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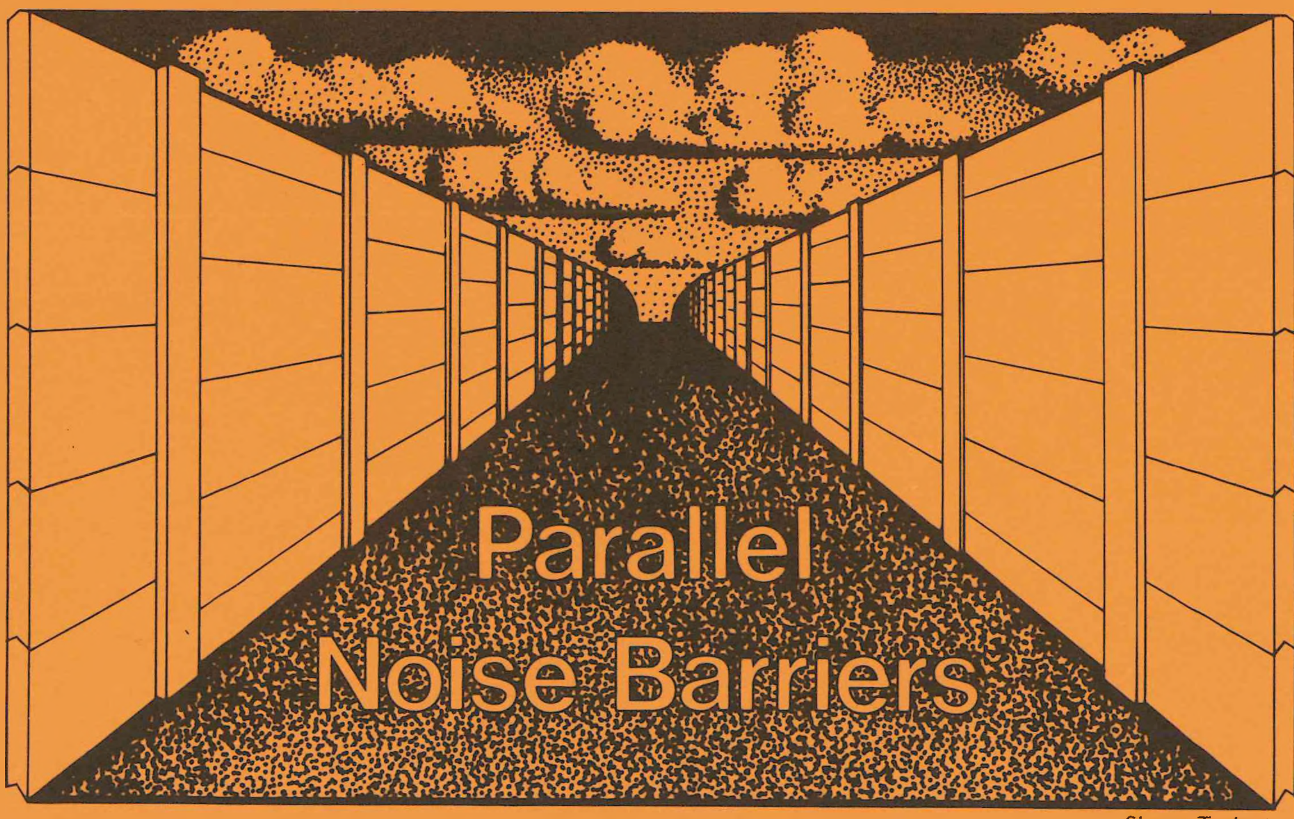

Simon Tuckett

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Articles on 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

A reminder to our readers to plan to spend the week of October 18-22, 1982, in Toronto. Details of the week's activities are given in this issue and include three 2-day seminars, the CAA Annual Symposium on Acoustics, and the CSA Committee on Acoustics and Noise Control Annual General Meeting. Those planning to attend the CAA Symposium are encouraged to participate. Why not sit down today and write a short abstract (less than 200 words), and mail it to the convenor, John Manuel (address on inside back cover).

If you wish to nominate CAA officers at the CAA Annual business meeting, see following news item for details.

EDITORIAL

Ceci est un rappel pour nos lecteurs d'envisager de passer la semaine du 18 au 22 octobre 1982 à Toronto. Le programme d'activités se trouve dans ce numéro, il inclut des détails à propos de 3 séminaires (chacun dure 2 jours), du symposium annuel de l'ACA sur l'Acoustique, et de la Reunion Générale Annuelle du Comité de l'ACN sur l'Acoustique et le Contrôle du Bruit. Ceux qui assisterons sont invités à participer : écrivez un sommaire (moins de 200 mots), aujourd'hui même et envoyez-le à John Manuel (voir l'adresse à la dernière page).

ACOUSTICIAN MOVES WEST

A.G. (Tony) Taylor recently took up an appointment as Engineer, Mechanical Engineering Services, with Bently-Nevada Canada Ltd., Nisku (Edmonton), Alberta, TOC 2G0. Telephone (403) 995-8922.

CAA NOMINATIONS/NOMINATIONS DE L'ACA

The bylaws of the Canadian Acoustical Association require that the past-president nominate persons to fill vacancies that occur on the Board of Directors and Officers of the Association.

Past-president, Bill Bradley has advised us that he will make the following nominations/L'ancien président de l'ACA Bill Bradley nous a appris qu'il nommera les personnes suivantes:

President/Président: Cameron Sherry
Executive Secretary/Secrétaire:
John Manuel (continuing)
Editor/Editeur: Deirdre Benwell
(continuing)
Treasurer/Trésorier: Jean Nicolas
(continuing)

Directors: The terms of two of our directors, Joe Piercy and Doug Whicker, expire this year. To replace them, David Quirt (National Research Council) and Raymond Hétu (University of Montreal) will be nominated to serve for a four year period.

Further nominations are invited and should be in the hands of the Executive Secretary, together with the consent of the nominees to serve, prior to the Toronto meeting./Autres nominations sont invitées et doivent être reçues avec le consentement des nominés par le Secrétaire (John Manuel) avant le Réunion Générale Annuelle à Toronto.

CAA TORONTO CHAPTER MEETING

The CAA Toronto Chapter held a meeting in the Mount Sinai Hospital Auditorium on Easter Monday, April 12, 1982. The subject of the meeting was Industrial Audiometry and the meeting was chaired by Dr. Sharon Abel. In spite of the holiday and change of venue, some 20 members attended the meeting and the question sessions were lively. There were 3 guest speakers. The first speaker

Dr. Wills, spoke on "Monitoring Noise-Exposed Workers at Ontario Hydro", with particular emphasis on achieving follow-up action when a worker with a hearing loss problem is identified. The second speaker, Mrs. Benwell, presented a paper on "Calibration and Evaluation of Audiometers", outlining results obtained when evaluating acoustical parameters of new audiometers using CSA Standard Z107.4. Five out of the 13 audiometers tested had non-linear attenuators at hearing levels less than 20 dB. The final presentation was made by Mr. Davis, on "Computerized Hearing Testing, Storage and Analysis". Mr. Davis ably elucidated the benefits of computerized hearing testing, and the advantages of using a microprocessor interface. The versatility, speed and reasonable cost of this type of system were emphasized.

The meeting closed with a short speech of thanks to the speakers given by Winston Sydenborgh, who also kindly provided the doughnuts. Coffee and the projectionist were by courtesy of Dr. Peter Alberti.

ASTM COMMITTEE E-33 ON ACOUSTICS REPORT

A new Task Group on Procedures to Evaluate Acoustical Communication Between Work Stations in Open Plan Offices was formed during the meetings on American Society for Testing and Materials (ASTM) Committee E-33 on Environmental Acoustics at ASTM Headquarters in Philadelphia, 5-7 April 1982. The task group will develop one or more standard methods to measure the degree of speech communication or isolation between work stations in open plan offices.

A new Task Group will revise ASTM Method C 367, "Strength Properties of Prefabricated Architectural Acoustical Tile or Lay-in Ceiling Panels." The revision will include a new precision and accuracy section and a section on laboratory accreditation. The Committee seeks new members for this task group.

Another Task Group will revise ASTM Recommended Practice E 497, "Installation of Fixed Partitions of Light Frame Type for the Purpose of Conserving Their Sound Insulation Efficiency". The revision will expand the scope of the standard to include demountable office partitions.

The organization of a round robin test series using "Proposed Test Method for Measurement of the Interzone Attenuation of Ceiling System Assemblies for Open-plan Spaces" was announced. The results of the round robin will be used to determine the precision and accuracy of the proposed method.

An adjunct that contains a drawing of the "Sound Absorption Panel, Oct. 1964 Standard Sample" was submitted to ASTM Headquarters. The adjunct also contains data obtained with this standard sample on Acoustical Materials Association (AMA) No. 4 and No. 7 mountings. Copies of the adjunct are available at a nominal cost from ASTM Headquarters.

Prof. Howard F. Kingsbury received the ASTM Award of Merit "for dedication to the cause of voluntary standards in acoustics and for shaping the destiny of Committee E-33 on Environmental Acoustics through his leadership and friendship". The Award, which is the highest honor ASTM can bestow on a member, was presented by G.O. Atkinson, ASTM Vice President for Standards Development.

The next meeting of Committee E-33 will be 25-27 October 1982 in Toronto, Ontario, Canada, at the Royal York Hotel. Further information about Committee E-33 and its activities can be obtained from David R. Bradley, ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103; Telephone (215) 299-5560.

BLACHFORD RECEIVES AN ACADEMY AWARD FOR SOUND REDUCTION

H.L. Blachford together with Dr. Louis Stankiewicz received a Technical Achievement Award for the development of

Baryfol sound barrier materials used in silencing cameras on movie sets. The Award, given by the Academy of Motion Picture AMS and Sciences, was presented in late March 1982 at Beverly Hills, California.

NELSON INDUSTRIES INC. 1983 ACOUSTICAL PAPER AWARDS PROGRAM

Nelson Industries is sponsoring an open paper competition for outstanding original papers on mufflers, silencers and related acoustical technology. Entries may be in the form of a research paper, engineering study, case history, or review paper. The first prize is $2000.00 and the deadline for submission is September 1, 1982. Entry forms and additional information are available from: - Larry J. Eriksson, Corporate Research Dept., Nelson Ind. Inc., P.O. Box 428, Stoughton, WI, U.S.A. 53589, Tel (608) 873-4373.

SEVENTH GENERAL ASSEMBLY OF I-INCE.

I-INCE met in Amsterdam on October 9th 1981 in Amsterdam. Hugh Jones represented the Canadian Acoustical Association. The following meetings of I-INCE are planned: May 17-19, 1982, San Francisco; July 13-15, 1983, Edinburgh, Scotland, December 3-5, 1984, Honolulu, Hawaii.

NEW RESEARCH CONTRACTS

To Hydroman Inc., Trois-Rivieres, Que., $98,645 for "Development of a methodology for inspecting submerged works using electro-acoustical devices". Awarded by the Dept. of Public Works.

To Mr. Morissette, Dept. of Electrical Engineering, U. of Sherbrooke, Sherbrooke, Que., $30,073 for "Transmission of spoken information - phase I". Awarded by the Dept. of Communications.

To Melville Shipping Ltd., Calgary, Alta., $300,000 for "Continuation of stress analysis - M.V. Arctic hull girder stress and vibratory response during ship-ice interaction. Awarded by the Ministry of Transport.

To IBI Group, Toronto, Ont., $75,000 for "Identification and assessment of the communication/information needs for the visually/hearing/speech-impaired travellers". Awarded by the Ministry of Transport.

To Caulfield Creative Arts Ltd., Sherwood Park, Alta., $977,184 for "Development of a correlation sonar current meter and ice movement detector". Awarded by the Dept. of Fisheries and Oceans.

To Dr. R.B. Hicks, Dept. of Physics, U. of Calgary, Calgary, Alberta, $16,993 for "Development of digital controller processor for acoustic sounder". Awarded by the Dept. of the Environment.

To Dr. Richarz, Inst. for Aerospace Studies, U. of Toronto, Toronto, Ont., $10,303 for "Development of a thunder recognition device". Awarded by the Dept. of the Environment.

To Dr. A. Schwarz, Vancouver, B.C., $23,279 for "Study to investigate the response of pacific herring to waterborne sounds produced by fishery operations in British Columbia - phase II. Awarded by the Dept. of Fisheries and Oceans.

To Techno Scientific Inc., Downsview, Ont., $88,862 for "Advanced ultrasonic techniques for non-destructive evaluation". Awarded by the National Research Council.

To Drs. Gottlieb and Hansen, Institute for Aerospace Studies, U. of Toronto, $279,197 for "Blast simulation and structural response". Awarded by the Dept. of National Defence.

To Drs. Gottlieb and Richarz, Institute of Aerospace Studies, U. of Toronto, $10,074 for "Development of a calibrated microphone system for noise measurements in the Defence and Civil Inst. of Environmental Medicine experimental deep diving facility. Awarded by the Dept. of National Defence.

To ZVOOK Corporation, Toronto, Ont., $37,695 for "Development of a voice synthesizing reading system". Awarded by the National Research Council.

To J.M. Shearer, Ottawa, Ont., $25,000 to "Conduct an evaluation of side scan sonar technology and mosaicing techniques for Beaufort Sea Shelf/Slope and Hibemia Seabed Morphology Research. Awarded by the Dept. of Energy, Mines and Resources.

To Arctic Sciences Ltd., Sidney, B.C., $142,257 for "Study of the measurements of winds over coastal waters by acoustic remoe sensing". Awarded by the Dept. of Fisheries and Oceans.

SITUATIONS WANTED

1. Graduate, mechanical engineering, with lab and field training in acoustics, psychoacoustics, instrumentation, data analysis and software development.
2. B.Sc. Honours, Southampton. Ten years of applicable experience in laboratory testing and design, room acoustics, environmental and industrial noise control, and vibration.
3. Laval graduate in civil engineering. Limited training in acoustics. Bilingual. Software development experience, Fortran, Basic, APL.

If interested, more information on these files can be obtained from John Manuel (416) 965-1193.

POSITION WANTED

Ph.D. in Psychoacoustics

U.S. trained landed immigrant in Canada with experience in psychoacoustics (masking and noise); physiological acoustics (single cell, and average evoked potential electrophysiology); pharmacology of the auditory system (iontophoretic manipulation of auditory neurons using putative neuro-transmitters); neuroanatomy of auditory structures; as well as techniques of acoustical measurement, calibration and spectral analysis.

In addition to upper level teaching experience I was project leader in charge of support personnel contracted to the neuro-physiology laboratory at NASA's Johnson Space Center in Houston, Texas, conducting both auditory and vestibular research in a strongly application-oriented engineering environment.

Following a post-doctoral year in the U.S., I am seeking a Canadian position in an industrial, medical or academic context.

For a complete resume and references, contact:

Maurus J. Moore
15 Tangreen Court, #611
Willowdale, Ontario
M2M 3Z2

Phone: (416) 223-1520

JOB WANTED

THOMAS KELLY is looking for a suitable position in the acoustics field. He holds a bachelors degree in acoustical engineering from the Institute of Sound and Vibration Research, University of Southampton, England. His five years experience, gained in the U.K. and Canada, encompasses most aspects of acoustics including the engineering of room acoustics, building service noise and vibration control, industrial noise and vibration control, environmental and community noise, silencer testing and airflow and acoustics commissioning of H & V systems.

Please contact the applicant at Suite 3, 2043 Collingwood Street, Vancouver, British Columbia V6R 3K7. Telephone: (604) 734-9467

REPORT ON PLANNING OF
12TH ICA IN CANADA, 1986.
TORONTO, JUNE 17-18, 1982

The expanded 12th ICA planning group met with CAA Directors and other co-opted delegates in Toronto on June 17-18, 1982 to consider the reports of working groups, to review the proposed organizational structure, to assign tasks and to approve plans for future activities.

The following members participated in the discussions:

S. Abel **+	J. Hemingway +
T. Brammer	J. Manuel
A. Cohen *	T. Northwood
R. Cyr +	M. Osman +
A. Edwards	J. Piercy +
T. Embleton	W. Richarz
G. Faulkner	L. Russell *+
S. Forshaw	C. Sherry +
F. Hall	E. Shaw
	A. Warnock

Apologies were received from eight of the twelve remaining delegates invited to the Toronto Meeting:

W. Bradley	D. Hill
D. Cheeke	H. Jones
L. Cuddy	J. Nicolas
R. Hetu	D. Whicker

LEGEND:
+ CAA Directors
* June 17, 1982 only
** June 18, 1982 only

On opening the meeting, President Tom Northwood reviewed the progress to date in organizing the 12th ICA in Canada in 1986. He also briefly reviewed the minutes of the two teleconferences held prior to the Toronto meeting. A proposed organizational structure was then tabled for discussion. The CAA Directors present then unanimously accepted the planning group's nominations for the 12th ICA Canada Executive Committee. The following appointments were confirmed:

Chairman, Executive Committee 12th ICA CANADA	E. A. G. Shaw
Vice-Chairman and Chairman, Technical Program Committee	T. F. W. Embleton
Secretary-General	J. Manuel
President, Canadian Acoustical Assoc.	T. D. Northwood
Chairman, Congress Advisory Committee of CAA	T. D. Northwood *
Vice-Chairman, Congress Advisory Committee of CAA	A. C. C. Warnock **
Chairman, Toronto Congress Planning Committee	A. T. Edwards
Chairman, Committee on Coordinated Meetings	J. E. Piercy
Chairman, Budget, Finance and Banking Committee	F. L. Hall
Chairman, Commercial Exhibits Planning Committee	J. R. Hemingway
Chairman, Facilities & Accommodation Committee, U of T	W. Richarz
Chairman, Funds Raising Committee	J. Manuel

* Incumbent's term ends October 20, 1982
** Assumes Chair October 21, 1982.

It was also recommended that the existing thirty-one members of the planning group would become the Congress Advisory Committee of CAA with powers to co-opt additional members as required. Tony Embleton and John Manuel reported on contacts established with International INCE and other bodies. To facilitate coordination with INTERNOISE '86 the planning group agreed to the suggestion of running the Toronto Congress from Thursday to Thursday instead of the traditional Wednesday to Wednesday. Tony Embleton was empowered to continue these negotiations with I/INCE and others on behalf of the Canadian Acoustical Association and the 12th ICA Executive Committee.

Joe Piercy presented his report on the planning of coordinated technical meetings being proposed for other Canadian centres. In order to accommodate the proposed INTERNOISE '86 schedule, it was agreed that the other coordinated meetings being planned should focus on specialized areas of acoustics that would attract those that would normally not participate in an INTERNOISE meeting.

Reports were also received from Aubrey Edwards, Fred Hall, Werner Richarz and John Manuel on their respective responsibilities. Sharon Abel agreed to work with Werner Richarz in reviewing U. of T. accommodation to ensure that adequate, air-conditioned space is available on campus for as many as fourteen parallel sessions, plenary sessions, commercial exhibits, official functions and other social activities.

It was agreed that the 12th ICA Executive Committee would prepare a more detailed report for presentation to the Directors and the CAA annual meeting in Toronto on Wednesday, October 20, 1982

J. Manuel
Secretary-General

NOTICE OF 1982 ANNUAL GENERAL MEETING

The 1982 annual general meeting of the Canadian Acoustical Association will be held at the Westbury Hotel, Toronto, on Wednesday, October 20, 1982 commencing at 2:00 p.m. in the afternoon. The agenda and notices of motion will be circulated to members in due course.

FINAL CALL FOR PAPERS

1982 CAA Symposium On Acoustics

The CAA technical symposium will be held at the Westbury Hotel, Toronto, on October 21-22, 1982. Abstracts on all aspects of acoustics are invited for presentation at the symposium. Abstracts, not more than 200 words in length, should be received by the Convenor, John Manuel, not later than July 31, 1982.

To mark the 21st annual meeting of members, a number of structured sessions are being organized for presentation at the symposium. Members wishing to contribute in these closely defined areas of acoustics, should contact the structured session organizers directly.

Hall Acoustics	-	John Bradley & Ted Schultz (613) 993-2305 (617) 491-1850
Outdoor Propagation	-	Tony Embleton & Joe Piercy (613) 993-2840 (613) 993-2840
Hearing & Speech	-	Edgar Shaw & Sharon Abel (613) 993-2840 (416) 596-3014
Ultrasound	-	Hugh Jones & David Cheeke (902) 424-2272 (819) 565-3588
Non-Destruct. Test.	-	John Baron (416) 231-4111 Ext. 6057
Dosimetry	-	Alberto Behar & Shal Gewurtz (416) 683-7516 (416) 965-4066

1982 CAA SEMINAR PROGRAM

Three 2-day seminars will be offered concurrently during the Toronto Acoustics Week for CAA members and others working in these fields. The seminars offered are topical and informative. Ample opportunity for discussion will be provided during and at the end of each session.

1) VIBRATION: Aspects of vibration will be examined in a multi-session program. Random excitation, analysis, experimental methods, instrumentation, control of vibration, case studies, effects on humans, standards and regulations, will be covered.
The vibration seminar coordinator is Werner Richarz (U Of T). Speakers may include specialists such as:
Gunnar Rasmussen (B & K), Don Allen (U of T)
Tony Brammer (NRC), Stan Forshaw (DCIEM)
Mo Dokainish (McMaster), Hans Rainer (NRC)
Jan Tiessinga (OMTC), Alex Hunt (TTC)
John Swallow (BCS Assoc.), Moustafa Osman (Ont. Hydro)
Dev Gorsain (SPAR), Ron Venter (U of T)
Louis Strasberg (OMTC), Vic Schroter (OME).

2) NOISE CONTROL IN THE WORKPLACE: The proposed Ontario occupational noise regulation and measurement guidelines will be examined in detail. Methods of controlling noise exposure in the workplace will be discussed. Case histories will be used to illustrate the implementation of the proposed noise regulations. This seminar will be coordinated by Shal Gewurtz (OML) and Marilyn Pike (OML). Other speakers may include: Peter Pelmear M.D., Director, (OML), Hazem Gidamy (OME), Mal Sacks (Tacet Eng.), Tim Kelsall (Hatch), Errol Davis (SLD), George Menzies (Stelco), Alberto Behar (Ont. Hydro), Margaret Haley, M.D. (WCBO), representatives of the Joint Health & Safety Committee, Ontario, and representatives from management and labour.

3) NOISE CONTROL IN LAND USE PLANNING: The prevention of noise problems occurring in new residential developments will be the central theme of this seminar. Methods for predicting the impact of noise and methods for the control of noise in new housing subdivisions will be examined. Standards, regulations and guidelines will be evaluated. This seminar will be coordinated by Sheldon Benner (OME). Other speakers may include: Hazem Gidamy (OME), Al Lightstone (VIBRON), John Coulter (BCS Assoc.), Jim Clifford (OME), John Manuel (OME), Brian Ward (OME), Don Pirie (OME), Gary Leveck (Dillon), Marv Rubenstein (MMM), Mike Merritt (J.B. Assoc.), Andy McKee (B & K), Jerry Hajek (OMTC), Fred Jung (OMTC).

Detailed information on the seminars, the symposium and other CAA activities will shortly be circulated to CAA members and others. Registration forms and hotel arrangements will be included in this separate mailing which will follow. The notices given above are provided for information only and are subject to change without notice.

FIELD PERFORMANCE OF PARALLEL BARRIERS

By:

R.E. Halliwell
Division of Building Research
National Research Council of Canada
Ottawa, Ontario K1A 0R6

ABSTRACT

The behaviour of single highway noise barriers is fairly well understood, but little attention has been given to possible interactions when two barriers are built parallel to each other. A series of measurements on two barriers along Highway 417 suggest that the effects of any interactions are small if they exist at all.

SOMMAIRE

On comprend déjà très bien le comportement des écrans anti-bruit isolés installés en bordure des autoroutes. Toutefois, peu d'études ont été entreprises dans le but de comprendre l'interaction de deux écrans de ce genre placés en parallèle. Une série de mesures portant sur deux écrans anti-bruit installés le long de l'autoroute 417 porte à croire que si une telle interaction existe, elle est faible.

INTRODUCTION

The field performance of highway noise barriers has been studied extensively in the past few years. These studies usually have involved measurement of the performance of a single barrier parallel to one side of a roadway, with little or no interest being given to the situation where barriers are present on both sides of the roadway. It has been suggested by some workers[1,2] that this latter configuration can result in degradation of the barrier performance due to a reverberant build up of sound, in some cases producing a net increase in noise level behind the barriers. There is also evidence from other workers[3] indicating that there is no interaction between the barriers, and that the two barriers may be treated as being independent.

The proposed construction of two noise barriers, one on each side of Highway 417 in Ottawa, between Woodroffe and Maitland Avenues, provided an opportunity to test the performance of this configuration.

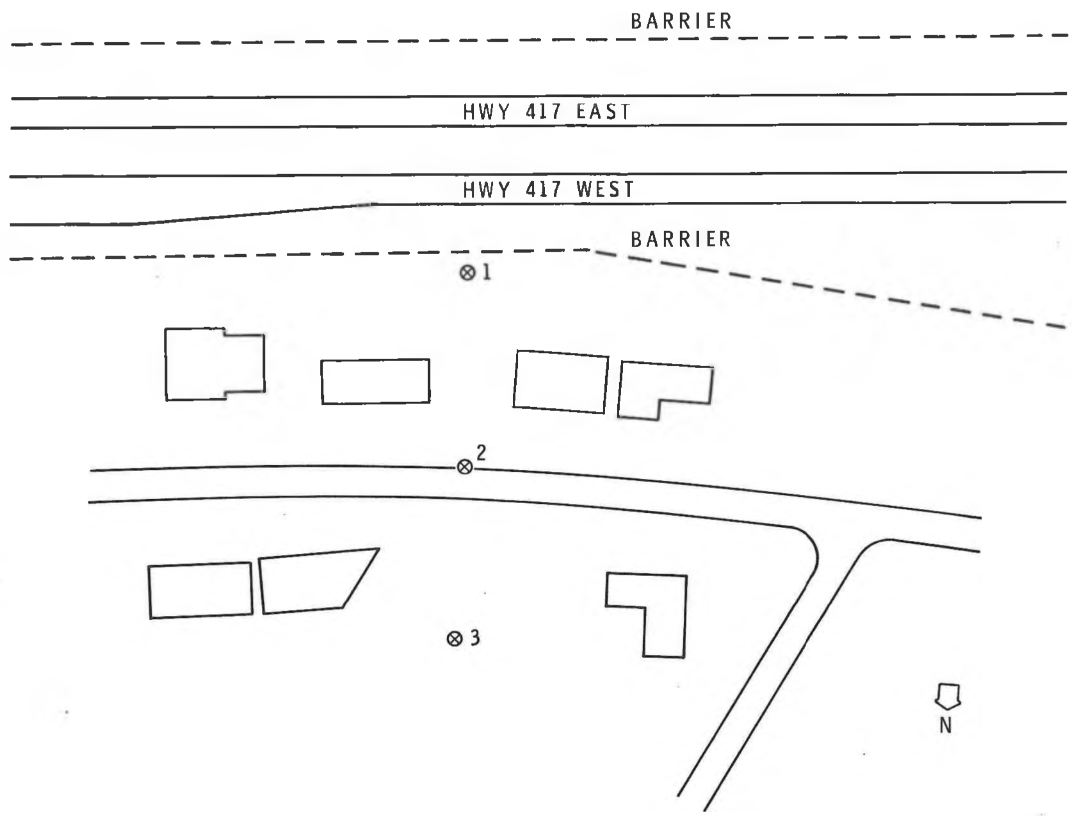

FIGURE 1
SITE 1

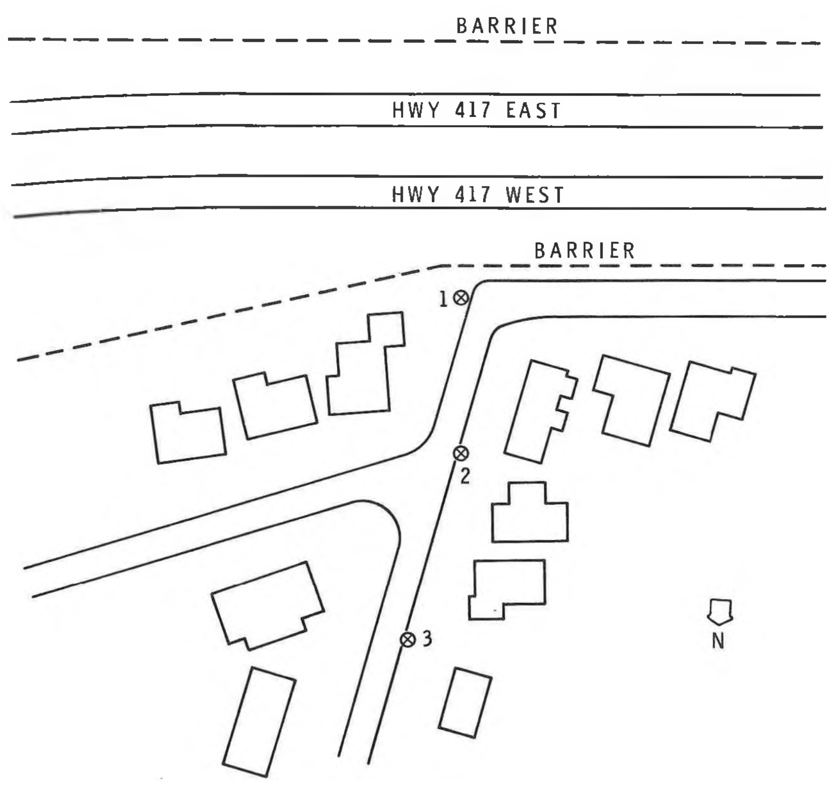

FIGURE 2
SITE 2

MEASUREMENT LOCATIONS

Measurements were made at six locations, three on the north and three on the south sides of Highway 417.

The three sites on the north side are shown in Figs. 1, 2, and 3. There was no barrier constructed on the south side of Highway 417 at Site 3.

Figure 4 shows Sites 4 and 5 which were on the south side of the highway. The third site on the south side, Site 6, was an open playing field on the opposite side of the highway to Site 3 with no barrier between it and the south side of the highway. Since there was a barrier on the north side measurements at Site 6 could possibly have been affected by sound reflected from it.

At each site, ten or more microphones were arrayed on three masts which extended to 7.6 m. The first mast was placed as close as possible to the right-of-way fence, the second was located approximately 50 m behind the first, and the third approximately 50 m behind the second. The most distant mast was thus about 100 m from the fence. The most pronounced effect of parallel barriers is expected at distances in excess of 100 m,[(2)] however it was found that the ambient noise in the neighbourhood made meaningful measurement of the highway traffic noise impossible at such distances.

MEASUREMENT PROCEDURE

Measurements were made using Metrosonics dB 301/14 data loggers that take four sound level readings each second and calculate the equivalent sound level each minute. The one-minute equivalent levels are stored internally for later readout. Equivalent levels for 15-minute periods were calculated as energy averages of 15 consecutive one-minute equivalent levels. Data were collected for three or four 15-minute periods during which traffic counts were taken to permit a check with prediction models.

Measurements were made in three phases. Phase 1 measurements were made before any construction began to determine the noise environment before the noise barrier were erected. These measurements were made during off-peak hours on weekdays and traffic counts showed there to be a fairly consistent 1600 vehicles per hour travelling in each direction, of which about 10 per cent were heavy vehicles.

Phase 2 measurements were made after the erection of the barrier along the north side of the highway, and Phase 3 measurements were made after the erection of the second barrier along the south side. Care was taken to place the microphones as close as possible to the same positions for all three phases of the measurements.

Unfortunately, the Phase 2 and Phase 3 measurements had to be made on weekends because of equipment and manpower limitations. The traffic volume was found to be very nearly the same as on weekdays, but the percentage of heavy vehicles was down sharply from 10 to 1 - 2 per cent. The ambient level in the neighbourhood caused by local traffic, children playing, lawn mowers, etc. would also be expected to be higher

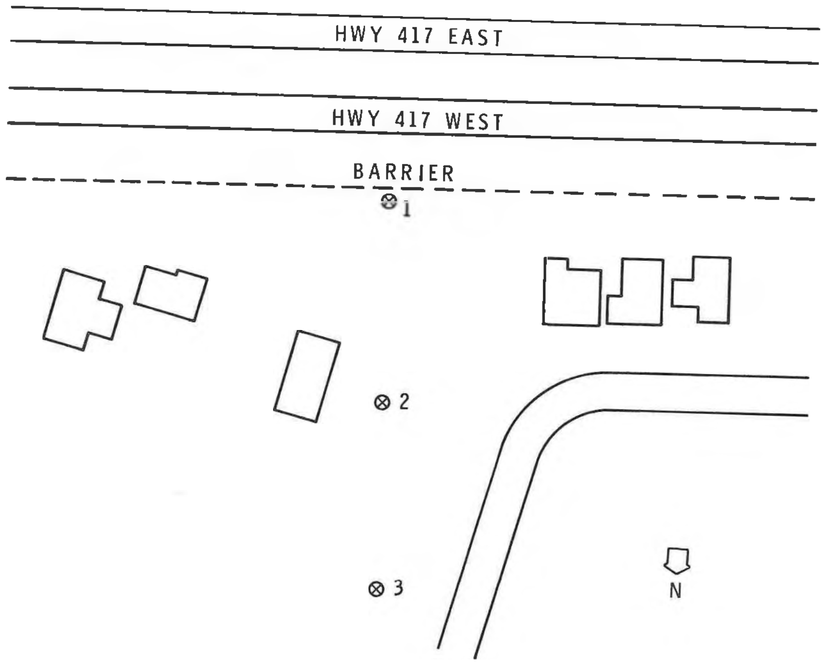

FIGURE 3
SITE 3

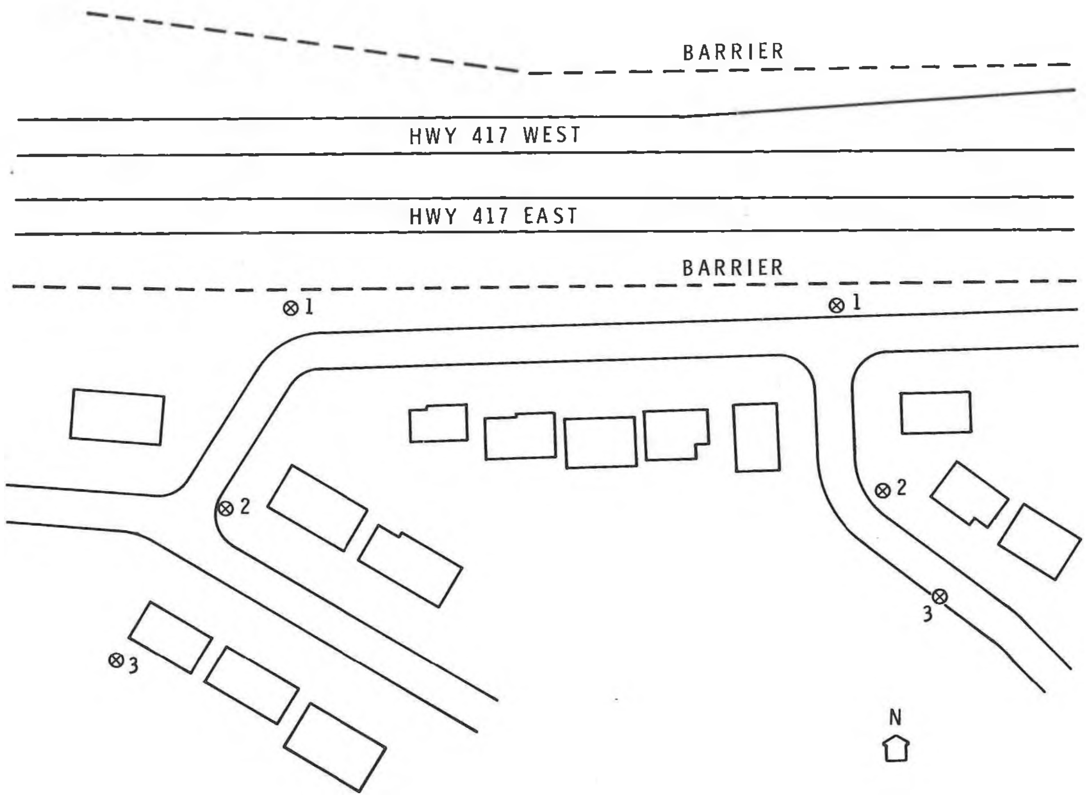

FIGURE 4
SITES 4 AND 5

on weekends. This means that measurements made at the mast furthest from the highway are somewhat less reliable. The time available for the Phase 2 measurements was very short because of the construction schedule so some of the measurements were made under less than ideal conditions.

DISCUSSION OF RESULTS

At each measurement site a microphone was placed at the top of the first mast to provide a reference microphone that would be unaffected by the erection of a barrier on the same side of the roadway as the site. The level measured at this microphone is affected by sound reflected from a barrier erected on the opposite side of the roadway. However this change can be determined by comparing measured levels with those calculated from traffic counts. The differences between the level at the reference microphone and the levels at the other microphones, averaged over the three or four measurement periods, are given in Tables 1 to 6 for the six sites. Also given in the tables are the average level measured at the reference microphone and the level predicted on the basis of the traffic counts using the National Research Council of Canada traffic noise prediction model.[4] The following is a detailed discussion of the results from each site.

Measurements on the North Side of the Highway

Site 1 The Phase 2 measurements given in Table 1 show an increase in attenuation consistent with the erection of a barrier between the highway and the microphones.

The Phase 3 measurements do not show any clear change in attenuations measured at this site. Compared with the Phase 1 measurement, there appears to be a 1 dB increase at the reference microphone, although a change of this magnitude is within the measurement uncertainty of 1 dB. The apparent increase in attenuation at the second mast (microphones 5 to 8) is more likely due to a change in the percentage of heavy vehicles, however traffic counts are not available for the Phase 2 measurement so this cannot be verified.

Site 2 The Phase 2 measurements, given in Table 2 show an increase in attenuation consistent with the erection of a barrier between the highway and the microphone.

The Phase 3 measurements indicate that there is an increase in level at the upper microphones relative to the Phase 2 measurements, although there is still a net attenuation relative to Phase 1. This may be due to the erection of the second barrier.

Site 3 This site is behind the barrier on the north side of the highway but beyond the end of the southern barrier. The Phase 2 measurements given in Table 3 indicate that the barrier is behaving normally. The noise levels at the back mast were unchanged at 57 dBA which is not an unusual level for a suburban site during the daytime. The highway traffic was audible, but was not the dominant noise source.

Measurements on the South Side of the Highway

Site 4 The Phase 2 measurements given in Table 4 show that there was an increase in noise level after the erection of the barrier on the north side of the highway. However, the measurements were made on a fairly windy day with the wind blowing in the direction of propagation. This would result in higher noise levels at the more distant microphones. The rapid construction of the second barrier prevented a repeat of these measurements.

The Phase 3 measurements indicate that the barrier is effective in attenuating the noise at all of the measurement positions. It should be pointed out that the levels at the back mast for the Phase 3 measurements were dominated by the local ambient level rather than the highway and that nearby construction equipment may have raised the local ambient levels during the Phase 1 measurements.

Site 5 The Phase 2 measurements given in Table 5 were made on the same day as those at Site 4, thus the comments regarding the wind are equally applicable. A second complicating factor was that the back mast was in the rear yard of a house and partially shielded from the road. As a result the levels measured at microphones 10, 11 and 12 were dominated by local noises and cannot be considered reliable. On the basis of these considerations it is believed that the apparent increase in levels are an artifact of the measurement conditions.

The Phase 3 measurements show the levels at the back two masts to be between 55 and 60 dBA. These are typical of a suburban environment and are indicative of local noise sources, although the highway traffic is still audible. These measurements do not provide a valid estimate of the attenuation provided by the barrier.

Site 6 This site consisted of a large level grass-covered field with no nearby reflecting surfaces and should have provided a good test of the effect of reflections from a barrier on the opposite side of the road. The data given in Table 6 certainly show an increase in the relative levels, but they also show that the level measurements at the reference microphone are much lower than expected. This is the result of this section of the highway being repaved between the two measurements. The old concrete surface was replaced with a coarse aggregate asphalt which resulted in a substantial reduction in the tire noise and a change in the spectral balance of the noise.

The Phase 2 measurements show an increase in level close to the ground relative to several metres above at both of the more distant masts. There are three factors that may have influenced the measurements; the barrier on the north side of the road, the reduced fraction of heavy vehicles, and the new pavement which both changes the spectral balance and raises the effective source height. These complications make it difficult to determine the exact cause of the observed changes in relative level.

CONCLUSIONS

This series of measurements clearly point out at least two of the problems inherent in the measurement of outdoor noise propagation in a suburban situation. It is often not possible to make measurements under ideal weather conditions and if the conditions are poor there is no reliable means of estimating the effect that may have on the measured levels. Noise measurements in a subdivision, particularly those made on a weekend, are invariably contaminated by the sounds of children playing, lawn mowers and local traffic. Levels of 50 to 55 dBA, such as were found at the rear masts at most of the sites, are normal in a suburban setting, thus it is apparent that measurements made at these locations are more indicative of the local noise environment than they are of noise emanating from the highway and thus should not be used as a reliable measure of the barrier performance.

On the basis of the measurements reported here, there is no clear evidence that building a second barrier parallel to an existing one will degrade the performance of the original barrier. Nor is there clear evidence that a barrier can cause an increase in the noise level on the unprotected side of the road.

It is possible that there are real effects associated with the second barrier, however they cannot be considered important in most practical situations as the traffic noise is soon masked by local noise sources as the distance behind the barrier is increased.

This paper is a contribution from the Division of Building Research of the National Research Council of Canada and is published with the approval of the Director of the Division.

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TABLE 1

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB) Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-3	-13	-
2	2.9	-1	-13	-12
3	4.1	-.5	-10	-11
4 ref.	7.6	0	0	0
Mast 2				
5	1.6	-15	-	-17
6	2.9	-13	-16	-
7	5.3	-12	-16	-18
8	7.6	-10	-14	-15
Mast 3				
10	4.1	-18	-19	-19
11	6.4	-17	-18	-
12	7.6	-16	-17	-16
Measured level at reference		74	73	71
Predicted level at reference		75	-	73

SITE NO. 1, north side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 2

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB) Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-2	-14	-
2	2.9	0	-13	-13
3 ref.	7.6	0	0	0
Mast 2				
4	1.6	-10.5	-16	-18
5	4.6	-10.5	-19	-17
6	6.4	-9	-17	-12
Mast 3				
7	1.6	-18	-21	-
8	2.9	-17	-21	-21
9	5.3	-16	-20.5	-18
10	7.6	-15	-19.5	-17
Measured level at reference		74	72	72
Predicted level at reference		76		74

SITE NO. 2, north side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 3

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB): Phase 1 (no barriers)	Phase 2 (1 barrier)
Mast 1			
1	1.6	-3	-12
3	4.1	0	-7
4 ref.	7.6	0	0
Mast 2			
5	1.6	-13	-13
6	2.9	-11	-12
7	5.3	-10	-12
Mast 3			
10	4.1	-16	-15
11	6.4	-14	-15
12	7.6	-14	-14
Measured level at reference		73	72
Predicted level at reference		75	74

SITE NO. 3, north side of Highway 417

Average Level at Each Microphone Relative To Reference at Top of Front Mast

TABLE 4

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB): Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-3	-2	-
2	2.9	-1	0	-11
3	4.1	-	-1	-6
4 ref.	7.6	-0	0	0
Mast 2				
6	2.9	-10	-9	-17.5
7	5.3	-8	-7	-16
8	7.6	-6	-5	-12.5
Mast 3				
10	4.1	-16.5	-9	-
11	6.4	-13.5	-11	-17.5
12	7.6	-13	-10	-17
Measured level at reference		75	74	73
Predicted level at reference		75	74	73

SITE NO. 4, south side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 5

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB) Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-1	-1	-
2	2.9	-3	0	-10
3	4.1	-2	0	-4
4 ref.	7.6	0	0	0
Mast 2				
5	1.6	-15	-	-16
6	2.9	-13	-10	-14
7	5.3	-11	-8	-11
8	7.6	-9	-7	-
Mast 3				
10	4.1	-21	-12	-
11	6.4	-18	-13	-16
12	7.6	-17	-12	-15
Measured level at reference		74	73	71
Predicted level at reference		75	75	72

SITE NO. 5, south side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 6

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB) Phase 1 (no barriers)	Phase 2 (1 barrier)
Mast 1			
1	1.6	-3	-3
2	2.9	-1	-2
4 ref.	7.6	0	0
Mast 2			
5	1.6	-13	-6
6	2.9	-11	-5
7	5.3	-4	-4
Mast 3			
10	4.1	-12	-6
11	6.4	-9	-5
12	7.6	-8.5	-5
Measured level at reference		75	70
Predicted level at reference		77	75

SITE NO. 6, south side of Highway 417

Average Level at Each Microphone Relative To Reference at Top of Front Mast

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LE TRAITEMENT DIGITAL DES SIGNAUX ACOUSTIQUES

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SOMMAIRE

Le traitement numérique des signaux acoustiques est étudié sous une approche globale permettant d'identifier les lacunes et les avantages des différentes approches possibles. Des solutions sont proposées en ce qui a trait aux différentes étapes de l'acquisition et du traitement des données. On insiste sur les effets nocifs de la non-stationnarité des signaux et leurs conséquences lors de l'analyse fréquentielle dite en temps réel. La manipulation de la phase et les techniques du zoom font l'objet d'un développement particulier. Tous les aspects concernant l'analyse numérique multicanale seront traités dans un autre article.

SUMMARY

Using a comprehensive approach, a numerical analysis of acoustic signals has enabled us to bring out the advantages and disadvantages of possible analytical methods. Means of acquiring and treating data step by step are proposed. We emphasize the deleterious effects of non-stationary signals and their consequences on the interpretation of a real time spectrum analysis. Phase handling and "zooming" techniques are discussed at length. Various aspects of multi-channel numerical analysis will be examined in a subsequent paper.

INTRODUCTION

La décennie 70-80 a été celle de l'électronique. Grâce à ces nombreux développements dans le monde des microprocesseurs, les acousticiens se voient maintenant offrir des possibilités de mesures et d'analyses inconcevables il y a quelques années. L'essentiel des théories était connu depuis fort longtemps (Fourier 1812) mais leur mise en pratique se heurtait généralement au nombre important de calculs à effectuer et au volume de données à prendre en considération. Depuis le début de ce siècle, les acousticiens ont dû se contenter de mesurer la pression tout en laissant de côté des paramètres-clefs, telle l'intensité. Cependant, l'avènement des circuits intégrés et leur miniaturisation ont brusquement permis de franchir toute une série d'étapes importantes. Les chercheurs peuvent donc maintenant utiliser le potentiel que leur apportent les techniques de traitement des signaux numériques. Mais les embûches et les sources d'erreurs sont nombreuses. De plus, l'expérimentateur en arrive à perdre complètement l'interprétation et la signification physique de ces résultats: il est en effet beaucoup plus facile de visualiser la variation d'amplitude et de fréquence d'une sinusoide de façon analogique (sur un oscilloscope) que de la visualiser via la représentation binaire de sa transformée de Fourier complexe!... Qu'il s'agisse de manipuler numériquement des signaux dans le domaine temporel ou le domaine fréquentiel, notre expérience nous a montré que les sources de difficultés étaient nombreuses et parfois méconnues. Cette étude a donc pour but d'analyser les différentes étapes-clefs du traitement de signal et d'apporter les correctifs qui s'avèrent souhaitables et nécessaires.

Etant donné l'étendue et la complexité du sujet nous traiterons dans ce premier article des éléments fondamentaux: le type de signal, l'acquisition des données et l'analyse spectrale mono-canal. Dans un deuxième article actuellement en préparation, nous porterons notre attention sur l'analyse multi-canal et ses applications ainsi que de la conversation bidirectionnelle entre les instruments de mesure et l'ordinateur.

TYPE DE SIGNAL

Les signaux temporels que l'on doit traiter se classent généralement en deux grandes catégories: les signaux déterministes et les signaux aléatoires. Les signaux sonores que l'on ne peut pas prédire à partir de lois de physique, sont donc des signaux aléatoires et chaque expérience identique fournira des résultats distincts. Les signaux acoustiques sont donc aléatoires mais il est généralement[1] admis que l'aspect le plus important est de savoir s'ils sont stationnaires ou non. Rappelons ici que les caractéristiques probalistiques d'une histoire temporelle tirée à partir d'un grand nombre d'enregistrements $x_i(t)$ $(i = 1,N)$ sont fournies par la moyenne

$$\mu_x (t_o) = \lim_{N\to\infty} \frac{1}{N} \sum_{i=1}^{N} x_i(t_o) \qquad (1)$$

et la moyenne quadratique

$$\psi_x^2(t_o) = \lim_{N\to\infty} \frac{1}{N} \sum_{i=1}^{N} x_i^2(t_o) \qquad (2)$$

Parallèlement la fonction autocorrélation R_{xx}, pour un délai temporal τ, s'écrit:

$$R_{xx}(t_o, \tau) = \lim_{N\to\infty} \frac{1}{N} \sum_{i=1}^{N} x_i(t_o)\, x_i(t_o + \tau) \qquad (3)$$

Si une ou plus de ces trois équations varient avec le temps t_o, les informations sont dites non-stationnaires. Ceci est excessivement important puisque la non-stationnarité d'un signal, causée par des éléments transitoires par exemple, peut être la source de mesures erronées lorsque le traitement est fait avec un analyseur à transformée rapide de Fourier.

ACQUISITION DES DONNÉES

Fréquence d'échantillonnage

Il est bien connu[2,3,4] que la conversion analogue à digital d'un signal consiste en un fractionnement du signal analogique en une série de tranches également espacées; une valeur numérique est associée au voltage ainsi détecté.

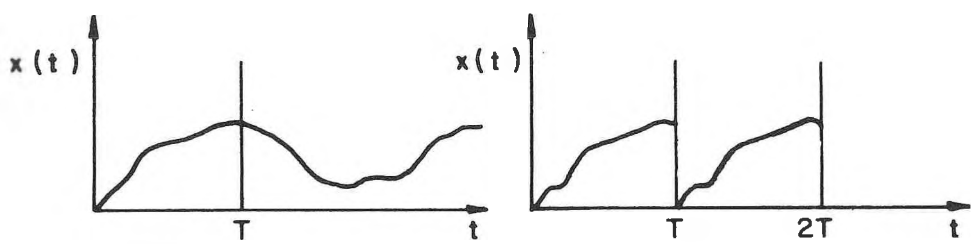
Pour un signal aléatoire stationnaire, on utilise l'intégrale de Fourier pour le passage du domaine temporel au domaine fréquentiel

$$X(f) = \int_{-\infty}^{+\infty} x(t)\, e^{-2\Pi jft}\, dt \qquad (4)$$

En pratique cependant, on ne peut étudier les signaux temporels que pendant une durée finie T; on calcule alors la transformée de Fourier finie

$$X_T(f) = \int_0^T x(t)\, e^{-2\Pi jft}\, dt \qquad (5)$$

le signal x(t) étant alors implicitement considéré périodique (Fig. 1).



Signal physique — Signal étudié

Fig. 1 Signal considéré comme périodique.

Mais en terme de traitement du signal, l'observation de l'histoire temporelle perdant une durée finie T équivaut à la multiplication du signal x(t) par une fonction "fenêtre" de largeur T centrée en t = T/2

$$x(t) \text{ devient } x_1(t) = x(t)\ \sqcap_{T/2}\,(t - T/2)$$

En pratique les fenêtres pour tronquer les signaux sont de deux types:

fenêtre rectangulaire (Fig. 2)

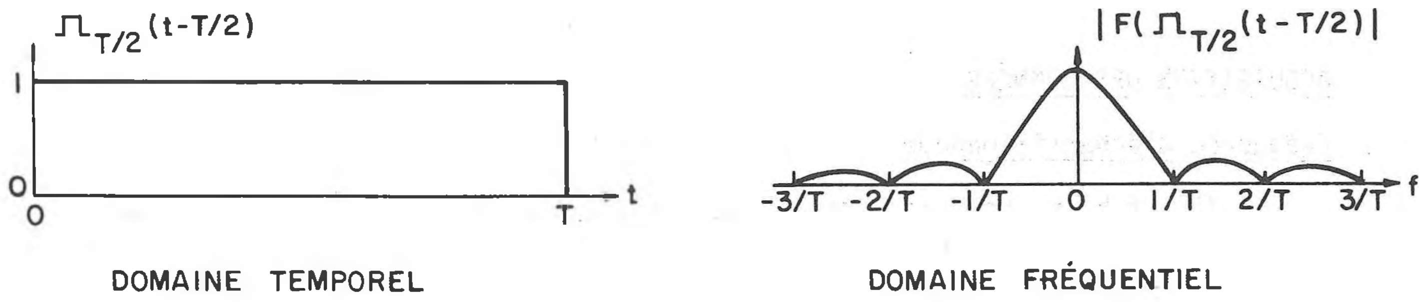


Fig. 2 Fenêtre de troncature de type rectangulaire.

Ce type de fenêtre est surtout utilisée pour les signaux transitoires, mais elle introduit des anomalies dans l'estimation des spectres quand le signal temporel est continu. Dans ces cas, il est préférable d'utiliser les fenêtres de pondération qui suppriment les discontinuités du signal aux instants $t = kT$; la plus utilisée est la fenêtre de Hanning

fenêtre de Hanning (Fig. 3)

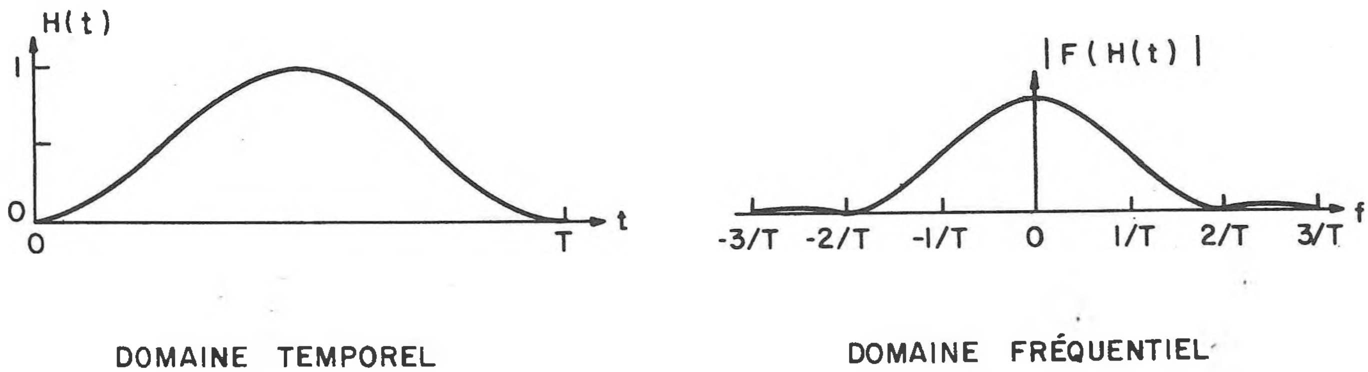


Fig. 3 Fenêtre de troncature de type "Hanning".

Cette pondération permet de lisser le spectre de la fonction tronquée en diminuant les lobes parasites qui ont pu être introduits par la troncature. Le choix de la durée d'observation est lié au problème d'échantillonnage et sera développé plus loin.

Dans une seconde étape, on procède à la périodisation implicite du signal (reprise d'une autre portion d'information temporelle). Ceci équivaut à la convolution de ce dernier par une fonction peigne:

$$\text{Ш}_T(t) = T \sum_{k=-\infty}^{\infty} \delta(t - kT) \quad \text{et alors}$$

$$x_1(t) \text{ devient } x_2(t) = x_1(t) * \text{Ш}_T(t)$$

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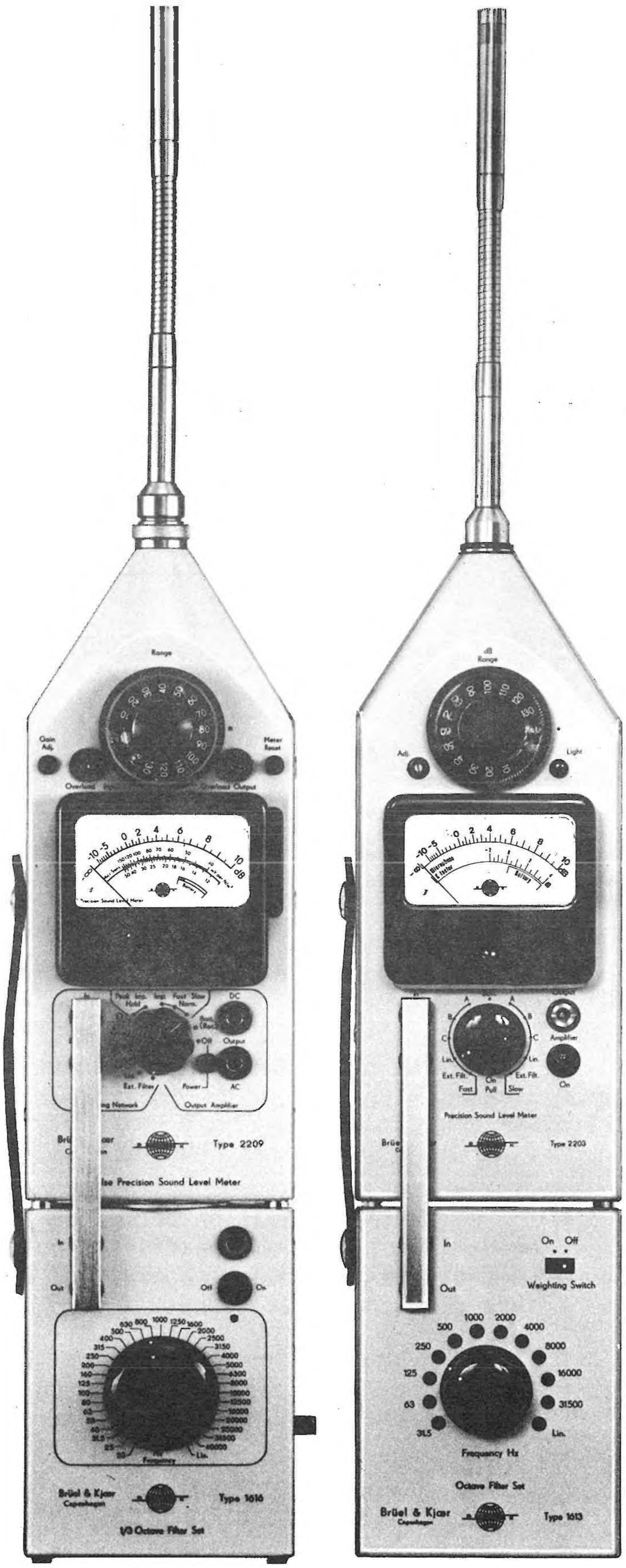

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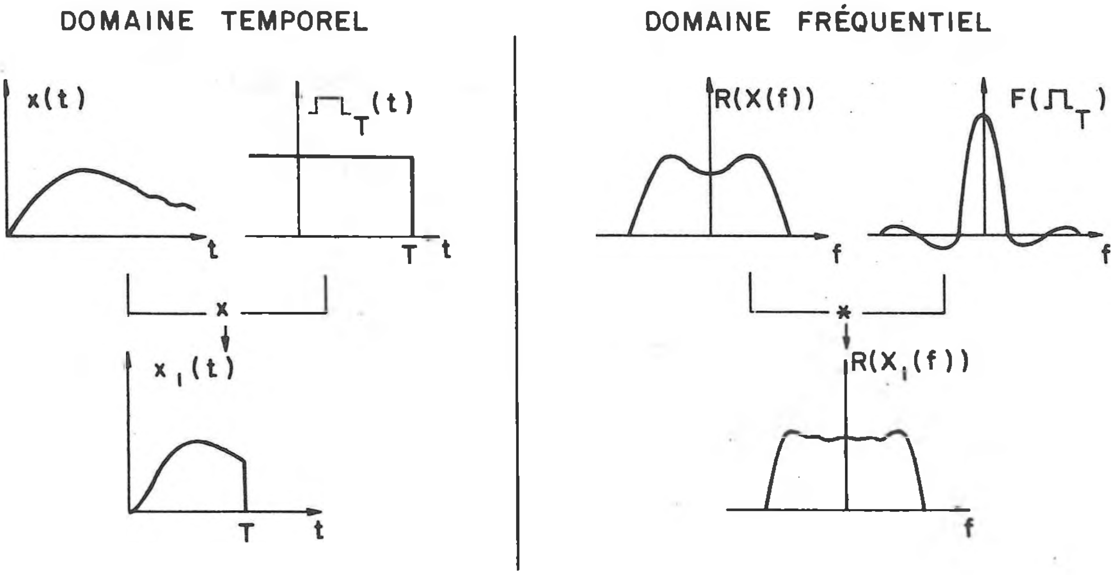

Fig. 4 Représentation temporelle et fréquentielle de la troncature.

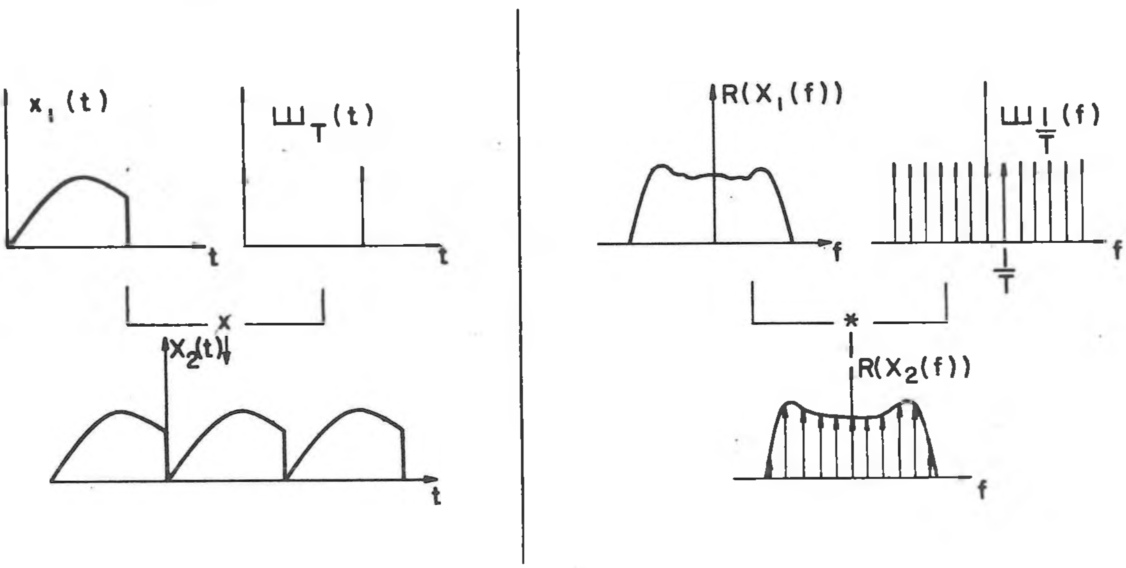

Fig. 5 Périodisation du signal de temps.

Depuis l'avènement des calculateurs digitaux, on n'étudie plus le signal analogique mais une série de valeurs x_2 (k T_e) où k est un entier et T_e la période d'échantillonnage. Le signal $x_2(t)$ subit donc une nouvelle transformation qui consiste en une multiplication par une fonction peigne ⊔⊔ T_e (t). Pour déterminer T_e la période d'échantillonnage, on applique le théorème de Shannon[5] qui nous indique que la fréquence d'échantillonnage doit être supérieure à 2 fois la fréquence maximale contenue dans le signal (Fig. 6a). Si cette condition n'est pas respectée, il se produit un phénomène de "repliement de spectre" qui entraîne des erreurs telles qu'illustrées à la figure 6b.

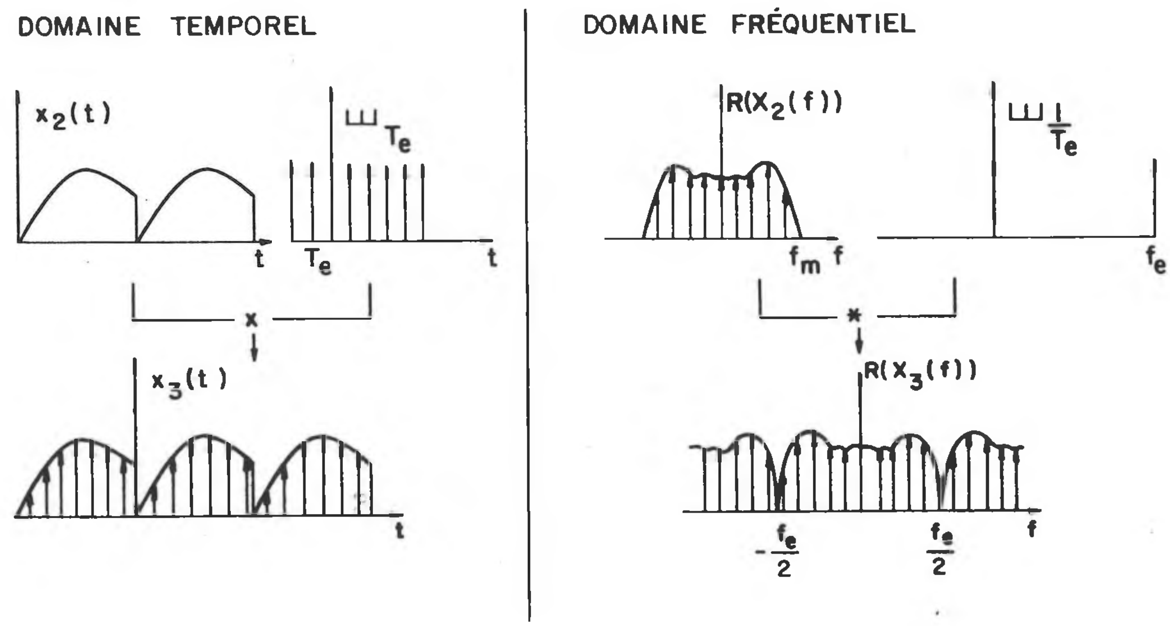

Fig. 6a Echantillonnage respectant le théorème de Shannon.

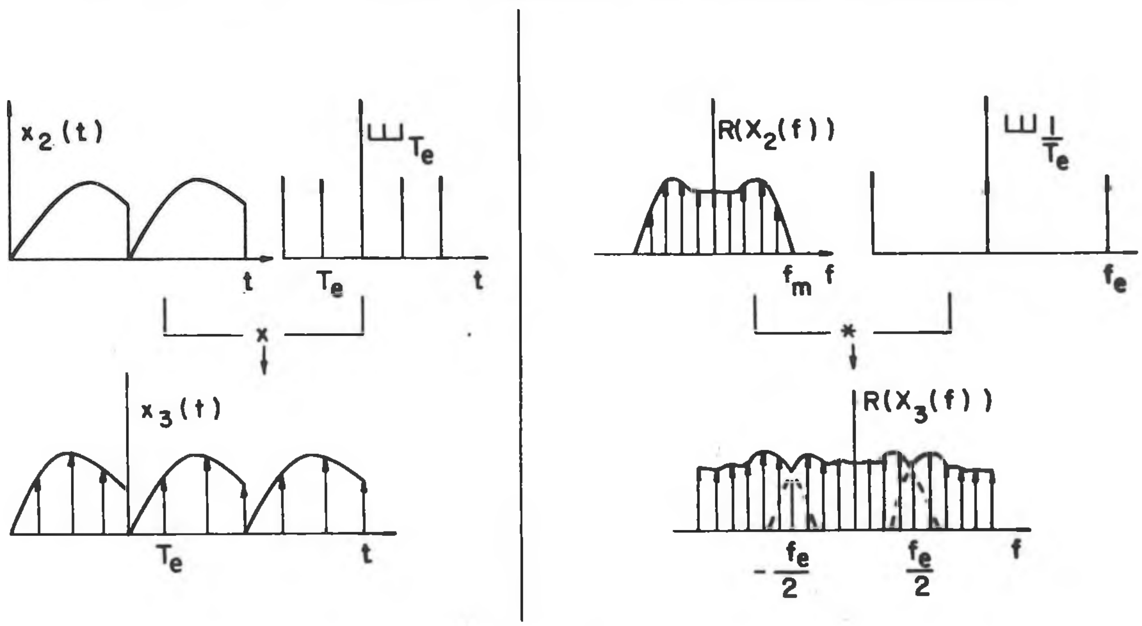

Fig. 6b Echantillonnage incorrect $f_e/2 < f_m$, phénomène de repliement.

Le signal $x_2(t)$ devient $x_3(t) = x_2(t)\, Ш_{T_e}(t)$

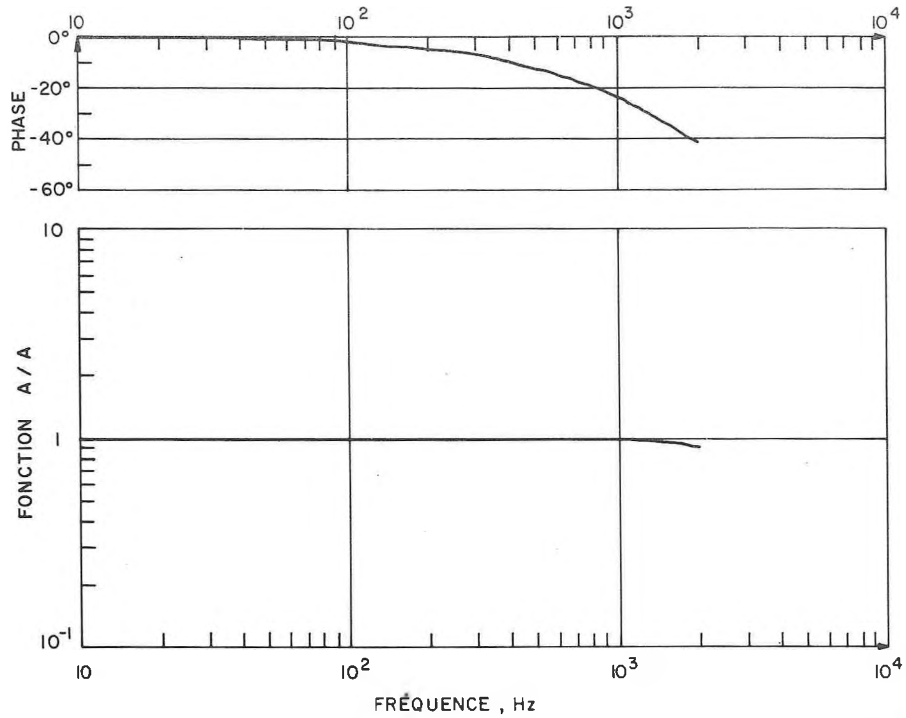

Fig. 7 Déphasage et rapport d'amplitude entre deux filtres anti-repliement, en réponse à un signal transitoire.

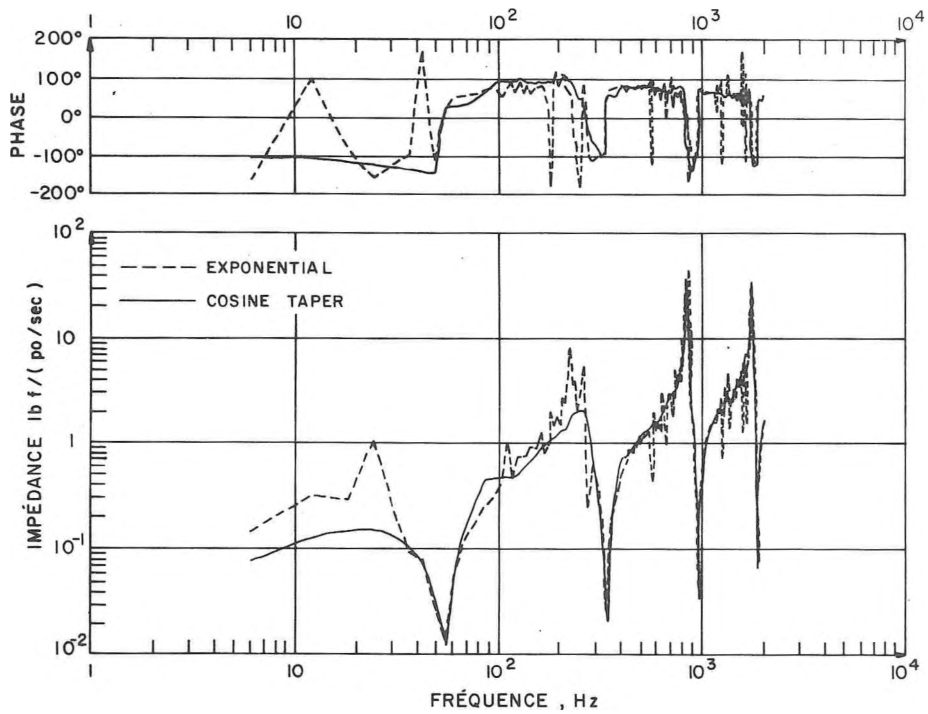

Fig. 8 Effet du type de la fenêtre de pondération.

En pratique, qu'il s'agisse d'une analyse via un acquisiteur et un ordinateur ou via un analyseur de fréquence, il importe de filtrer analogiquement le signal d'entrée avec un filtre passe-bas dont la coupure est faite à la fréquence maximum que l'on désire échantillonner. La fréquence d'échantillonnage (f_e) doit être alors supérieure à 2 fois la fréquence maximum (f_m) à étudier. (Pour les analyseurs en temps réel on prend généralement $f_e = 2{,}56\ f_m$).

Au stade final le signal temporel et son spectre sont tous deux échantillonnés et implicitement considérés comme périodique. La transformée de Fourier devient discrète:

$$X(k) = \frac{1}{N} \sum_{n=0}^{N-1} x(n)\ e^{-2\Pi jk \frac{n}{N}} \qquad (6)$$

où N est le nombre d'échantillons.

Un tel processus a été appliqué en utilisant un système d'acquisition de données de fabrication maison "Sherteck 1000" couplé à un ordinateur par un interface RS 232. Il s'agissait d'évaluer l'impédance vibrationnelle (canal A: force; canal B: vitesse) d'une structure via une excitation par impact à l'aide d'un marteau. Au point de vue traitement de signal, trois difficultés majeures ont été rencontrées. Primo, le fait que la réponse en phase de deux filtres antirepliement varie selon la fréquence pour des signaux transitoires. La figure 7 montre un déphasage croissant avec la fréquence allant jusqu'à 40° à 2 kHz, lorsqu'un même signal transitoire est soumis simultanément à deux filtres antirepliement. Pour pallier à cette erreur, une fonction de correction de phase a été introduite avec succès dans le programme principal.

Secundo, nous avons démontré que l'utilisation d'une fenêtre de type exponentiel telle que suggérée dans la littérature donnait un signal bruité (Fig. 8). En utilisant une fenêtre de type "cosine taper" la courbe d'impédance est maintenant exacte et il n'y a plus de possibilité de confusion quant aux valeurs possibles des fréquences de résonnances (Fig. 8).

Tertio, un phénomène de rebond se produit lors de l'impact (la structure vient rebondir sur le marteau avant qu'on ait eu le temps de retirer celui-ci). Ceci provoque un second maximum d'amplitude. Nous avons prévu un détecteur de ce phénomène au niveau de la fonction temporelle et un message interactif signale son erreur à l'opérateur.

<u>Erreur aléatoire</u>

On oublie généralement que le fractionnement du signal analogique implique que l'on extrait du signal une portion considérée comme représentative et qu'il est impossible de disposer d'un nombre infini d'échantillons. Les valeurs moyennes ainsi calculées ne sont que des estimations des valeurs "vraies" et sont donc entachées d'une erreur dite "erreur statistique d'échantillonnage". Par exemple, Bendat[1] indique que pour un spectre cohérent partiel ($G_{x:y \cdot z}$) l'erreur est définie par:

$$\varepsilon_r = \frac{|\hat{G}_{x:y \cdot z} - G_{x:y \cdot z}|}{G_{x:y \cdot z}} \qquad (7)$$

où $\hat{G}_{x:y\cdot z}$ est le spectre cohérent partiel estimé. L'erreur ε_r se calcule alors par[1]

$$\varepsilon_r(\hat{G}_{x:y\cdot z}) = \frac{(2 - \gamma^2_{x:y\cdot z})^{\frac{1}{2}}}{|\gamma_{x:y\cdot z}| \; \sqrt{n_d - 1}} \tag{8}$$

où $\gamma_{x:y\cdot z}$ est la cohérence partielle entre x et y sans l'effet linéaire de z et n_d est le nombre de moyennes utilisées pour le calcul du spectre.

Contrairement à la présentation habituellement utilisée (voir référence 1, page 276, fig. 11.5), on peut déduire des équations (7) et (8) que l'erreur entre le spectre estimé et le spectre réel est telle que

$$\hat{G}_{x:y\cdot z}(dB) = G_{x:y\cdot z}(dB) + 10 \log_{10} (1 \pm \varepsilon_r) \tag{9}$$

On peut alors calculer l'erreur aléatoire pour un spectre cohérent partiel et le présenter sous forme de courbes directement utilisables d'un point de vue d'ingénierie (voir Figures 9a, 9b). Sous cette forme on constate bien la nécessité pour avoir des résultats vraiment fiables d'effectuer au moins 10 000 moyennes et que 100 moyennes sont suffisantes si la cohérence partielle n'est pas trop faible ($\gamma^2_{x:y\cdot z} > 0,2$).

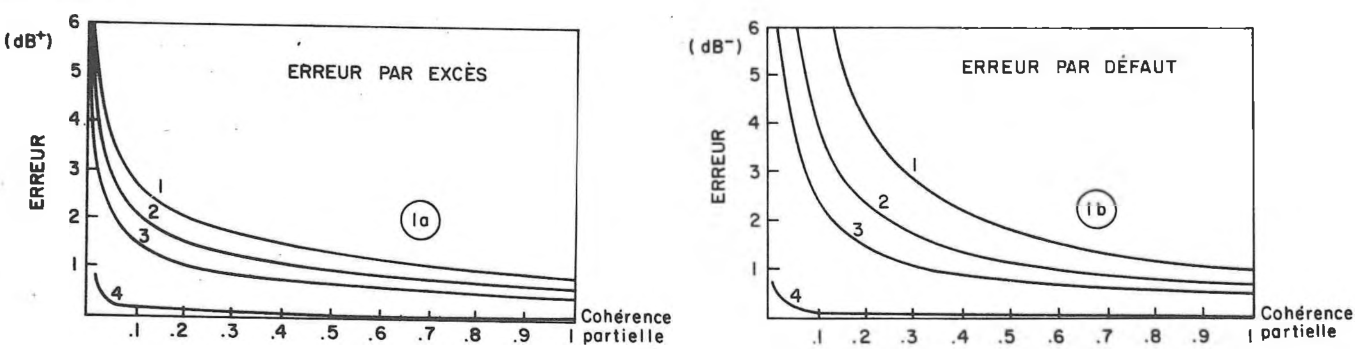

Fig. 9 Erreur aléatoire: (a) par excès, (b) par défaut sur la cohérence partielle. n_d nombre de moyennes.
(1) n_d = 25, (2) n_d = 50, (3) n_d = 100, (4) n_d = 10 000

On constate donc qu'il est nécessaire d'examiner avec attention chaque élément d'un processus d'acquisition de données afin de s'assurer de la validité des résultats. Notre expérience nous a également montré que tout système d'acquisition couplé à un ordinateur (software) est plus complexe et plus lent qu'un analyseur T.R.F. (hardware), mais il demeure beaucoup plus versatile et beaucoup plus souple d'utilisation. Il faut cependant noter, que si l'on interface convenablement un analyseur T.R.F. à un calculateur ou un ordinateur, on regagne alors toute la souplesse nécessaire.

ANALYSE SPECTRALE

Dans la très grande majorité des cas, l'intérêt des acousticiens se porte vers l'analyse fréquentielle d'un signal temporel donné[6]. Nous avons travaillé sur cette transformation en fréquence par les trois moyens les plus couramment utilisés:

- calcul du spectre fréquentiel par acquisiteur et ordinateur;
- calcul du spectre fréquentiel par analyseur T.R.F.*;
- calcul du spectre fréquentiel via des filtres digitaux.

Il en est ressorti un certain nombre d'éléments-clefs que l'expérimentateur doit manipuler avec soin: le temps réel exact, l'analyse en bandes fines versus en bandes 1/3 d'octave, la possibilité d'augmenter la résolution (zoom), et finalement l'extraction de l'information sur la phase du signal.

Temps réel

On se rappellera que pour trouver la transformée de Fourier on doit fractionner l'histoire temporelle. Si ce fractionnement est discontinu (intervalle de temps pendant lequel on n'acquiert pas de données), et que l'on a affaire à un signal non-stationnaire, il est évident que le résultat du contenu fréquentiel sera complètement faussé. Or, après avoir acquis les données, il faut calculer, transférer et afficher ou mémoriser les composantes spectrales, et pendant ce temps on continue d'acquérir des données qui ne pourront être traitées. C'est ainsi qu'apparaît la nécessité d'un paramètre quantifiant la rapidité du processus de calcul et de transfert: le temps réel. Pour un analyseur T.R.F., la manipulation est décrite à la Fig. 10. Grâce à une deuxième mémoire, l'appareil enregistre des données pendant que s'effectue le calcul des données fournies par la première mémoire, et ainsi de suite. Mais dès que le temps de calcul dépasse le temps d'acquisition des 1024 points de données, l'analyseur fonctionne hors temps réel[7]. Par exemple, si on admet que le temps de calcul de la T.R.F. des analyseurs couramment sur le marché est d'environ 200 ms, on perdra 90% de l'histoire temporelle si on cherche à étudier une gamme de fréquence allant jusqu'à 20 kHz (20 ms pour acquérir le bloc de 1000 points et 180 ms pendant lesquels les données ne seront pas utilisées). On pourrait donc croire qu'avec le progrès de l'électronique, un analyseur T.R.F. faisant le calcul de la T.R.F. en moins de 20 ms serait en temps réel: ceci est faux car on oublie généralement que tout signal temporel continu est pondéré comme nous l'avons dit précédemment par une fonction de Hanning pour éviter l'effet de troncature, ce qui veut dire qu'il y a facteur de perte de $(3/8)^{\frac{1}{2}}$, soit 61% des données qui sont faussées.

Ces deux éléments nous indiquent donc que l'appellation analyseur en temps réel est inadéquate et trompeuse et que l'on se doit de vérifier scrupuleusement la stationnarité d'un signal avant d'utiliser un tel analyseur. Si on se sert d'un acquisiteur couplé à un ordinateur, le temps de calcul (quelques secondes) sera donc encore plus long et les effets encore plus prononcés. Par contre, si l'on a accès à une série de filtres digitaux (numériques), le problème du temps réel est résolu. Cependant ceci implique une manipulation complexe impliquant

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* T.R.F.: Transformée rapide de Fourier.

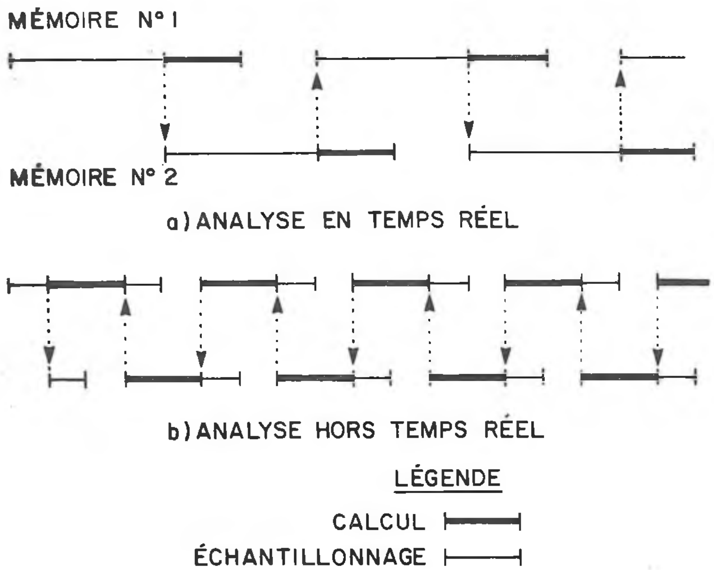

Fig. 10 Différence entre l'analyse en temps réel et l'analyse hors temps réel.

le passage simultané du signal par toute une série de filtres digitaux pré-programmés. Conséquemment, la réalisation électronique est délicate et coûteuse et c'est pourquoi on ne trouve sur le marché, actuellement, qu'un modèle d'analyseur en temps réel à 100%, utilisant 33 filtres digitaux (bandes 1/3 d'octaves). (L'analyseur idéal aurait 400 filtres digitaux à bandes fines!...).

Bandes fines versus 1/3 d'octaves

Les deux présentations ont fait l'objet d'études comparatives. Il n'est question ici d'entrer dans un débat sur l'opportunité d'utiliser une présentation plutôt que l'autre. Du point de vue ingénierie, les deux types d'informations sont utiles et nécessaires. D'où l'idée de synthétiser l'information en bandes fines pour l'obtenir sous la forme de bandes 1/3 d'octaves. Cela implique cependant un certain nombre de précautions: primo la synthétisation doit être effectuée en trois étapes avec des gammes de fréquences de 20 - 200 Hz, puis 200 - 2000 Hz, puis 2000 - 20 000 Hz, afin d'obtenir un résultat significatif pour les basses fréquences. Toute synthétisation directe avec les valeurs obtenues en bandes fines pour une gamme de 20 000 Hz entraîne des erreurs de plus de 5 dB. Ceci s'explique facilement puisque la largeur de bandes est alors de 50 Hz, ce qui implique que dans les bandes 1/3 d'octave allant de 63 Hz à 250 Hz, on n'a même pas un point d'information par bande.

Secundo, si le signal n'est pas stationnaire, s'il s'agit de signal transitoire, si le signal est quasi stationnaire mais avec les modulations rapides, si l'on veut mesurer des temps de réverbération, il est alors préférable d'utiliser des filtres digitaux en temps réel à 100%. (Voir Fig. 11).

Les études expérimentales ont également montré que les filtres digitaux perdaient l'avantage précédemment mentionné lorsqu'on voulait obtenir une information de phase. En effet, seul le calcul de la T.R.F. permet d'obtenir une information d'amplitude mais aussi de phase sur le signal. Si l'on songe par

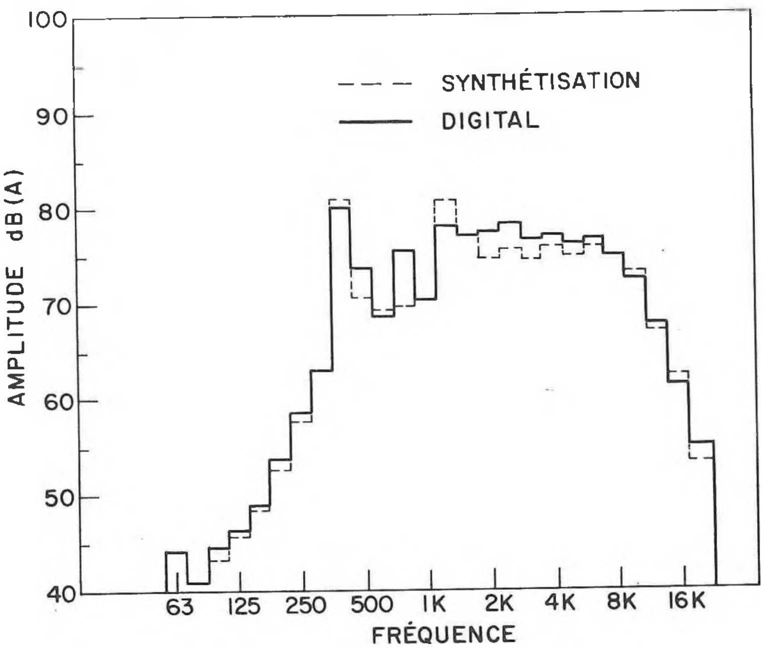

Fig. 11 Différence sur les spectres de puissance entre un processus de synthétisation (hors temps réel) et une analyse par filtres digitaux (temps réel) en présence d'un bruit quasi stationnaire à modulations rapides.

exemple à évaluer la réponse en phase comparative de deux micros, si l'on veut savoir quel est le changement de phase provoqué par une réflexion sur sol à impédance finie, il est évident que les filtres digitaux sont alors inadéquats. Il est bon de noter que les informations sur la phase peuvent être obtenues grâce à une source ponctuelle couplée à un générateur de fonction impulsive, genre fonction delta, sans avoir recours à un appareil à deux canaux, dans la mesure où on est capable d'extraire de l'interface de l'analyseur mono-canal, le contenu de phase correct de la transformée complexe de Fourier[8].

Information de phase d'un T.R.F. mono-canal

Il est surprenant de constater que certains analyseurs T.R.F. sur le marché ne donnent pas directement la vraie transformée complexe de Fourier. Nous avons, en effet, dû développer une procédure spéciale pour obtenir une information correctement référencée. En général les analyseurs T.R.F. donnent l'amplitude du spectre de puissance, ce qui ne nécessite aucune précaution particulière au niveau du contenu de phase. Or, il appert que les données acquises dans la mémoire temporelle qui est en "rotation" continue, ne sont pas réorganisées dans la dite mémoire. (Le 1er échantillon peut être en position 342 pour une prise de spectre, puis le même 1er échantillon peut être en position 950 pour la suivante, etc.).

Tout se passe donc comme si on créait une désynchronisation, c'est-à-dire un délai variable aléatoirement lors de la prise successive des spectres. La T.R.F. est de la forme $x(f) = A\,e^{i\phi}$, le spectre de puissante $x^2(f) = A^2(e^{i\phi})^2$ avec $(e^{i\phi})^2 = 1$, quel que soit ϕ, donc l'amplitude n'est pas affectée mais la phase oui. Pour obtenir la bonne information de phase, nous avons montré qu'il fallait réorganiser, réordonner les informations dans la mémoire de la fonction temporelle, c'est-à-dire 1er échantillon dans la mémoire 1, 2ième dans la 2, etc.

Ceci peut être réalisé en envoyant telle quelle la fonction temporelle dans un calculateur puis en retournant vers l'analyseur la même information mais convenablement réordonnée. Dès lors le contenu de phase est comparable non seulement d'une prise de spectre à l'autre mais aussi d'un essai à l'autre[9].

Résolution fréquentielle: zoom

La technique du zoom est en fait utilisée surtout pour signaux vibrationnels aux fins d'analyse d'engrenages ou en maintenance préventive. Cependant, nous avons utilisé une telle technique pour inter-relier les signaux de bruit et de vibrations afin d'identifier les sources de bruit sur une machine à filer. On se rappellera que la largeur de bande pour un analyseur T.R.F. à 400 lignes est donnée par,

$$B_w = \frac{f_{maxi}}{400} = \frac{1}{400\ n}\ f_s \tag{10}$$

où n est le nombre d'échantillons et f_s la fréquence d'échantillonnage. Il n'existe donc que deux façons de diminuer la largeur de bande; augmenter le nombre d'échantillons et/ou diminuer la fréquence d'échantillonnage. Nous avons utilisé les deux techniques: la première, qui est la plus couramment utilisée et qui est programmable, consiste à effectuer un traitement numérique d'un nombre N > n d'échantillons, à choisir une bande de fréquence digne d'intérêt et par une décimation appropriée, à limiter le calcul de la T.R.F. à 1024 points tout en augmentant la résolution fréquentielle sur une plage de fréquence donnée; la logique du processus est décrite à la Figure 12.

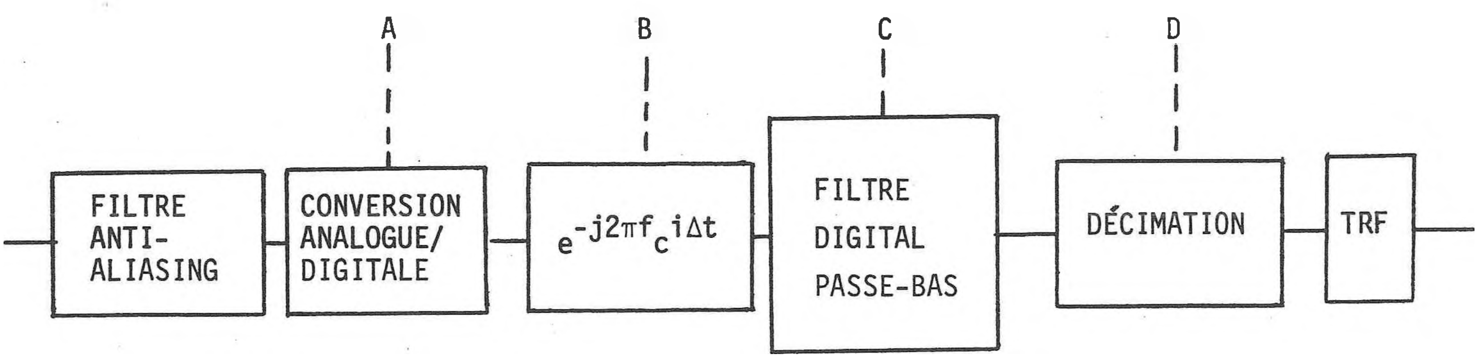

Fig. 12 Schéma de la technique du zoom

Nos essais[10] ont montré que cette méthode avait l'avantage de ne pas limiter le facteur par lequel on veut augmenter la résolution. Par contre, pour examiner une autre plage d'intérêt, il faut recommencer le zoom, ce qui nécessite beaucoup de temps et de plus impose que le signal soit parfaitement stationnaire.

La seconde technique consiste à augmenter le nombre d'informations par exemple de 1024 à 10 240. La T.R.F. est alors effectuée sur ces 10 240 points et on obtient d'un seul coup une augmentation par un facteur 10 de la résolution et ce, sur toute la gamme de fréquence choisie. A cet avantage s'ajoute le fait que la fonction temporelle est mémorisée pour un temps 10 fois plus long, ce qui est utile lorsqu'on parle d'amortissement de bruit irradié, par exemple. Cependant cela nécessite un analyseur ou un acquisiteur de données ayant au moins 10 K de mémoire par canal, le facteur de zoom est limité à 10 à cause du grand nombre de points de calcul pour la T.R.F., et conséquemment l'opération n'est pas en temps réel (temps de calcul du T.R.F. est beaucoup plus long).

Il nous est donc loisible de constater que le choix des outils et la méthode d'utilisation sont des éléments qui peuvent influencer notablement la validité des résultats de l'analyse fréquentielle obtenue par traitement numérique. Cependant les développements proposés précédemment permettent de solutionner adéquatement les principales difficultés.

Conclusions

Nous avons pu constater que le traitement numérique des signaux acoustiques se doit d'être effectué avec d'infinies précautions:

- dès que les signaux ne sont pas stationnaires, nous avons vu que l'analyse par filtres digitaux était absolument nécessaire;
- les erreurs de biais et les erreurs aléatoires faussent les résultats et on se doit d'en être conscient;
- le choix des fenêtres temporelles de filtrage est crucial, et les filtres anti-repliement sont sources de déphasage que l'on se doit de corriger;
- il est bon également de se rappeler que l'analyse en temps réel est un abus de langage en ce qui a trait aux analyseurs T.R.F.;
- l'information sur la phase d'un analyseur monocanal peut être obtenue grâce à une manipulation supplémentaire mais l'outil ainsi obtenu s'avère très utile;
- il y a différentes façons d'effectuer un "zoom" dépendant des objectifs d'utilisations.

Ces éléments fondamentaux se doivent d'être complétés car bien d'autres difficultés surgissent lorsqu'on aborde l'analyse multicanale: l'importance du déphasage entre canaux, le problème des délais temporels, la signification exacte des fonctions de cohérence, la gestion des essais et l'intercommunication bidirectionnelle entre les instruments et l'ordinateur; c'est pourquoi ces éléments feront l'objet d'un deuxième article que nous soumettrons prochainement.

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ACOUSTICAL STANDARDS CALIBRATION AT THE PHYSICS DIVISION OF THE NATIONAL RESEARCH COUNCIL OF CANADA

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Abstract

This paper describes some recent research and development in acoustical standards calibration at NRC. Topics included are: instrumentation and apparatus for precise reciprocity and comparison methods of calibration of condenser microphones. Also, a three-port two microphone cavity technique for the overall calibration of sound level meters is discussed together with various methods of verification of acoustical calibrators.

Résumé:

On décrit les plus récents travaux en recherche et développement sur l'étalonnage primaire acoustique au CNRC. On discute notamment de l'instrumentation et de l'appareillage pour l'étalonnage des microphones à condensateur par les méthodes de comparison et de réciprocité précise. On présente aussi une technique en cavité à trois orifices utilisant deux microphones pour l'étalonnage total des sonomètres ainsi que diverses méthodes de vérification des calibrateurs acoustiques.

Introduction

Most technology-based countries have national standards laboratories. In accordance with the mandate given NRC by Canada's Weights and Measures Act, the Division of Physics has responsibility for reference standards including national acoustical standards. This paper describes some recent research and development in acoustical standards calibration at NRC.

1.0 Reciprocity Pressure Calibration of Condenser Microphones

Various new and classical methods of microphone calibration have been described (1-8) and there are national and international standards (9, 10) to govern the absolute method of reciprocity calibration, which for the last 10 to 20 years, has achieved an accuracy of between 0.025 and 0.05 dB.

At NRC an arrangement has been developed (11) for precision reciprocity calibration of condenser microphones, and it is anticipated that in the very near future it will be possible to attain an accuracy of better than 0.005 dB.

The reciprocity method is essentially the measurement of the product of the sensitivities of each pair of a set of three microphones in terms of related electrical and mechanical quantities, from which the absolute sensitivity of each microphone can be calculated. It is outside the scope of this paper to describe the theoretical aspects of the reciprocity method. The combined result of two important developments which enable one to achieve an order of magnitude improvement on accuracy is explained as follows: The first development is,

a) The development of a precision A.C. null-detecting system which has a resolution of better than 0.001 dB. In the reciprocity calibration arrangement shown in Fig. 1, two microphones are mounted in a common cavity. Microphone (A) is driven by a signal (e) from an oscillator. After attenuation, signal (e_2) from the receiving microphone (B), is compared with signal (e_1), which is derived from the driving current (I) of microphone (A). The attenuator is a seven-decade ratio-transformer with an accuracy of 0.5 ppm. The A.C. null detector is a lock-in amplifier with full scale resolution of 100 nV.

The second development is,

b) The precise measurement of the equivalent volume of the calibration cavity by means of an unique acoustical method. The equivalent volume is expressed in terms of the readings of the ratio-transformer and a precisely known small change in volume, which is implemented with optical-flat spacers. The relation between the equivalent volume V and the readings of the ratio-transformer is (see fig. 2).

$$V = V_0 + \sum V_m = \Delta V_0 \left[\beta_0/(\beta_2 - \beta_1)\right]$$

where $\sum V_m$ and V_0 are the total equivalent volumes of the microphones and the cavity respectively, and ΔV_0 is the small change in volume.

Since the equivalent volume of the cavity is measured acoustically under controlled environmental conditions using frequencies similar to the reciprocity calibration, correction factors such as capillary correction, heat-conduction correction and wave-pattern correction are unnecessary. The precision of these corrections is only of the order of 0.1%, and they are essential for conventional calibration arrangements. It is estimated that the uncertainty of our reciprocity calibration is less than 0.005 dB.

Fig. 3 shows the sectional view of the cavity arrangements

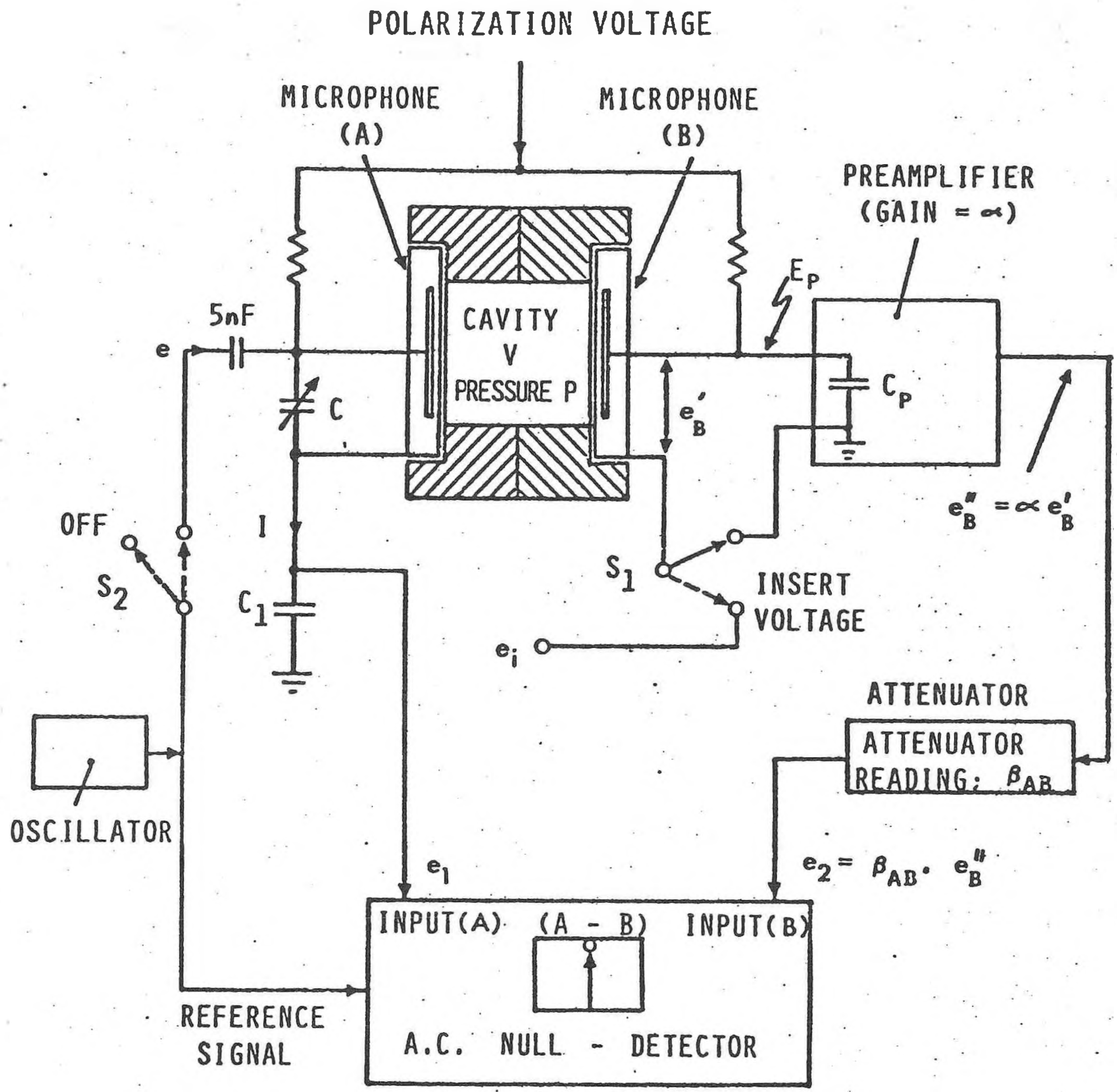


FIG. 1 GENERAL ARRANGEMENT OF AN A.C. NULL-DETECTING SYSTEM FOR RECIPROCITY CALIBRATION

2.0 Comparison Method of Microphone Calibration

The absolute method of reciprocity pressure calibration of microphones is relatively time consuming. For some microphone applications, the comparison calibration method developed at NRC is very attractive economically. The calibration procedure is as follows: -

(1) A standard microphone with a known pressure sensitivity, is closely coupled to a stable sound source (e.g. pistonphone calibrator). The signal from the microphone is monitored with a precision measuring amplifier (12) which was developed at NRC. The sensitivity of the reference microphone is entered into the multiturn potentiometer dial, which is calibrated in the format of microphone sensitivity (mV/Pa), of the measuring amplifier. A level reading is taken via an external digital voltmeter which has a resolution of better than 0.01 dB.

(2) The reference microphone is replaced with the test microphone. The calibrated sensitivity dial is adjusted until the same reading is obtained with the monitoring voltmeter. The dial reading gives the sensitivity of the test microphone in mV/Pa.

(3) As an added precaution, the abovce procedure is repeated with the reference microphone.

Some salient features of the above method are:

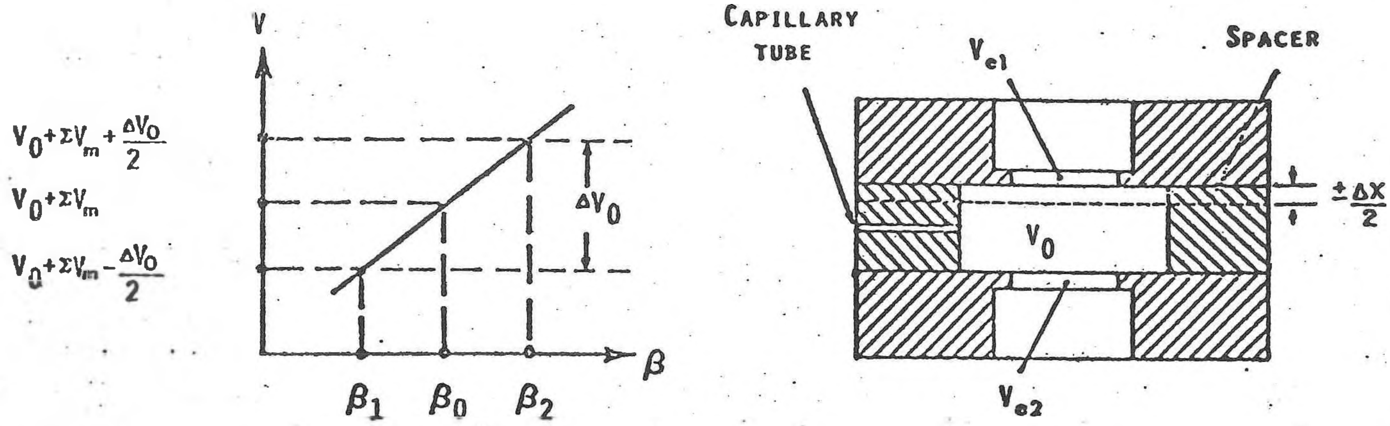
(a) The accuracies of the monitoring voltmeter and RMS detector of the measuring amplifier need not be stringent, since only good repeatability is needed.

(b) The multiturn potentiometer, which consists of an integral three-digit readout and a graduated dial has an accuracy of 0.02 dB.

(c) The total time required for the above comparison method is of the order of minutes.

The repeatability of the dial readings is better than 0.01 dB, and it is estimated that the error of the calibrated sensitivity of the test microphone is less than 0.05 dB plus the sensitivity uncertainty of the reference microphone.

There are several limitations which must be recognised: Since the two microphones are not presented to the sound field simultaneously, high accuracy can only be achieved if both microphones are of the same model so that the effective cavity volume remains essentially constant. The stability of the sound source and the mechanical positional repeatability of the microphones are some obvious requirements. However, the above limitations can be eliminated by the use of a three-port two microphone cavity which is described later.



$$V = V_0 + \sum V_m = \Delta V_0 \left[\beta_0/(\beta_2-\beta_1)\right]$$

FIG. 2. Equivalent volume of cavity

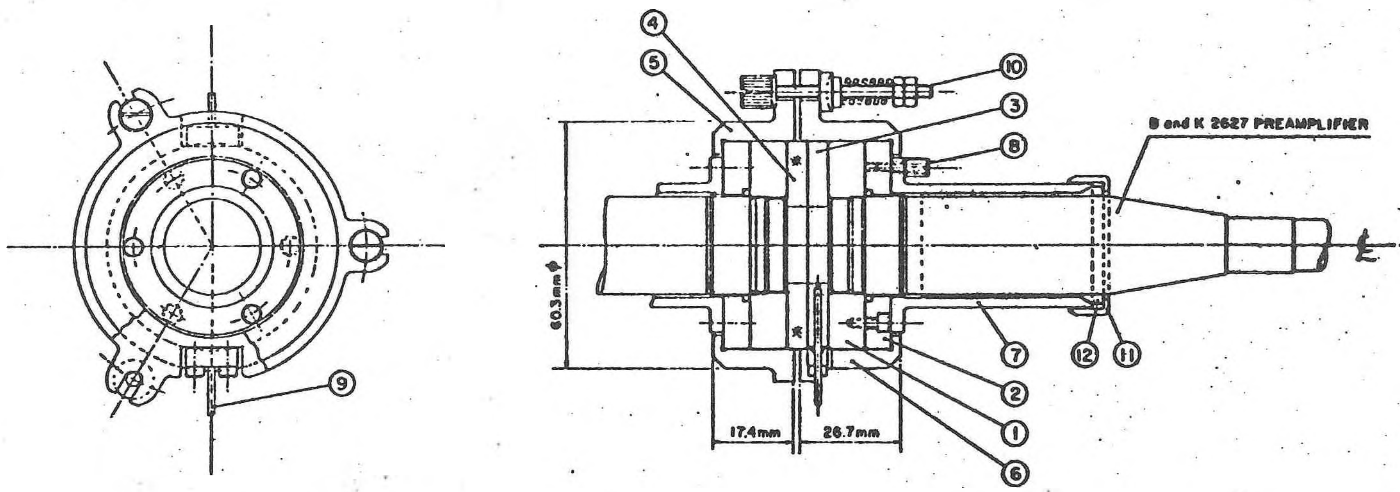


FIG. 3 CAVITY FOR PRIMARY STANDARDS

3.0 Calibration of Acoustical Calibrators

Acoustical calibrators are useful as a convenient means of checking the performance of acoustical measuring systems, and they are not intended to replace standard laboratory calibration procedures.

The arrangement for calibrator assessment is shown in Fig. 4. It consists of a standard microphone with a known pressure sensitivity, a pre-amplifier with a gain α, and the provision for insert voltage measurement.

The usual calibration procedure is to obtain a reading from the detector-indicator with the switch S at position 1. With the acoustical signal turned off, and the switch at the second position, the same reading is obtained by adjusting the insert voltage. Since the microphone pressure sensitivity is known, the measured magnitude of the insert voltage enables the calculation of the sound pressure level of the calibrator. In theory, the sole requirement of the detector-indicator is good repeatability. However, is practice, the RMS accuracy of the detector is important since the insert-voltage is usually a relatively pure sinewave, whereas the signal from acoustical calibrators may have 1 to 3% distortion.

A second approach is to measure the signal directly at the output of the pre-amplifier (switch S at position 1). The gain of the pre-amplifier can be measured accurately (to the order of ppm) by means of the A.C. nulling arrangement, and the assessment of the signal is performed with a precision RMS differential voltmeter (Fluke 931B) which has an accuracy better than 0.005 dB. The estimated error of the calibrated sound pressure level is less than 0.01 dB plus the sensitivity uncertainty of the reference microphone.

It is important to point out that the above methods only provide a calibrated sound pressure level for the particular model of microphone used as the reference. A correction is required for microphones with different equivalent volumes. Other corrections such as those due to barometric pressure and temperature variations are normally supplied by the manufacturer of the acoustical calibrator.

4.0 Theory of a Three-Port, Two-Microphone Cavity

The effects of the microphone equivalent volume and the stability of the sound source on the conventional comparison method of microphone calibration can be eliminated with the aid of a three-port, two-microphone cavity (13). The two microphones simultaneously monitor the sound field that is produced by a suitable driver unit (fig. 5).

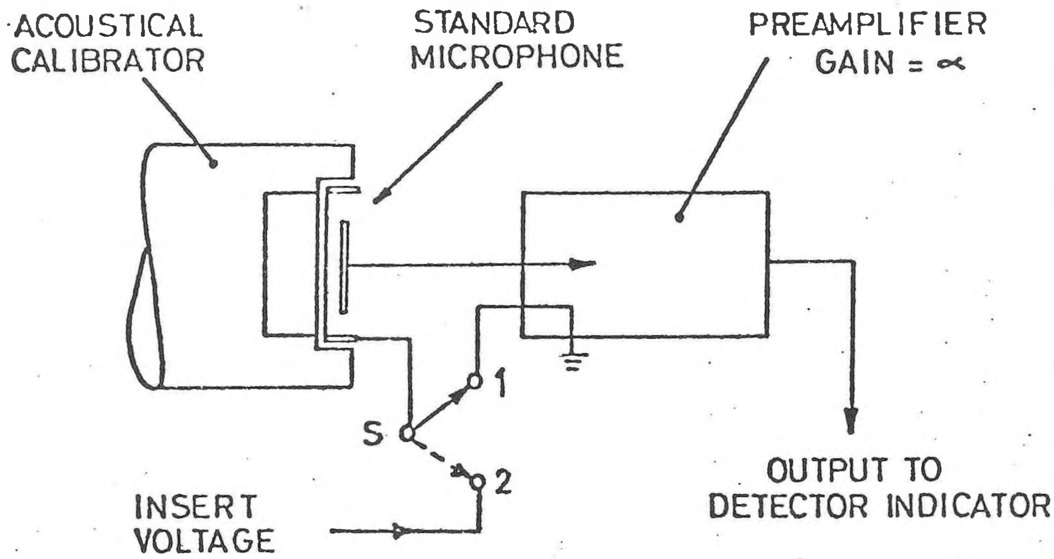


FIG. 4. SCHEMATIC ARRANGEMENT FOR ACOUSTICAL CALIBRATOR ASSESSMENT

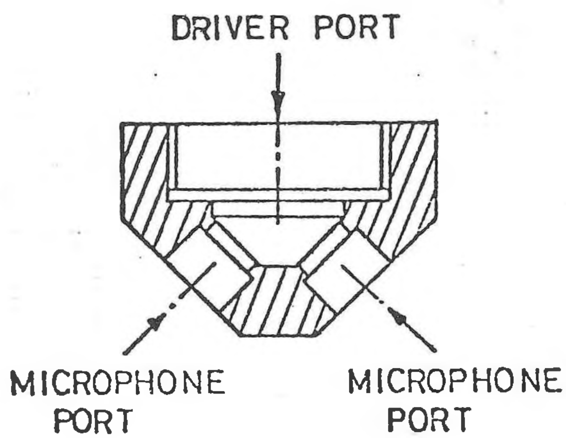


FIG. 5. A THREE-PORT TWO MICROPHONE CAVITY

The comparison procedure is as follows:

(1) The test microphone with the test measuring system, and the reference microphone with the corresponding reference measuring system simultaneously monitor the sound field of the cavity shown. Level readings are obtained for signals of various frequencies.

(2) With the microphones and their corresponding measuring systems: exchange microphone ports new level readings are taken.

(3) The test microphone and the reference microphone exchange measuring systems so that the test microphone is with the reference measuring system and the reference microphone with the test system; steps (1) and (2) are repeated.

It can be shown that based on the above level readings, the pressure response of the test microphone and the response of the test measuring system can be deduced.

Initial tests have shown that with two Type 1 measuring systems the error of the difference between the A-weighted responses is within 0.6 dB when compared with those obtained with direct electrical measurements, over the frequency range from 12.6 Hz to 16 kHz.; and the error of the difference between the frequency responses of two 1/2 inch condenser microphones (B & K model 4133 and model 4144) was found to be within approximately 1 dB when compared with those obtained with the electrostatic actuator method, over the frequency range from 1 kHz to 10 kHz. Below 1 kHz, the error was within 0.15 dB.

It must be pointed out that the above errors included the errors of the detector-indicators of the measuring systems; and the measurements were performed with the protecting grids on the microphones in place.

5.0 Conclusion

This paper describes some recent research and development in acoustical standards calibration in our laboratory. If any readers would like to have more information in the metrological procedures of the calibration methods described, we would be glad to discuss them in more detail.

Note: This paper was presented at the 101st Meeting of the Acoustical Society of America in Ottawa, 18-22 May 1981.

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EFFECT OF CONTINUOUS TRAFFIC NOISE ON PERCENTAGE OF DEEP SLEEP, WAKING AND SLEEP LATENCY.*

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A. BACKGROUND

Our original experiments tested the disturbing effect on sleep of individual truck passages with the intervals between them being relatively quiet (30 to 35 decibels due to the air conditioner). Being awakened was, of course, considered a disturbance but so was a shift from a deeper level of sleep to a shallower level. (The depth of sleep was monitored by means of an electroencephalograph which measured the brain waves from electrodes attached to the forehead of the subjects). The result showed that disturbances started at peak noise levels of 20 to 30 decibels and increased with the level until at 75 decibels a single truck passing through a city would disturb 80 percent of the sleepers on its route.

These results do not, of course, prove that the disturbances are harmful. The quiet periods between passages of trucks may be used to make up for the disturbance if the body has an appropriate mechanism for such adjustment. We therefore tried to measure the effect of the truck noise on the percentage of deep sleep that was obtained by the subjects. For this purpose the usual five stages of sleep (six if waking is included) were divided into only two stages "deep" sleep (stage 2, 3 and 4) and "shallow" sleep which included all the rest. This division was chosen because "spindles", which are clearly audible on a speeded up magnetic tape recording of the brain waves as chirping noises, occur in this "deep" sleep. This makes measurement simple, fast and objective. No subjective judgments confound the results.

As expected we found that the percentage of deep sleep was lower for the nights with truck noise than during the alternating quiet nights when only the air conditioning system could be heard. The amount was not great, being only about 3 percent, but quite consistent. Of 12 subjects only one showed an increase of deep sleep and that was only a fraction of one percent.

B. PRESENT EXPERIMENTS

Intermittent truck noise with quiet periods in between is, of course, quite different from the random noise of free flowing

*This is a summary of a paper submitted to JASA for publication Ed.

traffic. So the present experiments were conducted using a recording of actual traffic noise in a busy street. Again the noise-nights alternated with quiet nights when only the air conditioner could be heard.

When the average noise level of the traffic was 47 dB the effect on percentage of deep sleep for 12 subjects was 2.5 percent but this time in the opposite direction. That is, there was more deep sleep during the noisy nights. Only three subjects showed a small decrease.

Another group of 12 subjects was then subjected to average levels of 60 dB. The response was now a 4.8 percent increase in deep sleep and all subjects were in the same direction (although the variation was great among individuals).

These results probably will not surprize mothers who sing their infants to sleep. But there is a seeming contradiction here since, when the number of wakings are counted, it is found that they behave in the expected way - they are greater during the nights with the truck noise. The group subjected to 47 dB had nearly 13 percent more wakings on noise nights while the group with the 60 dB noise had an increase of 36 percent.

But, as was found before and confirmed in the present work, the waking reaction adapts to the noise. After two weeks the number of wakings drops by a half. In a couple of months one would expect them to be essentially zero.

People often complain that noise interferes with their falling asleep. Accordingly this was also measured by timing the interval between lights-out and the onset of spindles (the latency of "deep" sleep onset). To within experimental error it was found to be nil for both groups.

So we may well ask: what is the harm - if any - that noise can have on sleep? For certain individuals it is clear. But for the population in general we cannot answer that question. In a way this is not surprizing since we do not yet even know the function of sleep.

Why do we have to sleep?

FUTURE ACOUSTICAL EVENTS

October 27-29, 1982, San Diego, CA., U.S.A.

IEEE 1982 Ultrasonics Symposium

Deadline for receipt of abstracts is July 2, 1982. For further information contact R.S. Wagers, Texas Instruments Inc., P.O. Box 225936, Dallas, Texas 75265, U.S.A., Telephone (214) 995-4619

October 21-22, 1982, Toronto, Ontario, Canada

CAA 21st Technical Symposium

For further details see special article in this publication (page)

November 8-12, 1982, Orlando Florida, U.S.A.

104th Meeting of the Acoustical Society of America

Deadline for receipt of abstracts: July 23, 1982. For further information contact: A.L. Van Buren, Naval Research Laboratory, P.O. Box 8337, Orlando, Florida 32856, U.S.A.

March 21-23, 1983, MIT, Cambridge, MASS., U.S.A.

NOISE-CON 83

"Quieting the Noise Source" will be the theme of NOISE-CON 83, the 1983 National Conference on Noise Control Engineering. NOISE-CON 83 will be sponsored jointly by the Institute of Noise Control Engineering and the Massachusetts Institute of Technology.
To be held on 21-23 March 1983 on the MIT campus, NOISE-CON 83 will emphasize a physical understanding of noise generation and noise reduction at the source.
For further information on NOISE-CON 83, contact the Institute of Noise Control Engineering, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603, U.S.A.

July 19-27, 1983, Paris, France

11th International Congress on Acoustics/11e congrès international d'acoustique

Every three years an international Congress on Acoustics is convened under the double patronage of the International Commission on Acoustics and the Acoustic Society of the host country.

The 11th Congress will be held in Paris (Hotel SOFITEL, Paris) July 19-27, 1983. The venue for the opening session will be the main theatre at the Sorbonne, in Paris. GALF (a group of French speaking acousticians) will be wholly

responsible for the organisation of the Congress.
The Congress will deal with every aspect of acoustics and will be heralded by three smaller "Satellite" Symposia, held in:
MARSEILLE: July 12-13 on active sound absorption and acoustic feedback control;
LYONS: July 15-16 on acoustic radiations from vibrating structures;
TOULOUSE: also July 15-16 on oral communication.

Tous les trois ans, un Congrès International d'Acoustique se tient sous la double égide de la Commission Internationale d'Acoustique (ICA) et de la Société Acoustique du pays hôte.
Le 11e Congrès se tiendra en France, à Paris (Hôtel SOFITEL-PARIS), du 19 au 27 juillet 1983. La Séance inaugurale se tiendra dans le Grand Amphithéâtre de la Sorbonne. Le GALF (Groupement des Acousticiens de Langue Française) assume l'organisation de ce Congrés.
Il concernera tous les domaines de l'acoustique, et sera précédé de Symposia satellites:
- à Marseille les 12 et 13 juillet sur l'absorption acoustique active et les asservissements acoustiques;
- à Lyon les 15 et 16 juillet sur le rayonnement acoustique des structures vibrantes;
- à Toulouse les 15 et 16 juillet également, sur la communication parlée.

CALENDAR OF PROCEDURE - CAUTION: DEADLINES WILL BE FINAL!

June 15, 1982: return of all provisional registration forms. Return of all authors' cards for presentations and poster presentations, for both the 11th Congress and the satellite symposia.
November 15, 1982: Submission of texts of contributed papers (4 pages) accepted by the 11th Congress, or accepted by one of the symposia. Submission of outlines (1 page) for poster contributions.
March 1983: After circular Nr. 3 will have been received: Final registration, reservations, hotels, transports etc.

RAPPEL DU CALENDRIER. ATTENTION AUX DATES LIMITES!

15 juin 1982: Envoi des formulaires d'inscription provisoire. Envoi des fiches d'auteur pour les communications orales ou affichées, 11e Congrés et Satellites. Demande d'emplacement d'exposition.
15 novembre 1982: Envoi des textes des communications orales (4 pages) proposées au 11e Congrès ou acceptées à un Symposium. Indications (1 page) pour panneau.
Mars 1983 (après réception de la circulaire n^{o} 3): Inscription définitive, réservations, hôtels, transports etc.

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