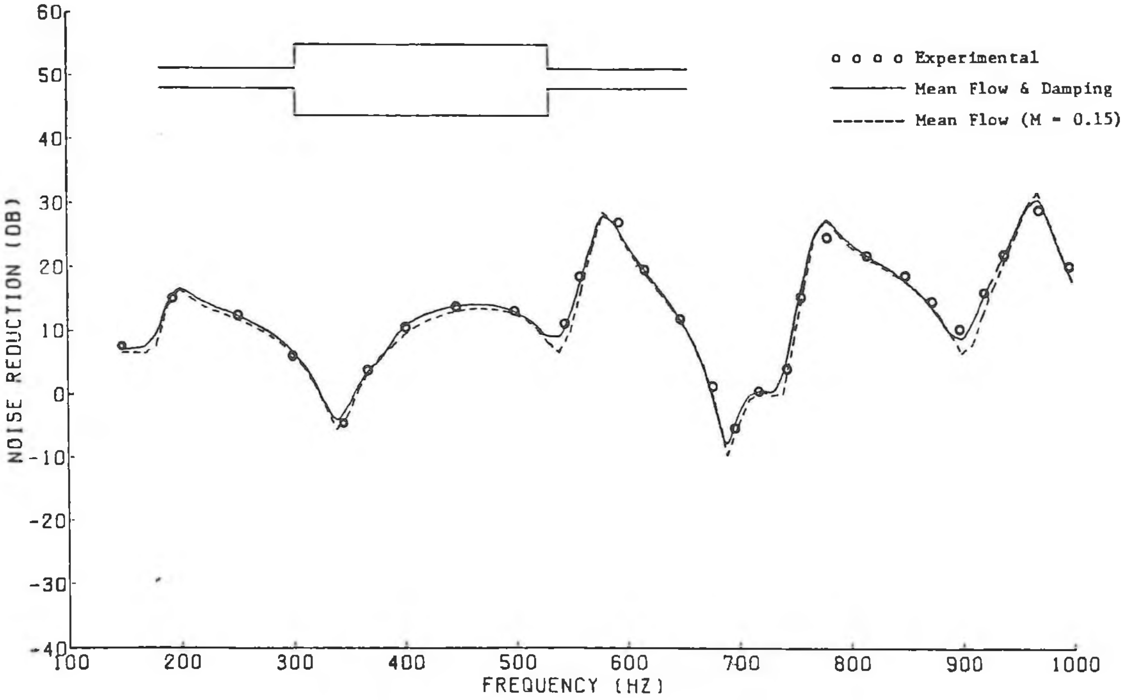


Figure 8. NOISE REDUCTION CHARACTERISTICS OF LARGE EXPANSION CHAMBER MUFFLER.

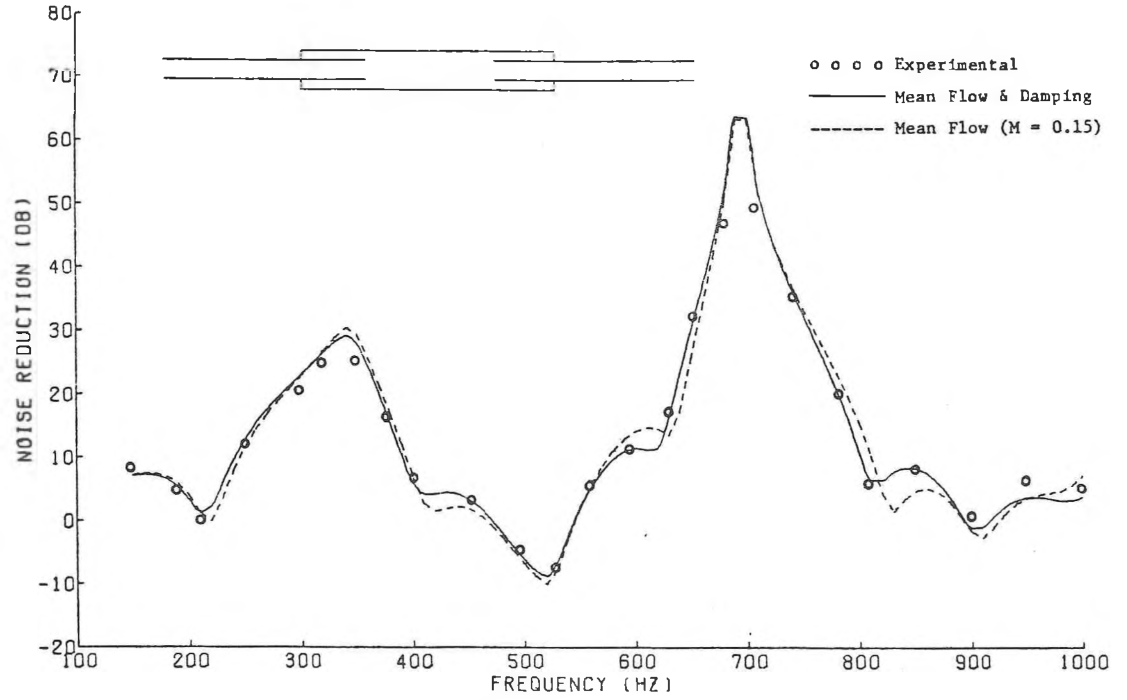


Figure 9. NOISE REDUCTION CHARACTERISTICS OF SMALL EXPANSION CHAMBER WITH EXTENDED INLET AND OUTLET.

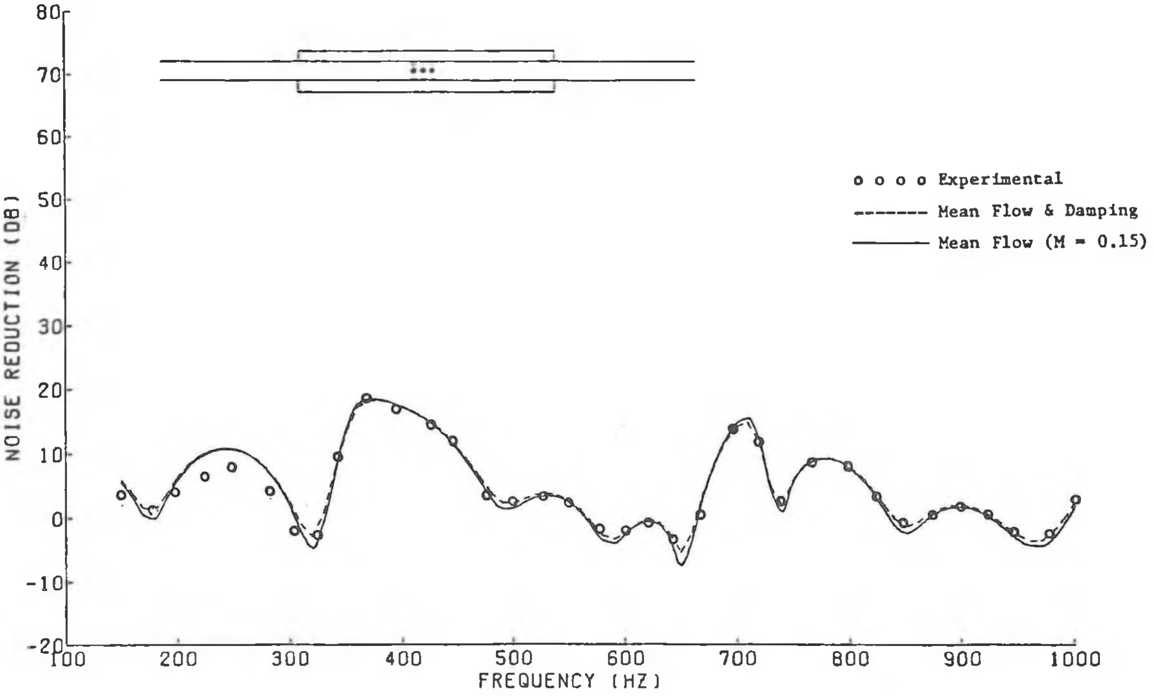


Figure 10. NOISE REDUCTION CHARACTERISTICS OF HOLE-CAVITY RESONATOR MUFFLER.

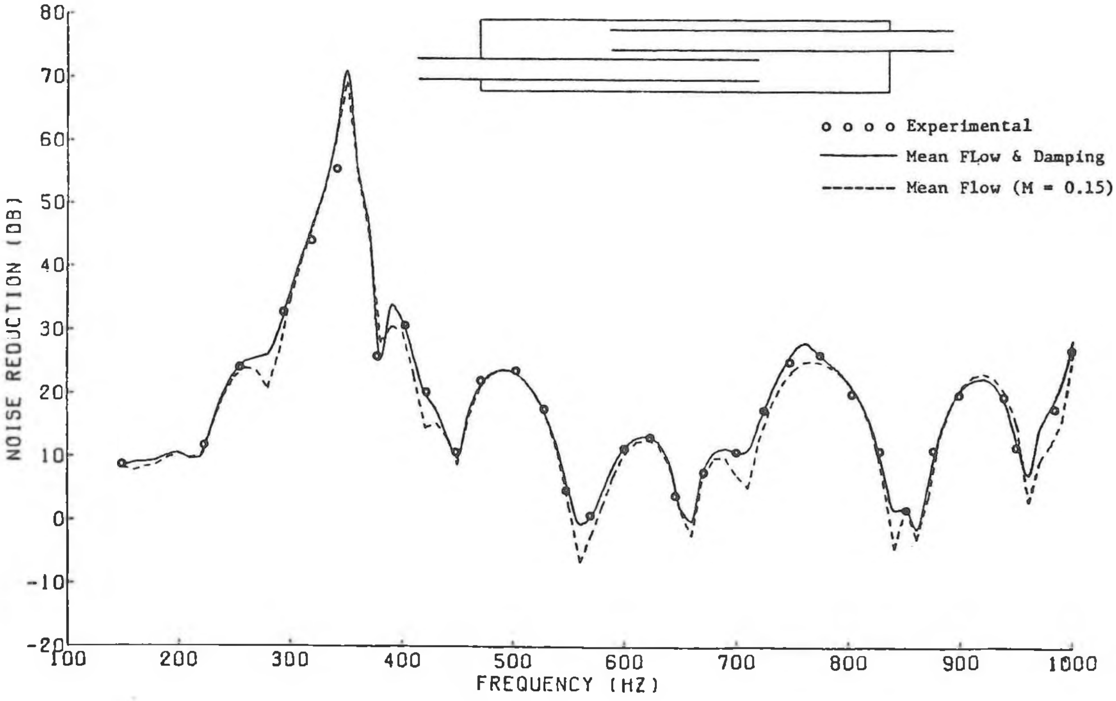


Figure 11. NOISE REDUCTION CHARACTERISTICS OF REVERSAL MUFFLER.

APPENDIX A

TRANSFER MATRICES FOR VARIOUS MUFFLER ELEMENTS

(a) Uniform Pipe

No Flow

$$\begin{bmatrix} \cos(k\ell_r) & iY_r\sin(k\ell_r) \\ \frac{i}{Y_r}\sin(k\ell_r) & \cos(k\ell_r) \end{bmatrix}$$

Mean Flow

$$e^{-iM_r(k_c\ell_r)}\begin{bmatrix} \cos(k_c\ell_r) & iY_r\sin(k_c\ell_r) \\ \frac{i}{Y_r}\sin(k_c\ell_r) & \cos(k_c\ell_r) \end{bmatrix}$$

where $k_c = \frac{k}{1-M^2}$; r is a subscript corresponding to the element.

(b) Sudden Contraction

No Flow

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Mean Flow

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

(c) Sudden Expansion

No Flow

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Mean Flow

$$\begin{bmatrix} 1 & M_{r+1}\cdot Y_{r+1}(1-2N+N^2) \\ 0 & 1 \end{bmatrix}$$

where $N = \frac{S_{r+1}}{S_{r-1}}$.

(d) Extended Inlet

No Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

Mean Flow

$$\frac{1}{1+2NA}\begin{bmatrix} 1+A & M_{r+1}\cdot Y_{r+1}(1-2N+N^2+N^2A) \\ \frac{1}{Z_r} & 1+N^2A \end{bmatrix}$$

where $A = M_{r+1}\cdot Y_{r+1}/Z_r$; $Z_r = -iY_r\cot(k\ell_r)$

(e) Extended Outlet

No Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

Mean Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

where $Z_r = iY_r \cot(k\ell_r)$.

(f) Hole-Cavity Resonator

No Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

Mean Flow

$$\frac{1}{1+2A}\begin{bmatrix} 1+A & M_{r+1} \cdot Y_{r+1} A \\ \frac{1}{Z_r} & 1+A \end{bmatrix}$$

where Z_r is the impedance of the resonator.

(g) Reversal Expansion

No Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

Mean Flow

$$\frac{1}{1+N-NA(1-a)}\begin{bmatrix} 1+N-NA(1-a) & M_{r+1} \cdot Y_{r+1} a \\ \frac{1+N}{Z_r} & 1 \end{bmatrix}$$

where 'a' would vary between 2 and 3; it needs to be determined experimentally.

(h) Reversal Contraction

No Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

Mean Flow

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z_r} & 1 \end{bmatrix}$$

where $Z_r = -iY_r \cot(k\ell_r)$.

WALLACE CLEMENT SABINE AWARD
OF THE
ACOUSTICAL SOCIETY OF AMERICA

Thomas David Northwood

1982

CITATION TO THOMAS DAVID NORTHWOOD

. . . for important contributions to the theory and measurement of sound transmission in buildings and of the sound absorption of acoustical materials, for the development of acoustical standards, and for the general furtherance of architectural acoustics.

ORLANDO • 10 NOVEMBER 1982

THE WALLACE CLEMENT SABINE MEDAL of the Acoustical Society of America is being awarded this year to Thomas D. Northwood for his contributions to architectural acoustics. His activities over a long and distinguished career have covered many areas in this field.

Tom was born in Peterborough, Ontario in 1915 and studied engineering physics at the University of Toronto, receiving his B. Sc. in 1938. After a short period spent doing design work with Northern Electric, he joined the National Research Council of Canada in 1940 as a research physicist working in underwater sound. After the war years, his area of interest was expanded to include architectural acoustics, and in 1948 he was given leave of absence from NRC to do postgraduate studies in seismology. He received his MA in 1950 and his Ph.D. in 1952 from the University of Toronto, both in Physics.

He rejoined the National Research Council to head a new research section concerned with structural dynamics, building acoustics and vibration, noise, and related matters. He held this position in the Division of Building Research until his retirement in 1979.

These activities in building research and acoustical testing developed quite naturally into a strong interest in acoustical standards. He joined the American Society for Testing and Materials (ASTM) around 1951 and has been active on the Committee on Environmental Acoustics for over 30 years, serving as its chairman from 1966 to 1972. Over the years Tom has been active on many task groups and subcommittees charged with writing standards and solving problems in building acoustics. In 1975 he received the ASTM Award of Merit for "outstanding contributions to research and development of standards in building acoustics" and was made a Fellow of the Society.

As chairman of the Canadian Advisory Committee on Acoustics reporting to the Standards Council of Canada he extended his work into international standards, and represented Canada at meetings of the Interantional Organization for Standardization for many years.

He has held membership in the Engineering Institute of Canada, the Association of Professional Engineers of Ontario, and the Seismological Society of America. He is a member of the Institute of Noise Control Engineering and a Fellow of the Acoustical Society of America and of the American Association for the Advancement of Science.

In 1962 he invited together a small number of Canadian acousticians to discuss topics of mutual interest and from this gathering, the Canadian Committee on Acoustics was born. The group has since grown considerably, and was recently renamed the Canadian Acoustical Association. Tom was President of the Association from 1979 until 1982.

His most notable research interests over the years have included noise control, architectural acoustics, and the measurement of sound transmission and absorption. His considerable presence in the field of architectural acoustics led to an appointment as associate editor of the *Journal of the Acoustical Society of America* in 1964, a position he still holds. He has edited a volume in the Benchmark series entitled "Architectural Acoustics" and has published many papers in every area he has worked in.

Tom Northwood has had a long and productive career and made many significant contributions to architectural acoustics. The present award is a fitting acknowledgement of these achievements.

A. C. C. WARNOCK

Reorganization of the Noise Pollution Control Section
Ontario Ministry of Environment - November 29, 1982

In June, 1982, the Ontario Deputy Minister of Environment announced a sweeping reorganization of the Ministry. The former Pollution Control Branch would disappear and its constituent Sections would be re-assigned to other Branches in the Ministry while the Noise Section staff and resources were to be split between two separate Divisions. The future roles of the two Noise Control staffs have now been resolved and the following changes will occur on November 29, 1982. Further staffing and role adjustments may follow.

Noise Policy

New Tel: (416) 965-6343

J. Manuel, Supervisor

C. Krajewski

V. Schroter

Noise Program Delivery

Tel: As Before

H. Gidamy, Supervisor
L. G. Kende
S. D. Benner
J. Clifford
G. Murphy
H. Cotter
E. Granell
D. Choy

The noise policy staff will review policy and planning issues, liaise with other bodies, promote municipal responsibility for local noise control, develop standards and guidelines, promote technology transfer, and the training of municipal noise control officers and others. The role will be expanded to include the development of expertise in all forms of non-ionizing radiation defined in the Environmental Protection Act as contaminants of the natural environment.

The noise program delivery staff will liaise with technical staff in the Environmental Approvals and Project Engineering Branch and Ministry Regional Offices, provide technical comment and analysis of new projects, maintain legal standards and the test lab, investigate noise complaints and support enforcement.

The Ministry re-organization will considerably strengthen the Province's preventative planning capability, improve its ability to respond effectively to long term noise issues, enhance the technology transfer and training process, and provide increased opportunities for applied research by external consultants in areas affecting human health and welfare.

Enquiries regarding Environment Ontario noise policy and related issues, training courses, softwear design and technical publications should continue to be addressed to John Manuel, Environment Ontario, 135 St. Clair West, Toronto, M4V 1P5.

John Manuel

inter•noise 83

THE INTERNATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING

Secretariat:- Institute of Acoustics, 25 Chambers Street, Edinburgh EH1 1HU, Scotland, UK.

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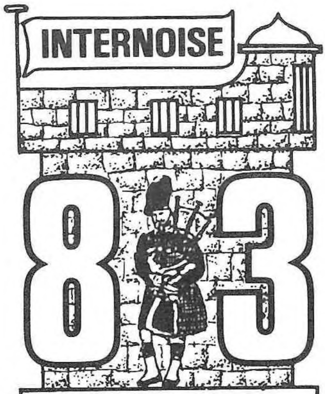

EDINBURGH
13–15 JULY 1983

CALL FOR PAPERS

The Twelth International Conference on Noise Control Engineering will be organised by the British Institute of Acoustics and will be held in the City of Edinburgh

13th – 15th July, 1983.

The theme of the Conference will be the International Scene with emphasis on practical engineering approach and solutions.

The technical program will consist of invited and contributed papers and poster sessions and will cover the following topics and any other connected with noise control engineering :-

1. Effects of industrial vibration on man
2. Occupational noise, its effect and control
3. Effects of industrial vibration on structures
4. Machine noise and vibration – prediction and control
5. Diagnostics, including monitoring
6. Noise in industry, including planning
7. Noise control in buildings and building services
8. Opencast mining and quarrying
9. Ships and offshore noise and vibration
10. Transportation noise control
11. Community noise, including construction, aircraft etc
12. Domestic appliance noise and vibration
13. Diesel engine noise
14. Low frequency noise, occurrence/effects
15. Instrumentation
16. Application of active noise reduction

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AIAA 8TH AEROACOUSTICS CONFERENCE

April 11-13, 1983

Terrace Garden Inn
Atlanta, Georgia

The objective of this conference is to present and exchance information on current research related to noise generation by flight vehicles, and methods of noise reduction. The conference is directed to representatives of all disciplines concerned with fluid flow noise generation, propulsion noise, propagation and transmission. Particularly solicited is participation from workers in underwater acoustics with emphasis on areas in which either physical principles or problem solving techniques overlap with aeroacoustics.

Experimental, theoretical, and applications oriented papers are solicited in, but not limited to, the following technical areas: Jet Noise Turbo Machinery Noise, "Core" Noise, Propeller Noise, Flight Effects on Inlet Fan Noise, Airframe and Propulsive Lift Noise, Interior Noise and Structural/Acoustic Interaction, Near Field Noise Environment, General and Nonlinear Acoustics, Sound Propagation, Underwater Acoustics.

The inclusion of underwater acoustics in this conference represents the intent of the Aeroacoustics Technical Committee to foster interaction between practitioners in the two fields in recognition of the fact that a large area of common interest exists. Toward this end, an invited lecture in underwater acoustics will be a feature of the technical program.

Submit abstracts (approximately 1,000 words) in triplicate by October 1, 1982, to the Conference General Chairman:

Professor Walter Eversman,
Department of Mechanical & Aerospace Engineering,
University of Missouri - Rolla,
Rolla, MO. 65401.

Authors should indicate which of the above areas is most relevant to their papers. Contributors will be notified of acceptance by December 13, 1982, and manuscripts will be due on February 7, 1983.

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