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EDITORIAL

Dans ce numéro, vous trouverez d'excellents articles portant sur la physique acoustique et, pour une seconde fois, sur les vibrations. Nous nous permettons de rappeler aux gens qui travaillent dans le domaine des vibrations que, malgré son nom, l'Acoustique Canadienne vous appartient autant qu'aux acousticiens.

Les récents développements concernant la mise sur pied d'un institut d'acoustique dans les Maritimes sont présentés. Prenez note - il se passe des choses dans l'Est.

Vous trouverez aussi le programme complet de la Semaine de l'Acoustique qui se tiendra à Montréal, ainsi que les résumés des communications. Cette rencontre promet d'être très intéressante tant du point de vue technique que social. Etant natif de Montréal, je peux vous assurer (très objectivement, bien sûr!) que Montréal est la ville la plus excitante du monde. Au plaisir de vous y rencontrer!

Le procès-verbal de la dernière rencontre du conseil d'administration est présenté. Nous avons récemment éprouvé des problèmes de diffusion des informations officielles de l'ACA. A partir de maintenant, nous tenterons de publier le plus rapidement possible ces informations dans le journal.

Un mot au sujet du questionnaire d'opinions sur l'Acoustique Canadienne publié dans les deux derniers numéros. A ce jour, une vingtaine de questionnaires ont été retournés (moins de 5% des membres). D'ici là, en espérant avoir reçu de nombreuses autres réponses, nous reportons la discussion des résultats au prochain numéro. Nous reportons également la publication de l'annuaire des membres de l'Association.

Nous terminons en lançant deux appels aux membres. Premièrement, s'il y a parmi vous un artiste en herbe intéressé à produire l'illustration de la page couverture, veuillez communiquer avec le rédacteur en chef. Deuxièment, sous sollicitons activement des articles pour le numéro de janvier. Comme toujours, les articles de recherche, les revues d'articles et la description de vos activités sont bienvenus.

In this issue are published excellent research papers on physical acoustics and, for the second month in a row, vibration. May I emphasize to people working in the field of vibration that, despite its name, Canadian Acoustics belongs to you as much as to acousticians.

Also published is a description of recent developments to establish an acoustics institute in the Maritimes. Take note everyone - things are happening in the East.

You will also find the programme of the 1990 Canadian Acoustics Week to be held in Montreal, along with abstracts of all papers to be presented. This meeting promises to be very interesting from both technical and social points of view. As a native Montrealer, I can assure you (totally objectively, of course) that Montreal is the most exciting city in the world. See you there!

The Minutes of the recent Directors' meeting are also included. There have been problems with poor diffusion of official CAA information recently. From now on, all such information will be published quickly in the journal.

A word about the Canadian Acoustics opinion survey circulated in the last two issues. To date, I have received about 20 replies (that is, from less than 5% of members). In the hope of receiving a flood of replies between now and then, I'm putting off discussing the results until next issue. I'm also delaying publication of the Association membership list.

Finally, two appeals to members. First, if there are among you any budding graphic artists who would be interested in doing the journal's cover illustrations, please contact the Editor-in-Chief. Secondly, we are actively soliciting articles for the January issue. As always, research papers, review articles and descriptions of your activities are welcome.

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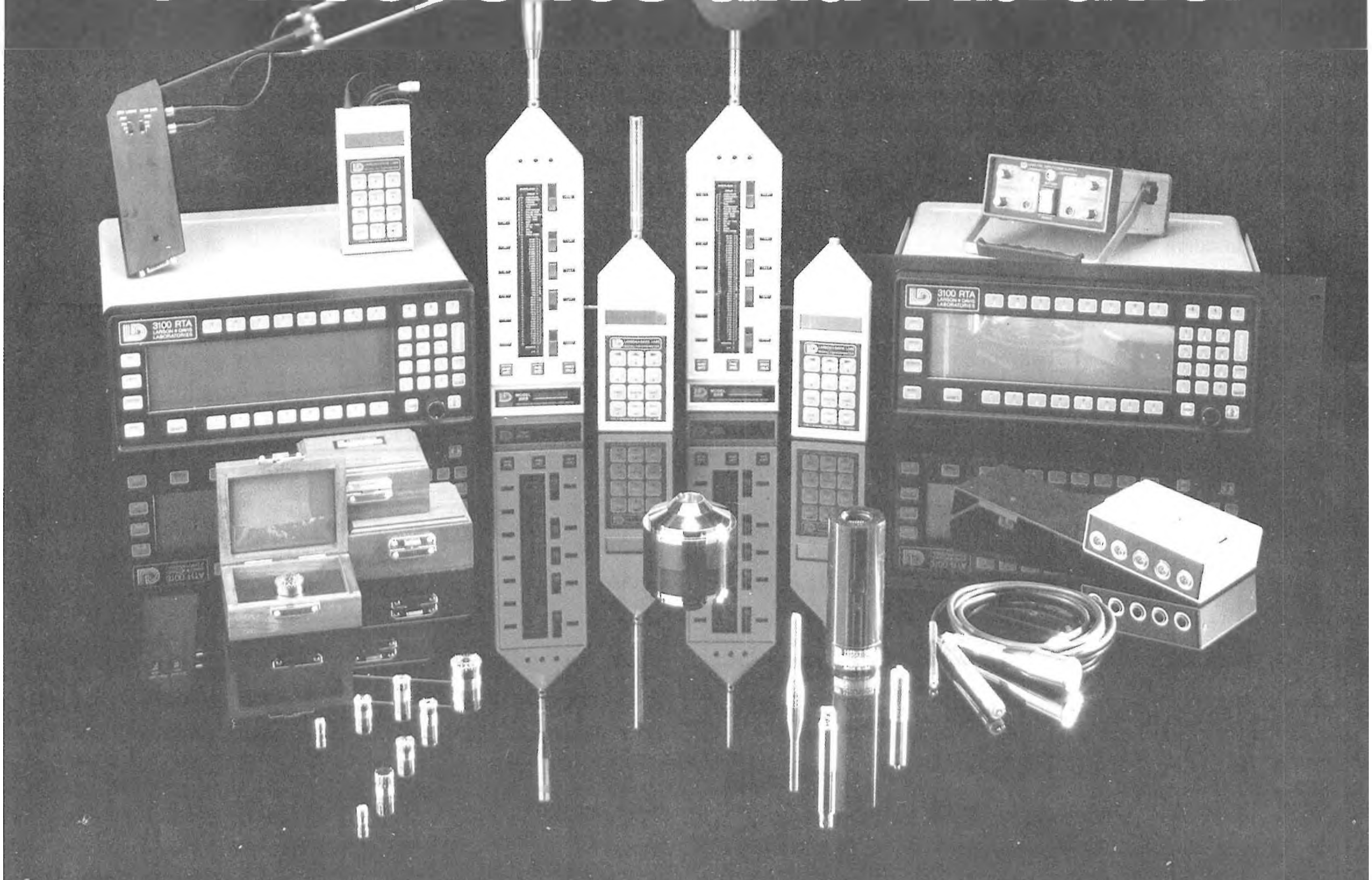

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PREDICTED ACOUSTICAL PERFORMANCE OF MULTI-UNIT SPLITTER SILENCERS

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Abstract

Passive silencers with acoustic fill are commonly used to reduce the fan noise in rectangular ducts of conventional air-handling systems. Design procedures for silencer performance evaluation of simple configurations have been available for some time. Design curves for a wide variety of rectangular silencers were made available recently. Many methods for predicting silencer insertion loss assume the silencers to be a single unit. In many air-handling systems however, the duct is divided into many small units by installing splitters in the duct. Predicted insertion loss results for multi-unit splitter silencers are presented in this paper. Multi-unit silencer performance is compared to that of a single unit within the full duct. The accuracy of using a single-unit model to represent the different types of conventional rectangular silencers is also presented.

Sommaire

Les conduits d'air rectangulaires dans les systèmes conventionnels sont composés de silencieux passifs accompagnés de remblai acoustique afin de réduire le bruit de ventilateur. Des procédures établies servant à evaluer le fonctionnement des silencieux à compartiment simple existent depuis quelque temps. Des courbes typiques représentant la ligne complète de silencieux rectangulaires ont récemment été disponibles. La perte dut a l'insertion calculée de façons diverses prenait pour acquis que les silencieux étaient composés d'une piece unique. Plusieurs conduits d'air sont réduits de taille par l'introduction de partitions.

Les résultats présentés dans cette dissertation, démontrent la perte dut à l'insertion de partitions dans les silencieux. La performance des silencieux à plusieurs compartiments est comparée à celle des silencieux à compartiment unique. L'exactitude de l'utilisation d'un modèle réservé aux silencieux à compartiment unique afin de représenter la ligne de silencieux conventionnels est également discutée.

1.0 Introduction

Fan noise in air-handling systems is conventionally reduced by the use of absorptive silencers. Theoretical models for describing the wave propagation in simple lined ducts as well as for predicting the acoustical insertion loss were presented by Scott [1], Morse [2] and Cremer [3]. Many prediction schemes are available [4, 5, 6, 7, 8, 9] and all are based on the two models of Scott [1] and Morse [2]. The differences in the various procedures are due to the amount of complexity applied while solving the mathematical model and range from the simplistic procedures [4] to the calculation of a large set of design curves [9].

All of the available prediction schemes assume that the passive silencers consist of a single unit, that is, acoustic fill - open air way - acoustic fill. In large air handling systems however, splitters are inserted to divide the duct into a number of identical single units. The prediction schemes assume that the insertion loss of splitter silencers can be predicted by calculating the performance of one single unit. Cummings [8] discussed the possible extension of a single-unit model to multi-unit splitter silencers. The use of a single-unit model to represent the rectangular splitter silencers must be validated.

The main aim of the present paper is to extend the results of Ramakrishnan and Ball [9] to include splitter silencers. The results of the present paper are limited to the range of rectangular silencers manufactured in conventional HVAC (Heating, Ventilating, Air Condtioning) systems [10, 11]. Silencer insertion loss results for two combinations of splitter silencers are presented in this paper. Results for a single-unit silencer are compared to those predcited by the multi-unit splitter models. The accuracy of using the results from a single-unit system to predict the performance of a wide variety of silencers is also presented.

2.0 System Description

2.1 System Criteria

The aim of the present paper is to present methods that are accurate within 3 dB in each frequency band of interest. A number of simplifications are therefore inherent in the procedure used to predict the insertion loss. The results presented in this paper are based on the theoretical model described in Ramakrishnan and Watson [12]; details are not presented here. The accuracy of the prediction procedure was validated for single-unit silencers in reference 12 by providing comparisons with experimental results. Results are applicable only to low-speed HVAC system ducts. Thus they are not applicable to, for example, aircraft engines or automobile mufflers.

2.2 Multi-unit Silencer Model

Three splitter silencer configurations commonly used in HVAC systems are shown in Figure 1. Single unit, two unit and three unit silencers have the same basic unit width 'M'. The dimensions of the basic unit are described using the general convention of major silencer manufacturers in Canada [10, 11]. It consists of a hard-walled duct with two liners of depth 'd' separated by an open air way of depth '2h'.

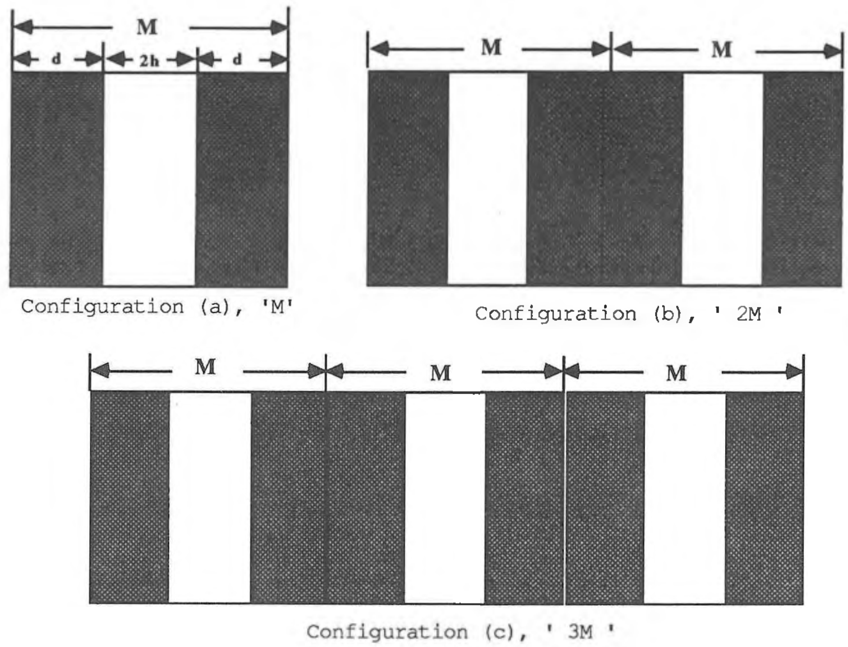

Figure 1. Types of Splitter Silencers.

Layers of isotropic, homogeneous sound absorbing material are used for the lining. The open airway of the duct is separated from the liners by sheets of perforated material with uniformly spaced holes.

Existing insertion loss prediction methods assume that a hard septum separates the basic units in a multi-unit system. This allows one to solve for the insertion loss of a single duct of size 'M'. The same result is then applied for silencers of size '2*M', '3*M' and so on. It is obvious that the above procedure is valid only if it can be shown that plane waves alone propagate in the duct system. The aim of the present work is to investigate the possibility of extending the same procedure for all possible propagating modes. A brief description of the solution procedure is given in the next section.

2.3 Prediction of Insertion Loss

The acoustical evaluation procedure follows conventional theoretical methods. The sound absorbing material is considered to be homogeneous, isotropic and made up of either foam or fibrous type materials. Even though the isotropic condition is not realistic, the differences in the insertion loss results between isotropic and anisotropic conditions are well within the required accuracy for HVAC system silencers [13]. The sound absorbing material is also treated as bulk reacting, unlike the local reaction model used in references 2 and 3. Propagation in the acoustic material is thus included with proper accounting of its bulk properties.

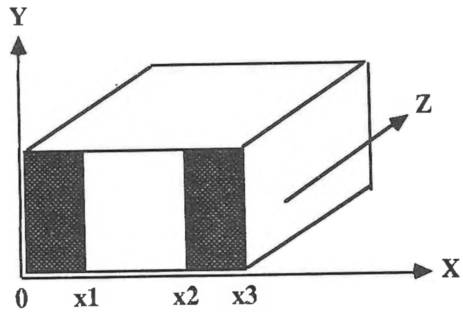

Figure 2. Co-ordinate System Used for the Analysis

The rectangular duct geometry and the coordinate system used are shown in Figure 2. The sound field in the duct is evaluated by solving the following set of wave equations:

$$\partial^2 p / \partial z^2 + \partial^2 p / \partial x^2 - (1 / c_1^2) \, \partial^2 p / \partial t^2 = 0 \qquad (1)$$

$$\partial^2 p / \partial z^2 + \partial^2 p / \partial x^2 - (1 / c_2^2) \, \partial^2 p / \partial t^2 = 0 \qquad (2)$$

Equation (1) is valid in the open air way [$x_1 \leq x \leq x_2$] with c_1 being the sound speed in air. Equation (2) is valid in the sound absorbing material [$0 \leq x \leq x_1$; $x_2 \leq x \leq x_3$] which has a complex sound speed of c_2. Pressure and velocity continuity are applied at the various interfaces between the absorbing material and open air way. The number of such interfaces is equal to twice the number of units in the duct system. For example, there are '2' interfaces for Configuration (a) and there are '6' interfaces for Configuration (c).

The two wave equations are solved for the common axial wave number k_z by applying a cubic finite element algorithm [12]. The propagation constant and characteristic impedance of the sound absorbing material are complex and are obtained from Beranek [5]. The real part of the axial wave number k_z is directly proportional to the attenuation rate per unit length of the silencer. All possible modes propagating in the 'X' direction are considered. Only those modes with slow rates of attenuation are summed to determine the final insertion loss on the assumption that these modes carry equal amounts of the incident sound energy.

3.0 Results and Discussion

The silencer unit size 'M' of conventional rectangular silencers varies from 250 mm (10 in.) to 910 mm (36 in.). The frequency range of interest is from 100 Hz to 10 kHz. The type of absorbing material is another variable that must be included. In addition, the ratio of 'd' to 'h', commonly represented by the open-area percentage, is varied between 0.5 and 3.0. Since it was not practical to present predictions for all combinations of the parameters, insertion loss results are generated for extreme values. The length of the silencer is chosen to be one metre.

The values chosen for the various parameters used in the calculations are as follows:

- Material type (Flow resistance in MKS Rayls / m): 8000, 20000
- 'M', the Unit Size (mm): 300, 600
- Open-Area Percentage (%): 25, 50
- Configuration of Splitters : 'M', '2M', '3M'

The insertion loss values reported by silencer manufacturers [10, 11] are usually limited to 50 dB. One main reason for such a convention is perhaps due to the fact that it is very difficult to measure insertion loss values more than 50 dB by any of the standardised test procedures [14]. The predicted results presented in this paper are not limited to 50 dB.

Unit Size 'M'	d / h	Material Rayls / m	Silencer Type	Frequency, Hz											
				125		250		500		1000		2000		4000	
				a	b	a	b	a	b	a	b	a	b	a	b
600 mm	1	8000	M	2	1	2	1	3	1	4	1	8	1	14	3
			3M	2	2	3	3	6	3	9	3	21	3	42	6
600 mm	1	20000	M	2	1	2	1	3	1	5	1	8	1	14	3
			3M	2	2	3	3	6	3	9	3	21	3	42	6
300 mm	1	8000	M	1	1	1	1	2	1	3	1	4	1	7	1
			3M	1	1	2	2	3	3	6	3	11	3	21	3
600 mm	3	8000	M	2	1	2	1	3	1	5	1	8	1	14	3
			3M	2	2	3	3	6	3	9	3	21	3	42	3

NOTE: a) Number of Propagating Modes ; b) Number of Modes used in Insertion Loss Evaluation.

Table 1. Number of Higher Order Modes in the Silencer.

The numbers of propagating modes for silencer 'M' and '3M' are given in Table 1. The modes that were included in the calculation of the insertion loss are also identified in the table for a representative sample of frequencies. It is seen that for multi-unit silencers the actual number of modes used is well below the total number of modes that are cut-on at a given frequency. The number of modes included in the calculation is seen to be similar for the two configurations of silencers represented in the table.

The insertion loss results for the various silencers tested are shown in Figures 3 through 6. Results for eighteen frequencies centered at 18 third octave bands from 100 Hz to 5000 Hz are presented in the figures.

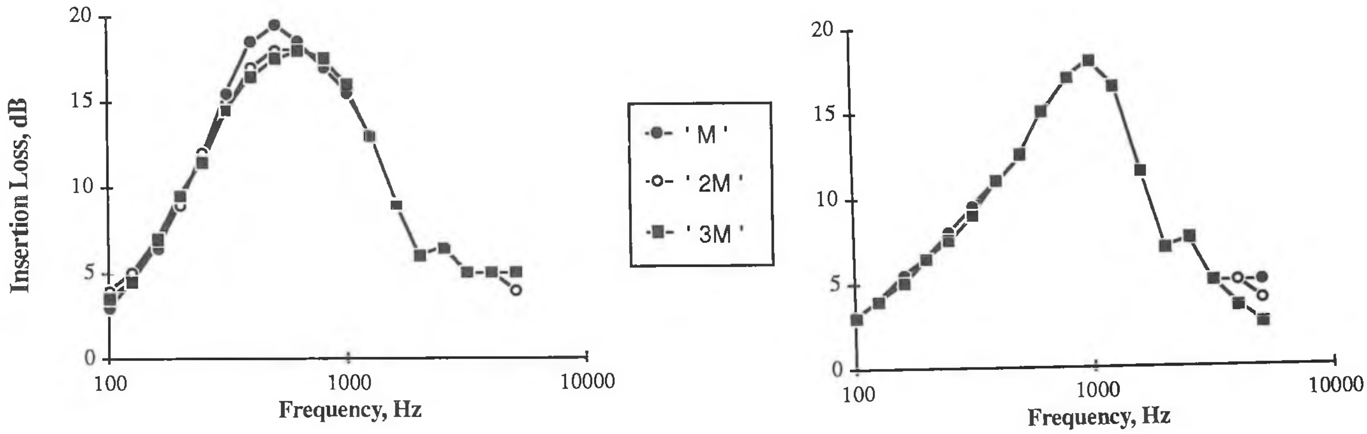

Figure 3. Insertion Loss of Splitter Silencers : M = 0.6 m, d / h =1 ;
a) R = 8000 MKS Rayls / m, b) R = 20000 MKS Rayls / m

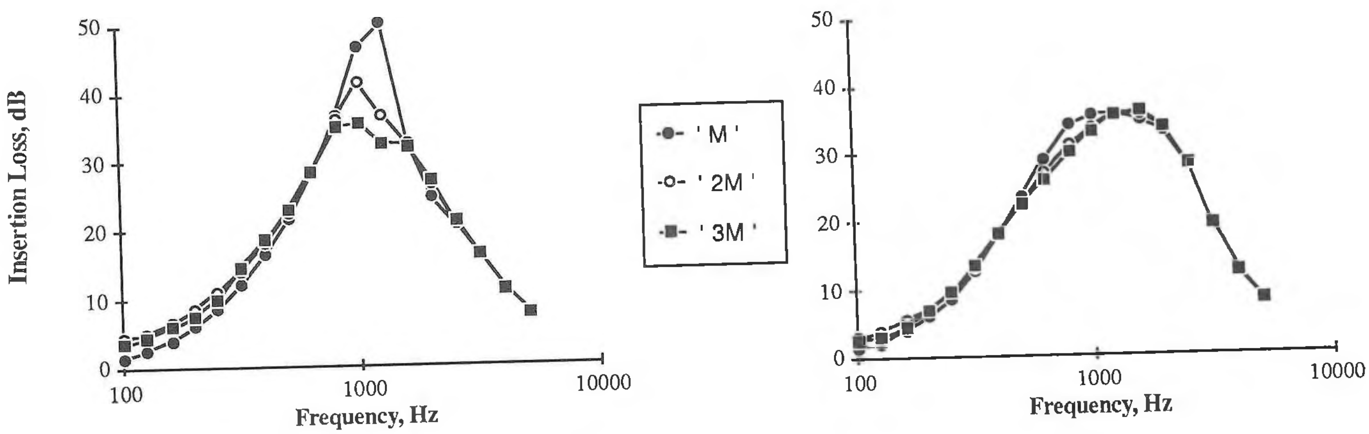

Figure 4. Insertion Loss of Splitter Silencers : M = 0.3 m, d / h =1 ;
a) R = 8000 MKS Rayls / m, b) R = 20000 MKS Rayls / m

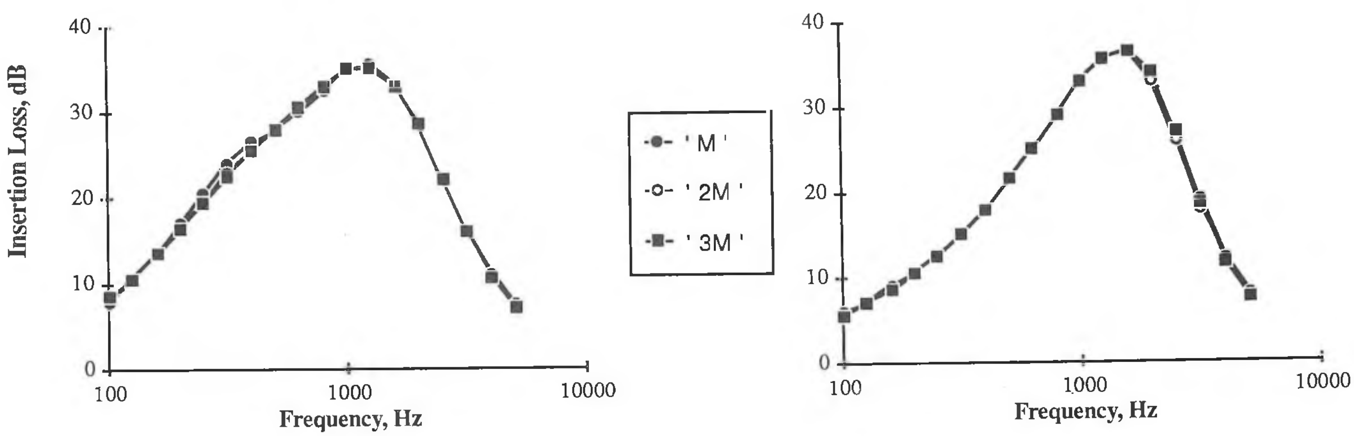

Figure 5. Insertion Loss of Splitter Silencers : M = 0.6 m, d / h =3 ;
a) R = 8000 MKS Rayls / m, b) R = 20000 MKS Rayls / m

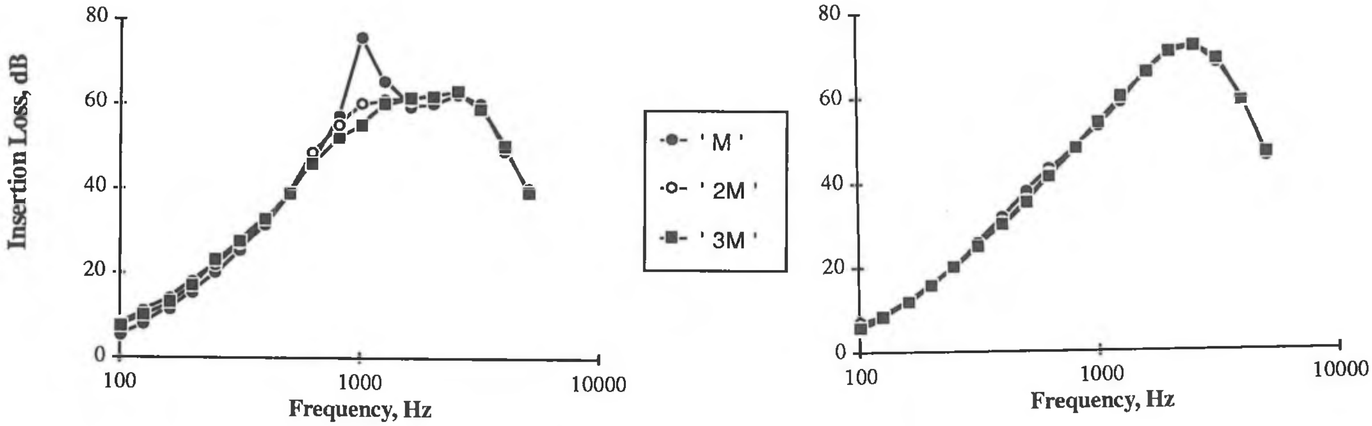

**Figure 6. Insertion Loss of Splitter Silencers : M = 0.3 m, d / h =3 ;
a) R = 8000 MKS Rayls / m, b) R = 20000 MKS Rayls / m**

The open-area percentage is 50 (d = h) for the results presented in Figures 3 and 4. The unit size is 0.6 m for Figure 3. It is seen from Figure 3 that there is hardly any difference between the insertion loss values for the three configurations.

A unit size of 0.3 m was used for the results shown in Figure 4. The insertion loss values for the three configurations are slightly different. One reason for this is that the influence of the absorbing material is more pronounced on the higher order modes in a smaller duct. The differences are within the predicted accuracy for most of the frequency bands. Large differences are seen in the results presented in Figure 4a for the light density material. The maximum difference is 11 dB at 1000 Hz; the difference is 17.5 dB at 1250 Hz. The predicted insertion loss is highest in the case of the single-unit silencer. This is due to the tuning of the silencer for the particular combination of frequency, material type (density is approximately 22 kg /cu.m.), unit size and open-area percentage. Outside the range of the tuning phenomenon, the deviations between the three configurations are well within the prediction accuracy.

The effect of increasing the material depth (d) is shown in Figures 5 and 6. The open-area percentage is 25 (d = 3 * h) for these results. The tuning effect is stll evident for the lighter material (Figure 6a). The maximum difference is 21 dB at 1000 Hz; the difference is 5.5 dB at 1250 Hz. The insertion loss values for the three configurations are remarkably similar to one another outside the 1000 Hz and 1250 Hz bands.

Finally, the complete octave band results are presented in Tables 2 to 5. The insertion loss results for the three configurations are very similar in all cases, with the exception of the cases summarized in Tables 3a and 6a for which differences of 7 dB and 6 dB occur at the 1000 Hz band.

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	4.5	11.5	19.0	15.0	7.0	5.0
2M	5.0	11.0	18.0	15.0	7.0	4.5
3M	5.0	11.5	17.5	15.0	7.0	5.0

a) Liner Flow Resistance = 8000 MKS Rayls / m

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	4.0	8.0	12.5	17.0	8.0	5.0
2M	4.0	7.5	12.5	17.0	8.0	4.5
3M	4.0	7.5	12.5	17.0	8.0	3.5

b) Liner Flow Resistance = 20000 MKS Rayls / m

Table 2. Insertion Loss of Splitter Silencers in Octave Bands, M = 0.6 m ; d / h = 1.0.

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	2.5	8.0	20.0	41.0	24.0	10.5
2M	5.5	11.0	21.0	37.5	24.5	10.5
3M	4.5	10.0	22.0	34.0	24.5	10.5

a) Liner Flow Resistance = 8000 MKS Rayls / m

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	2.5	8.5	21.5	35.0	31.0	11.0
2M	4.0	9.0	21.0	33.0	31.5	11.0
3M	3.0	9.0	21.0	32.5	31.5	11.0

b) Liner Flow Resistance = 20000 MKS Rayls / m

Table 3. Insertion Loss of Splitter Silencers in Octave Bands, M = 0.3 m ; d / h = 1.0.

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	10.0	20.0	28.0	34.0	25.5	10.5
2M	10.0	19.0	27.5	34.5	26.0	10.0
3M	10.0	19.0	27.5	34.5	26.0	10.0

a) Liner Flow Resistance = 8000 MKS Rayls / m

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	7.0	12.5	21.0	32.0	31.0	11.0
2M	7.0	12.5	21.0	32.0	30.5	11.0
3M	7.0	12.5	21.0	32.0	31.0	11.0

b) Liner Flow Resistance = 20000 MKS Rayls / m

Table 4. Insertion Loss of Splitter Silencers in Octave Bands, M = 0.6 m ; d / h = 3.0.

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	8.0	19.0	35.5	61.0	60.0	44.0
2M	10.5	21.0	37.0	58.0	61.0	43.5
3M	10.0	20.5	37.0	55.0	62.0	43.5

a) Liner Flow Resistance = 8000 MKS Rayls / m

Silencer Type	Insertion Loss, dB in Octave Bands with Centre Frequency, Hz					
	125	250	500	1000	2000	4000
M	8.0	19.0	35.5	52.0	69.0	51.0
2M	9.0	19.0	34.0	51.5	69.0	51.5
3M	8.0	19.0	33.5	51.5	69.0	51.5

b) Liner Flow Resistance = 20000 MKS Rayls / m

Table 5. Insertion Loss of Splitter Silencers in Octave Bands, M = 0.3 m ; d / h = 3.0.

4.0 Conclusions

Insertion loss predictions for splitter silencers were presented. The results of a parametric study based on unit size, material type, open-area percentage and frequency were shown. Results of an identical single-unit silencer were compared to the results of the splitter silencers. The comparison showed that there was hardly any difference in the insertion loss values for the three configurations of multi-unit silencers for all cases. The effect of tuning was highlighted. It can be concluded that the performance of splitter silencers can be evaluated from a single-unit silencer model with good accuracy.

Acknowledgement

The kind assistance of Ms. Valerie Chort, Review Engineer, Environment Ontario, in translating the abstract into French is greatly appreciated. We thank the editor for his helpful comments during the revision of the document.

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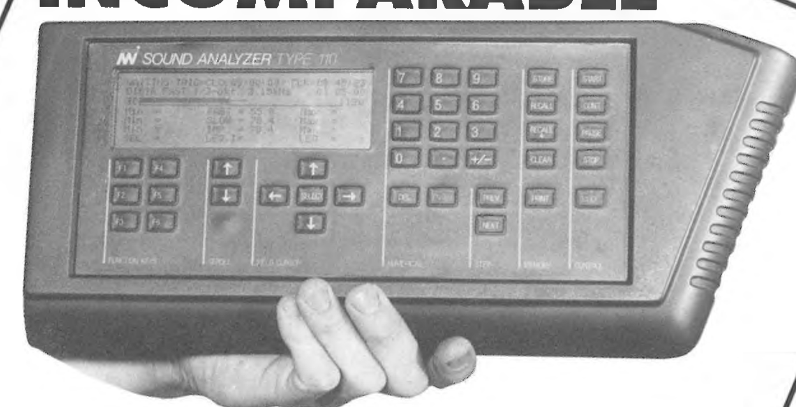

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EVALUATION OF MEASUREMENT LIMITS OF TRANSDUCER MOUNTINGS IN THE GROUND

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ABSTRACT

The distortion of ground vibration measurements by different methods for mounting transducers in the ground is investigated experimentally. The following mountings are considered: (i) Tapered stake having cruciform cross-section; (ii) Wood plate attached to the ground with threaded thin rods; and (iii) Embedded aluminum box of density equivalent to that of soil. The frequency range over which acceptable measurements of ground vibrations can be made is determined for each of these mountings using frequency response tests. These tests are performed by lightly impacting the mounting with a small instrumented hammer. The impact force and the response of the mounting were recorded and analyzed on a two-channel frequency analyzer. Tests were performed at two sites: stiff clay and fine loose sand. Results show that the frequency limit for acceptable accuracy was about 200 Hz for the plate and stake mountings, whereas that for the embedded box mounting was about 120 Hz. The plate and stake mountings were found more convenient to use than the embedded box mounting.

RESUME

Les auteurs étudient expérimentalement la distorsion des mesures de vibrations du sol effectuées à l'aide de différentes méthodes de montage de transducteurs dans le sol. Ils examinent les dispositifs de montage suivants : (i) un piquet de section cruciforme; (ii) une plaque de bois fixée au sol au moyen de minces tiges filetées; (iii) un coffret d'aluminium enterré et ayant une densité équivalente à celle du sol. Pour chacun de ces montages, on détermine, au moyen d'essais de réponse de fréquence, la bande de fréquences dans laquelle des mesures acceptables des vibrations du sol peuvent être effectuées. Ces essais consistent à frapper légèrement le montage avec un petit marteau doté d'un dispositif de mesure. La force d'impact et la réponse du montage ont été enregistrées et analysées à l'aide d'un analyseur de fréquences à deux canaux. Les essais ont été réalisés sur un terrain d'argile dense et sur un terrain de sable fin meuble. Les résultats montrent que pour obtenir une précision acceptable la limite de fréquence doit être d'environ 200 Hz dans le cas des montages avec plaque et piquet, et d'environ 120 Hz dans le montage à coffret enterré. Les deux premiers types de montages se sont révélés plus faciles d'emploi que le troisième.

1 INTRODUCTION

The measurement of ground-borne vibrations from sources such as railway and highway traffic, mining, tunnelling and blasting is important for investigating the effects of these vibrations on nearby buildings and their contents. It is necessary to ensure that these measurements be undistorted and accurate. In this respect, the complexity and difficulty of proper transducer attachment to the ground is a major obstacle. Measurement transducers, which are generally very small in size, are mounted on larger objects, e.g. a stake or a plate, to provide sufficient coupling to the ground. Contrary to expectations, however, proper coupling to the ground may not always be achieved; kinematic and inertial effects also occur due to the geometry and mass of the mounting device, respectively. Consequently the measurement system supported by the ground will form a resonant system that may be incapable of faithfully transmitting the free field motion.

At present, no standard methods for mounting transducers on the ground are known to the authors. In fact, a variety of methods exist. These methods are generally designed to minimize measurement errors within a frequency range of interest. However, due to the wide variety of soil types and the different characteristics of the mounting system in varying vibration modes, it is difficult to advocate a particular mounting design that would be applicable under all conditions. In addition, the lack of documented experimental evidence makes it impossible to evaluate available mounting designs and to clearly establish the superiority of any particular type.

The objective of this paper is to present a comparative assessment of the performance of different methods of mounting transducers in the ground and to determine the frequency range over which accurate measurement of the ground motion can be expected. Some of the transducer mounting methods reviewed below are believed to be appropriate for a wide range of conditions. Hence they are selected for further investigation and testing according to unified procedures. The following mounting methods were investigated:

- aluminum stake with a cruciform section [1]
- wooden plate attached to the ground with thin threaded rods [2]
- aluminum box, of effective density equivalent to that of soil, embedded in the ground [3]

2 REVIEW OF TRANSDUCER MOUNTING METHODS

Mounting methods can be in general classified into the following categories: (i) Surface plate mountings, (ii) Stake mountings, (iii) Embedded box mountings, and (iv) compensations methods.

Surface plate mountings

The surface plate mountings may be coupled to the ground by any of the following ways:

- Simply resting on the ground surface, slightly pushed into the ground, or set in the ground such that its top is flush with ground surface [4].
- Attaching the plate to the soil in an embedment of plaster of Paris [5].
- Attaching the plate to the soil by driving thin rods through the corners of the plate [2].

The vibration characteristics of a plate resting on the ground can be determined analytically employing a mass-dashpot-spring analog to model the mount (e.g. see [6,7,8]). Results should be treated with caution especially when the analytical assumptions are not well founded, e.g. poor coupling. Analytical results, however, can serve as guidelines for proper mounting design. As an example of poor agreement between analytical and experimental results, Gutowski et al. [4] reported a vertical resonance frequency of 90 Hz in the field for an aluminum disk, 15.25 cm in diameter and 2.5 cm in height, which was set 1.25 cm into soil. Analytical solutions indicate much higher resonance frequency (well above 200 Hz). The low value obtained in the field is probably due to poor coupling between the plate and the supporting soil.

Verhas [5] reported a resonance frequency of 468 Hz for an aluminum plate, 205x205x10 mm^3, in an embedment of plaster of Paris. Obviously, the embedment ensured intimate coupling with soil. The resonance frequency of this system is well above the frequency range of interest of ground vibrations. Attaching the plate to soil by driving thin rods through its corners seems to provide good coupling. For a 90 x 90 x 12.5 mm plywood plate and 75 mm and 50 mm long spiral nails as rods through the corners and in the interior, respectively, Barman and Coulter [2] report a vertical resonance frequency of 600 Hz for soft soils and much higher values for stiff soils.

Stake Mountings

In this method, the transducer is attached to one end of a steel or aluminum stake that is simply driven into the ground. The stake is usually 150 to 200 mm long. A small plate may be welded to the top end of the stake to which the transducer is attached.

Field tests performed with this mounting method indicate satisfactory performance for measurements of vibrations in the vertical direction but poor performance with horizontal vibrations [1] [3]. Nolle [1] tested several cross-sectional designs.

Johnson [3] tested the performance of stakes driven horizontally into the sides of a hole in order to measure the motion in the horizontal plane. No evidence of resonance was found in the measured vibrations generated by a hammer impact on the ground surface. However, it is pointed out that this method is useful only in cohesive soils in which the sides of the hole are firm enough for driving a stake into them.

Embedded Box Mountings

In order to eliminate the inertial interaction between the transducer mounting and the supporting soil, the concept of attaching the transducers inside a box and then burying it in the ground seems a reasonable approach. The dimensions of the box are selected such that the average density of the box, including the transducers, matches the density of the soil. The box is placed in a shallow hole in the ground and then backfilled with soil. The soil around the box is tamped to ensure good coupling. The size of the box is kept small in comparison with the shortest wavelength of interest in ground vibrations in order to minimize kinematic interaction effects.

Johnson [3] reported satisfactory performance of this mounting device. The box used was 160 x 160 x 12.5 mm made of 12.5 mm thick aluminum and buried in a 230 mm deep hole. No resonance was observed due to an excitation generated by a hammer impact on the ground surface. The disadvantage of this mounting method is the amount of soil disturbance caused by the installation of the box [2] [9]. In addition, if the backfill must be watered to achieve good compaction, the moisture may interfere with the transducer cabling especially if piezoelectric accelerometers are used [9].

Compensation Methods

An alternative to optimum transducer mounting design is to physically compensate for errors caused by the dynamic interaction between the mount and the supporting soil. Prange [10] presents a mechanism to compensate for the inertia effects of surface mountings in the vertical direction. The principle of the proposed mechanism is to satisfy the condition of zero dynamic contact pressure between the measurement system and the ground, i.e. preserve the free field condition. The proposed system consists of two parts held together by springs. An auxiliary vibrator (an electrodynamic system) is attached to the moving part of the assembly. The vibrator generates an internal force in such a manner that the condition of stationary center of gravity of the complete assembly is achieved, implying a condition of zero contact pressure. A special electronic circuit is designed to control the power supply to the auxiliary vibrator. Obviously this is a complicated system and the extension of the compensation mechanism to other modes of vibrations seems to be a formidable task.

3 TESTING METHOD

In order to assess the performance of a mounting system, a frequency response test is performed. The mounting system is excited by either of the following two methods:

- applying an impact to the mounting separately in the horizontal and vertical directions with a small instrumented hammer (e.g. PCB model 086A03) as shown in Figure 1, [5];
- coupling an electrodynamic shaker (e.g. model No. 89940 by Goodman Vibrators Ltd.) to the mounting as shown in Figure 2, [1,2].

The applied force and the acceleration response of the system are recorded on a two channel frequency analyzer. Fourier transforms of the force and acceleration are then computed and the results displayed in one of two forms: acceleration divided by force (i.e. acceleration frequency response); or, after double integration, displacement divided by force (i.e. displacement frequency response).

The criterion used to evaluate the frequency range over which the mounting provides satisfactory transmission of ground vibrations can be based on the frequency response characteristics of the mounting in terms of displacement or acceleration. Considering the displacement response curve, the accurate frequency range would be that over which the displacement response is nearly constant (or flat), as illustrated in Figure 3a. A constant displacement frequency response implies negligible inertial effects of the mounting. The part of the displacement response curve which is constant corresponds to a part of the acceleration response curve which is parabolic (Figure 3b). Expressing the acceleration amplitude in decibels (dB), the acceleration response function is then equal to

$$A(\omega) = 10\log(D_o\omega^2)^2 = 40\log(\omega) + 20\log(D_o)$$

where D_o is the constant displacement amplitude, and ω is the frequency. Hence, by examining the acceleration response curve of the system, the frequency range over which accurate measurements can be expected is that over which the response curve is sloping at 40 dB/decade, as shown in Figure 3c. The frequency at which the frequency response curve deviates by ±3 dB from the 40 dB/decade slope is taken as the limit of

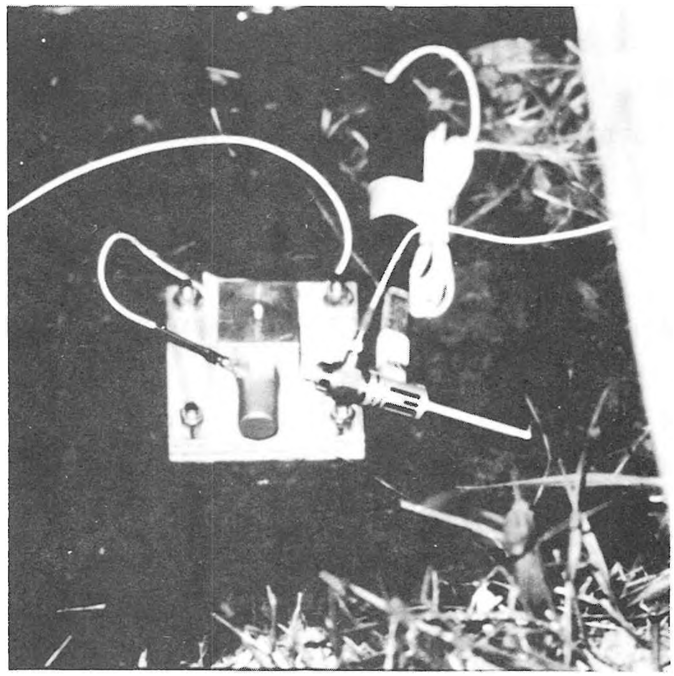

Figure 1 Instrumented small hammer

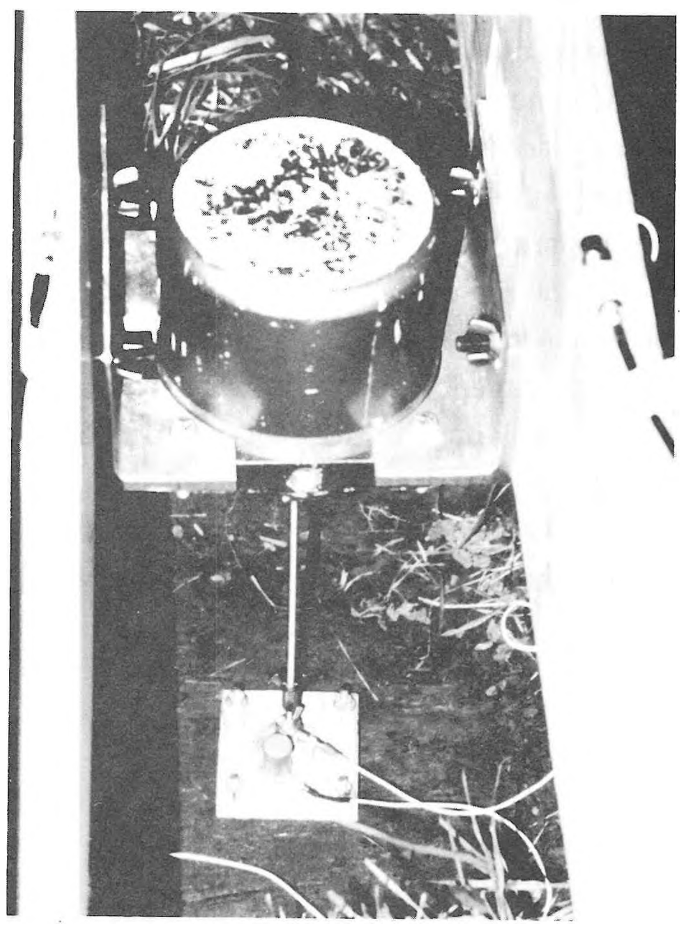

Figure 2 Electrodynamic shaker

acceptable measurements. This criterion is the same as that used in reference [1]. Alternatively, the corresponding frequency limit using the linear displacement curve (Figure 3a) is that at which the frequency response curve deviates from the constant displacement part by +41% or -29%.

Tests carried out in a laboratory soil box and in the field indicate that virtually the same frequency response of the mounting system can be obtained by exciting the system with either of the two methods: a light tap applied with a small hammer instrumented with a force transducer; or an electrodynamic shaker coupled to the mounting via a force transducer. This is illustrated in Figure 4, which shows the acceleration frequency response of the embedded box mounting obtained by the two different excitation methods. It can be seen that the two response curves are in good agreement. The hammer was subsequently used in all tests reported in this paper since it was found more convenient to use in a field environment than the electrodynamic exciter.

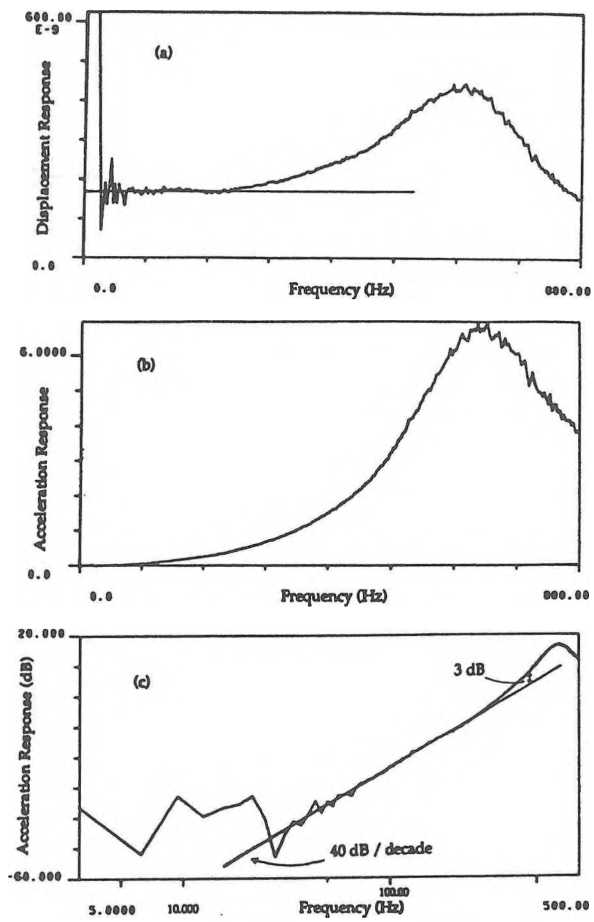

Figure 3 Typical frequency response function of a mounting

Initially, laboratory tests were performed to determine the frequency response of the mountings for different soil types under controlled laboratory conditions. For this purpose a 65x82x50 cm (deep) box filled with soil was used. A few tests were performed with loose sand and with a mixture of clay and sand. Soon it was found, however, that the frequency response functions from these tests have several resonance frequencies. These resonance frequencies are believed to be caused by the limited size of the soil box rather than the mounting/soil system. In order to eliminate the box effect, a larger box would be needed to allow wave energy radiating away from the mounting long enough time to dissipate before it arrives at the boundaries of the box. The effort involved in preparing a larger box was considered unwarranted, and therefore laboratory tests were abandoned in favour of tests carried out at two outdoor sites. The soil type at the first site was stiff clay and at the second site fine loose sand.

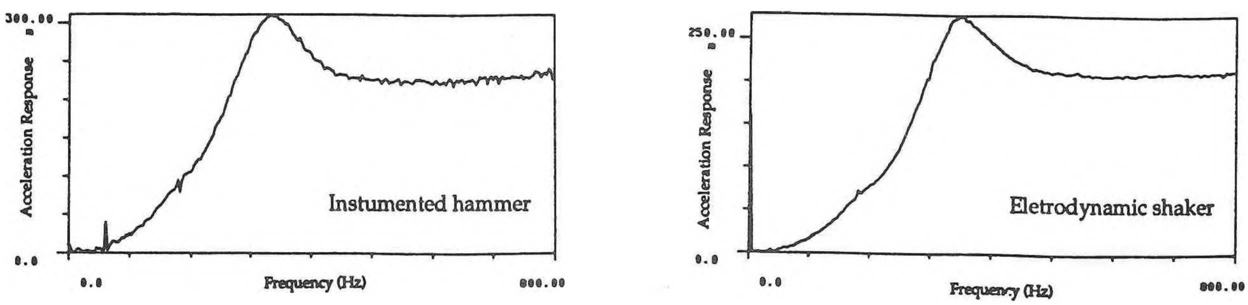

Figure 4 Comparison between response functions using different excitation methods

Employing the frequency response function of a mounting device is sufficient for establishing an acceptable measurement range. Ideally however, employing the so called transmissibility function is more appropriate since it is a direct indication of distortions caused by the mounting system. The transmissibility function of a mounting system is the ratio of the motion recorded using the mounting system to the free field motion. The transmissibility function defined as such is probably impossible to determine experimentally. Alternatively, it can be defined as the ratio of the force transmitted by the mounting system to the ground (reaction force) to the force applied with the impact hammer to the mounting. The the reaction force can be calculated analytically by employing the equilibrium equation of the mounting system. Obviously, this requires further data manipulation and calculations which might render the process impractical for field application. Work in this area is currently under progress.

4 DESIGN AND INSTALLATION OF MOUNTINGS

Frequency response tests using a light hammer impact were performed in the field for the following three types of transducer mountings (shown in Figure 5):

(a) A stake made of a 10 mm (thickness) x 50 mm (diameter) top plate and tapered 4 mm thick plates welded to form a cruciform section. Two different lengths were tested: 150 mm and 300 mm long, both made of aluminum, with tapering ratios of 10:1 and 20:1, and weights 175 g and 300 g, respectively. This design of the stake has a high surface area to mass ratio and hence is believed to provide good coupling with the soil and minimal inertia effects.

(b) A plate made of 19 mm thick plywood. It is attached to the ground with four 5 mm diameter 150 mm long threaded thin rods driven into soil through holes in the corners of the plate. Proper coupling to the ground is ensured by hand-tightening nuts attached to the top end of the rods. Two plate sizes were tested: 175 mm x 175 mm and 90 mm x 90 mm. The weights of the large and small plates (including the rods) are 440 g and 210 g, respectively.

(c) A box type mounting constructed of 12.5 mm thick aluminum and with dimensions 165 mm x 165 mm x 70 mm high and weighing 2880 g. The effective density of the box is equal to 1.6 t/m^3 (approximately equivalent to that of soil). The box is embedded in the soil, flush with the ground surface. The soil around the sides of the box is tamped down firmly to ensure proper coupling.

A 38x38x38 mm solid aluminum block (150 g) was attached to the wood plates and to the top end of the stake mountings. Accelerometers were then attached to this block by two-sided tape. Only one accelerometer was attached during a test, either in the vertical or in the horizontal directions. For the embedded box, transducers were directly attached to the inside walls of the box by two-sided tape.

To install the mountings, grass roots and top soil were carefully excavated to a depth of 150 mm. The bottom of the excavation was kept flat and undisturbed.

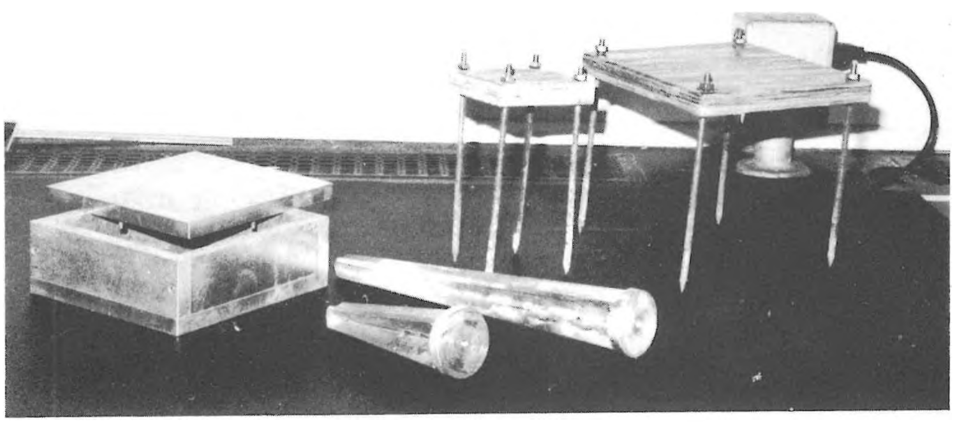

Figure 5 Transducer mountings

5 INSTRUMENTATION

Measurements were made using piezoelectric accelerometers (PCB model 308B10) with a sensitivity of 0.1 V/g (volts/acceleration due to gravity). The weight of the accelerometer is 78 g. The impact was applied with a small hammer (PCB model 086A03) of mass 135 g, fitted with a plastic tip. The hammer is instrumented with a force transducer (PCB model 208A03) having a sensitivity of 10 mV/lbf (milli volts /

pound-force). The signals were recorded and analyzed on a two channel narrow-band frequency analyzer (Hewlett-Packard model HP5423A).

6 EXPERIMENTAL RESULTS OF FREQUENCY RESPONSE TESTS

The frequency range over which reliable measurements can be expected is determined by inspecting the logarithmic acceleration frequency response of the mounting system. Typical acceleration frequency response curves for the vertical and horizontal directions for the various mountings are shown in Figure 6. In these figures it can be observed that the frequency response curves deviate substantially from the ideal 40 dB/decade line at low frequencies. This deviation can be attributed either to background noise or to noise in the instrumentation system. This noise becomes significant since the acceleration levels of the true signal in the low frequency range are very small. The peak which appears at 60 Hz in the response of the embedded box is apparently due to an electrical interference. The upper frequency limits for the ±3 dB acceptable measurement range are summarized in Table 1. From the results presented in this table, the following observations can be made:

- The maximum frequency for acceptable measurements for the horizontal direction of motion is lower than that for the vertical direction for all types of mountings except for the embedded box.
- As expected, the maximum frequencies for acceptable measurements for site 2 are lower than those of site 1 since the soil of site 2 has a lower modulus of rigidity than that of site 1. However, in the case of the short stake, the difference in maximum acceptable frequencies between sites 1 and 2 is not very significant. This could be an indication that the tapered cruciform design of the stake that has a high surface area to mass ratio provides good coupling with the soil, regardless of its type, and minimal inertia effects.
- The embedded box has the lowest limit for acceptable measurements (122 Hz). This, however, may still be considered sufficient for some applications such as road and railway traffic-induced ground vibrations.

It should be noted that the results in Table 1 are applicable for sites with soil properties similar to those of sites 1 and 2. Sites with lower modulus of rigidity should be expected to have lower limits for acceptable measurements. The acceptable frequency range would also decrease as the mass of the mounting and its elements increases. When doubt arises as to the reliability of a mounting system for a specific

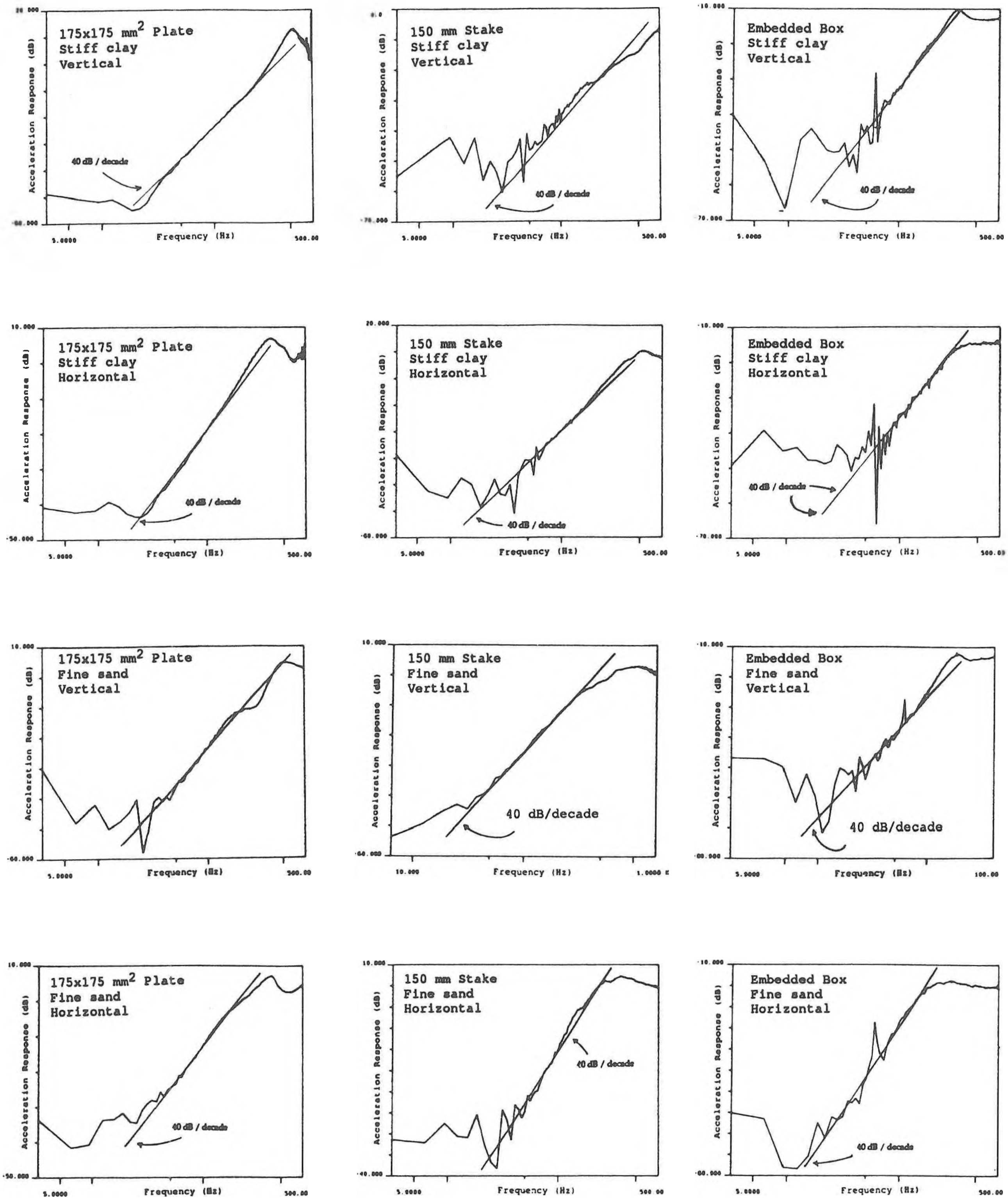

Figure 6 Frequency response functions of mountings

site, a frequency response test should be performed at the site in order to establish the frequency limit for acceptable measurements. This test, when performed with the hammer impact method, is quick and simple to carry out in the field.

Table 1 Upper frequency limits (Hz) of the acceptable measurement range (± 3 dB tolerance)

Soil Type	Direction	175 x 175 mm Wood Plate With Rods	90 x 90 mm Wood Plate With Rods	300 mm long Stake	150 mm long Stake	Embedded Box
Stiff clay	Vertical	350	720	-	482	322
	Horizontal	278	415	-	322	401
Loose sand	Vertical	255	330	759	442	122
	Horizontal	235	209	443	311	208

7 CONCLUSIONS

The frequency response characteristics of the tested mounting designs show that adequate accuracy of ground vibration measurements can be achieved for the soils of sites 1 and 2, stiff clay and fine loose sand, respectively. However, when these mountings are attached to weaker soils, it should be expected that the frequency limit of acceptable measurements will be lower than that of the test sites in this study. If the reliability of a mounting system for a specific soil is suspect, a frequency response test should be performed at the site in question to verify the acceptable measurement range.

Tests performed in this study indicate that lightly impacting the transducer mounting with a small hammer provides a reliable, quick, and simple method for obtaining the frequency response characteristics of a mounting design. Present capabilities of field instrumentation and analysis including implementation of FFT functions in portable equipment provide the opportunity to easily perform and analyse frequency response tests in the field.

Both the plate attached to soil with threaded rods and the aluminum stakes with a cruciform cross-section have acceptable measurement for frequencies up to about 200 Hz, and were found simple and convenient to use. The box type mounting, however, was not found convenient due to difficulties during its installation, e.g. improper leveling and inadequate compacting. In addition it has a smaller frequency limit for acceptable measurements (about 120 Hz) than the plates and aluminum stakes.

ACKNOWLEDGEMENTS

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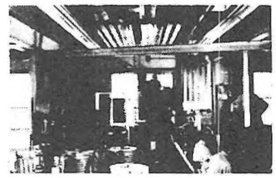

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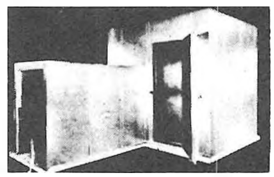

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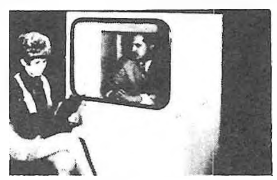

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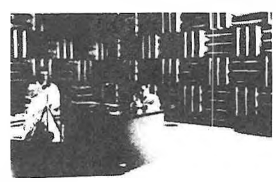

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The Halifax area has had a high level of activity in acoustics - especially underwater acoustics - for many years. During that time, several proposals have been put forth to promote the local acoustics community by creating a centre of expertise, by establishing test and calibration facilities, or by furthering our educational and research programs. While none of these proposals has ever met with complete success, these efforts have served to demonstrate that acoustics here is active and healthy in both the public and private sectors and holds potential for significant expansion of industrial activity.

In response to this opportunity, local CAA members have begun a grass-roots campaign to promote acoustics. A number of public meetings have been held, and consistently attended by twenty or more interested members of the Atlantic Canada acoustics community. Several surveys and a feasibility study have been carried out in order to better establish the size and nature of the needs and opportunities which exist in acoustics. These studies have shown that there is a fairly clear consensus on the need for improved educational programs in acoustics at the post-secondary level.

Other findings are summarised by a statement which was issued following a recent public meeting:

"1. Members of the Canadian Acoustical Association in the Halifax-Dartmouth Region and others interested in acoustics met on 15 May to consider the state of their discipline. They believe that there is an opportunity for significant growth in acoustics-related industries in Nova Scotia. There already exists a substantial research, engineering and manufacturing community active in several branches of the acoustics field. Underwater acoustics, geophysical applications of acoustics, medical ultrasonics, and many aspects of the ocean industry are well represented in this area. Potential growth is currently being hampered by poor opportunities for education in acoustics and by generally poor communication and utilization of existing capabilities within the local acoustics community. The CAA members intend to forge a development plan to capitalize on the opportunity.

2. A working group will be established to plan, coordinate, and promote acoustics-related activities in Nova Scotia in line with the following priorities:

   1) Improvement in acoustics educational opportunities at local post-secondary educational institutions,

   2) Improved communication within the local acoustics community, providing one another with better knowledge of and access to existing capabilities and facilities,

   3) Improving the ease of access by industry and the public to existing acoustics consulting expertise, and

   4) Improvement in the ease of access by local industry to acoustics facilities including such factors as universal access, access at appropriate cost, ways to better utilize existing facilities, and assurance that operators of facilities will not compete against local industry."

At a follow-up meeting on 13 June, we were encouraged to hear David Chapman report that his fellow CAA directors had expressed pleasure upon learning of our initiative and had wished us well.

A steering committee comprising 7 volunteers and chaired by Dr. Harold Merklinger of DREA was formed and charged with a number of responsibilities. Specific action items will include choosing a name for the organization - the Atlantic Canada Acoustics Institute (ACAI) is the current choice - and initiating the creation of an inventory of equipment and human resources in the area, in addition to implementing the above recommendations of the 15 May meeting.

Fred Guptill, Armdale, N.S.

MESSAGE FROM THE SECRETARY

Dear Members:

We have experienced considerable difficulties with Canada Post during the past six months. Approximately 50 membership renewals and other documents went astray in the mail forwarding process, between our postal station and the secretary's address. After considerable pressure on the postal people, a parcel was retrieved from the "dead letter file". Cheques dated between February 1 and February 15 are affected. We will be depositing those cheques now. Extreme care will be taken to ensure that no duplicates will be deposited. However, if you experience any problems, please contact me by telephone at 416-823-3200 or by fax at 416-823-9290. The post office has sent a letter of apology. To those members who have received their "Final Notice", please disregard if you have paid your dues. If you did not pay and wish to do so, please return invoices directly to:

The Secretary, CAA,
c/o H.L. Blachford, Ltd.,
2323 Royal Windsor Dr.,
Mississauga, Ontario L5J 1K5

Also, some members have had mail returned to them, even when this mail was properly addressed to the postal box. Please follow the same directions as above.

Our apologies; we will find a better way.

Winston V. Sydenborgh
Secretary, CAA

INFORMATION DU SECRETAIRE

Chers membres,

Nous avons rencontré d'importantes difficultés avec Poste Canada au cours des six derniers mois. Environ 50 renouvellements de membres et autres documents ont été perdus dans le processus d'expédition entre le bureau de poste et l'adresse du secrétaire. Après avoir fait pression sur le personnel du bureau de poste, un colis a été retrouvé dans la filière "lettres tombées au rebut". Des chèques datés du 1er au 15 février ont été récupérés. Nous procédons dès maintenant au dépôt de ces chèques. Une attention particulière sera portée pour éviter que des duplicata soient déposés. Cependant, si vous éprouvez des problèmes relatifs à ce sujet, communiquez avec moi au 416-823-3200 (téléphone) ou au 416-823-9290 (fax). Le bureau de poste nous a fait parvenir une lettre d'excuses. Tous les membres qui ont reçu un "avis final", s'il-vous-plaît ignorez le si vous avez payé votre adhésion. Si vous n'avez pas encore fait parvenir votre paiement, retournez le directement à:

The Secretary, CAA
c/o H.L. Blachford, Ltd.
2323 Royal Windsor Dr.,
Mississauga, Ontario L5J 1K5

Par ailleurs, certains envois ont été retournés aux membres, même si ces envois étaient adéquatement adressés au casier postal. S'il-vous-plaît, suivre les mêmes indications mentionnées ci-haut.
Toutes nos excuses; nous trouverons une meilleure formule.

Winston V. Sydenborgh
Secrétaire, ACA

CANADIAN ACOUSTICAL ASSOCIATION
MINUTES OF THE BOARD OF DIRECTORS MEETING

June 3rd, 1990, N.R.C. Boardroom of M36, Ottawa, Ont. 10:15 a.m.

Present:	S.M. Abel	T. Embleton	A. Behar	H. Forester
	D. Chapman	M. Hodgson	A. Cohen	C. Laroche
	B. Dunn	W. Sydenborgh		
Regrets:	C. Andrew	J-G. Migneron	L. Brewster	M. Zagorski
	M. Faulkner			

1) The President's Introduction - B. Dunn

The president welcomed the members of the board present and apologized for the members who were not able to attend.

2) Minutes of the previous Board of Directors Meeting held October 17, 1989 in the McKay Room, Chateau Halifax, Halifax, Nova Scotia. Minutes prepared by M. Osman, read by W. Sydenborgh.

The minutes are accepted with minor changes. Moved by S.M. Abel. Seconded by M. Hodgson and A. Behar. Carried.

3) Minutes of the CAA Annual Meeting, General Membership held in the Bluenose Room, Chateau Halifax, Halifax, Nova Scotia on October 18, 1989. Minutes prepared by M. Osman and read by W. Sydenborgh.

The minutes are to be read, discussed and approved at the Annual General Meeting to be held in Montreal, October 1990.

4) President's Report - B. Dunn

a) Usage of stickers with the CAA return address resulted in a saving of approximately $200.00, offsetting the higher cost of printing of the new stationery.

b) A letter to the 13th ICA in Beijing, China was sent reflecting the consensus of the board and general membership that we endorse the proposed meeting since we support the acousticians of China, not the government of China. Letters were read asking for support in education and/or information about acoustics in Canada. A committee is formed by S. Abel, A. Cohen and M. Hodgson as an Education in Acoustics Advisory Committee to deal with such requests.

d) The Eckel Prize - The first $2,000.00 has been received and turned over to the Treasurer. Total prize money is $5,000.00.

e) C. Laroche and J-G. Migneron attended the inaugural meeting of the French Acoustical Association. Board members attending functions of other acoustical associations are encouraged to make known that they are representatives of the CAA. Reports are solicited for publication in the Journal.

f) Request for funding of construction research development. We are not in a position to assist funding.

g) A letter from the Deafness Research Foundation in New York announces that funds are available for clinical research in hearing deficiencies.

5) Report of the Executive Secretary - W.V. Sydenborgh

a) The secretary reports that out of 512 membership and subscription renewal forms mailed out, payment and replies have been received from 303 to date. The secretary will prepare a second mailing as a final notice to those who have not mailed in their membership fees as yet. Non replies will be removed from the membership list and the Journal mailing list.

b) A mailing list, parallel to the membership list, has been developed in postal code priority order. This helps the post office in sorting the Journals and saves postage costs.

c) The secretary made an error in printing the student fees on the invoice as being $20.00. This should have been $10.00. A credit will be given to those students who have sent in the $20.00. No fees would be required for 1990 from these students.

d) Comment must be made here on the excellent work of John O'Keefe for getting the sustaining subscription and advertising back on track and Jim Desormeaux for his work in submitting news items to the Journal.

e) Approximately 30 copies of Noise News, distributed by INCE, are mailed to interested members.

f) Yearly registration of CAA under Section 133, together with the necessary fees, was submitted on April 1st for the current year listing the current directors at the above date.

g) Copies of letters of patent have been sent to H. Forester, Convenor of the Montreal Symposium in order for him to open a bank account in the name of CAA Montreal 1990.

h) Correspondence with the International Commission on Acoustics in Budapest, Hungary - current list of Officers and directors of the CAA were submitted for inclusion in their mailing list.

i) Membership list will be ready for publication with the July issue of the Journal.

6. Report of the Treasurer - C. Andrew

Status of Prizes and Awards:

PRIZE/AWARD	AMOUNTS		INVESTMENT
Directors' Award	3 @ $500.00=	$1500.00	T-Bill Account
Directors' Prizes	2 @ $500.00=	$1000.00	
Youth Science Award	1 @ $300.00=	$ 330.00 $2830.00	Interest on approximately $42,000* at market interest rate
121 ICA Prize in Underwater Acoustics (Merklinger royalties)	To be determined		$4000 GIC 2 years @ 11% - due March 2, 1991 - annual interest $440.00 - total interest $880.00
Edgar and Millicent Shaw Post Doctoral Prize	$3000.00 each year for two years		$30,000 GIC 5 years @ 10% - due March 31, 1993 - annual interest $3000.00 - total interest $15,000.00
Bell Prize	To be determined		$8,500 GIC 3 years @ 10.75% - due October 1, 1991 - annual interest $913.75 - total interest $2741.25

* Includes interest from GIC's and $2000.00 received to date from Eckel Industries for proposed scholarship fund.

7. Editor's Report - M. Hodgson

Over 500 Journals are prepared and mailed four times a year. Cost of each issue is about $2500. Reprints have been an additional source of revenue. Results of a questionnaire recently published in the Journal are discussed and results used to upgrade the Journal.

8. Report from the Membership Chairperson - M. Zagorski

None is available. The President is to look into this.

9. Report of the Convenor of Acoustics Canada '90 in Montreal - H. Forester

To be held at the Holiday Inn, Crown Plaza, on Sherbrooke St. W., near McGill University, from October 1-5. Participation by GAUS, NRC and Sonica in four seminars offered during Acoustics Week '90. Planning schedule and budgets are discussed. A small profit can be realized from this venture.

10. Acoustics 1991 - Edmonton, Alberta

The President announced that a committee is in place and all is under control.

11. Report on International INCE and Internoise '92 - T. Embleton

A request from INCE that we co-host Internoise '92 to be held in the downtown Holiday Inn in Toronto, Ontario in July of 1992. No financial assistance is required from the CAA.

Motion that the C.A.A. co-host Internoise '92 by S.M. Abel. Seconded by A. Behar. Carried.

About 600-700 participants are expected.

12. Awards and Prizes

Report on Director's Award by B. Dunn.

CAA Edgar and Millicent Shaw Post-Doctoral Prize by S.M. Abel. Winner to be announced at the October meeting.

Bell Prize - no report available.

Underwater Acoustics Prize by D. Chapman.

Canada Wide Science Fair by A. Cohen. Referred to October meeting.

Student Presentations by B. Dunn. This will be taken over by A. Behar.

13. Other Business

Reports received and discussed are the following:

* Acoustics Centre of Excellence in Halifax.
* Travel Subsidies - C. Andrew/B. Dunn.
* Sheridan College request for information to be dealt with by the Education Committee.
* Change in the Student Presentations by D. Chapman. Referred to the Awards Committee. Proposals of review of Graduate and Undergraduate levels. Open up eligibility to papers from those with B.A. and M.Sc. degrees currently working in industry, rather than only academia. Referred to Committee for proposal at October meeting.
* Request for the Secretary to combine 1990 dues receipts for income tax purposes in the same mailing as the dues notices for 1991 to save postage and envelopes. This is to start in November. Request granted.

14. New Business

Tony Embleton announced that he will be retiring from NRC after 17-1/2 years, effective June 22, 1990. From July 15, his new address will be 80 Sheardown Dr., Nobleton, Ontario.

Request from H. Forester for additional seed money for CAA '90. Request granted.

15. Adjournment at 5:30 p.m. - Moved by D. Chapman. Seconded by T. Embleton.

Meeting closed by the President, B. Dunn.

Prepared by W.V. Sydenborgh, Secretary, C.A.A.

NEWS / INFORMATIONS

COURSES/COURS

Occupational Noise Dosimetry and Sound Measurement Techniques: Sscan-Grodyne Controls and Quest Electronics, Toronto, Ontario, September 18, 1990. Contact: Sscan-Grodyne Controls, Richmond Hill, Ontario.

Occupational Noise Dosimetry and Sound Measurement Techniques: Sscan-Grodyne Controls and Quest Electronics, Cambridge, Ontario, September 19, 1990. Contact: Sscan-Grodyne Controls, Richmond Hill, Ontario.

Occupational Noise Dosimetry and Sound Measurement Techniques: Sscan-Grodyne Controls and Quest Electronics, Ottawa, Ontario, September 21, 1990. Contact: Sscan-Grodyne Controls, Richmond Hill, Ontario.

International Industrial Hygiene Workshop: The Pillar and the Post Inn, Niagara-on-the-Lake, October 1-3, 1990. Contact: (416) 978-3069.

Audiology or Speech-Language, Graduate Level: University of Western Ontario, Fall 1990. Contact: Donald G. Jamieson, Faculty of Applied Health Sciences, Department of Communicative Disorder, Elborn College, London, Ontario. Tel: (519) 679-2111.

Acoustics and Noise Control: Seven Springs Mountain Resort, Seven Springs, Pennsylvania. One week seminar, October 8-12, 1990. Contact: Jean at AVNC at (412) 265-4444. Fax (412) 367-9233. For technical details, call Bill Thornton at (412) 265-2000.

Signal Processing: Seven Springs Mountain Resort, Seven Springs, Pennsylvania. One week seminar, October 8-12, 1990. Contact: Jean at AVNC at (412) 265-4444. Fax (412) 367-9233. For technical details, call Bill Thornton at (412) 265-2000.

Pressure Measurement: Endevco Corporation, October, 1990. Contact: Colette Landerville at (714) 493-8181.

Shock and Vibration Meausrement: Endevco Corporation, December, 1990. Contact: Colette Landerville at (714) 493-8181.

Vibration Technology II - Machinery Vibration Analysis: IRD Mechanalysis, Inc. Contact: Andrea Applegate at (614) 885-5379.

CONFERENCES/CONGRES

Eleventh NRCC Machinery Dynamics Seminar: The Westbury Hotel, Toronto, Ontario, October 1-2, 1990. Contact: Nicole Leger at (613) 993-9009.

29th Conference on Acoustics: Building Acoustics, Room Acoustics, Urban Acoustics: Strbske Pleso - High Tatras, Czechoslovakia, October 2-5, 1990. Contact: House of Technology, Ing. 1, Boralikova, Skultetyho ul. 1 832 27 Bratislava, Czechoslovakia.

Noise-Con 90: The 1990 National Conference on Noise Control Engineering, Austin, Texas, October 15-17. Contact: Professor Elmer Hixson, Department of Electrical and Computer Engineering, University of Texas at Austin, Austin, TX 78712.

The International Environment and Ecology Exhibition Crossroads: Place Bonaventure, Montreal, Quebec, October 31 to November 2, 1990. Contact: C.I.E.E. Carex Ltd. at (514) 922-2545 or Fax (514) 649-8719.

Noise and Vibration Control in Industry: in the High Tatras, Tatranski Lomnica, Czechoslovakia, November 26-30, 1990. Contact: Dom Techniky Csvts, Nadja Bajova, Casta Miery 4, C8-011 32 Zilina, Czechoslovakia.

120th Meeting of the Acoustical Society of America: San Diego, California, November 26-30, 1990. Contact: Frederick H. Fisher, Marine Physical Lab., P-001, Scripps Institute of Oceanography, University of California, San Diego, La Jolla, CA 92093-0701.

22nd Annual Scientific Meeting of the British Medical Ultrasound Society: Harrogate, U.K., December 4-6, 1990. Contact: BMUSD, 36 Portland Place, London, W1N 3DB.

1990 IEEE Ultrasonics Symposium: Honolulu, HI, December 4-7, 1990. Contact: Dr. Harry Salvo (301) 765-4290.

Institute of Acoustics - Sonar Transducers for the Nineties: Birmingham, U.K., December 17-18, 1990. Contact: Institute of Acoustics at 0727-48195.

NEW PRODUCTS/NOUVEAUX PRODUITS

Audio Manufacturers Directory Available

The Schafer Library has produced the second annual edition of the audio manufacturers' address book. The subscription price is $65 per year plus $3.50 shipping and handling. Contact: (704) 786-3009.

ASTM European Office Opened in England

To serve its European members, ASTM opened an office in Hertfordshire, England. Contact: Bill Keeshan at 0462-437933 or Fax 0462-433678.

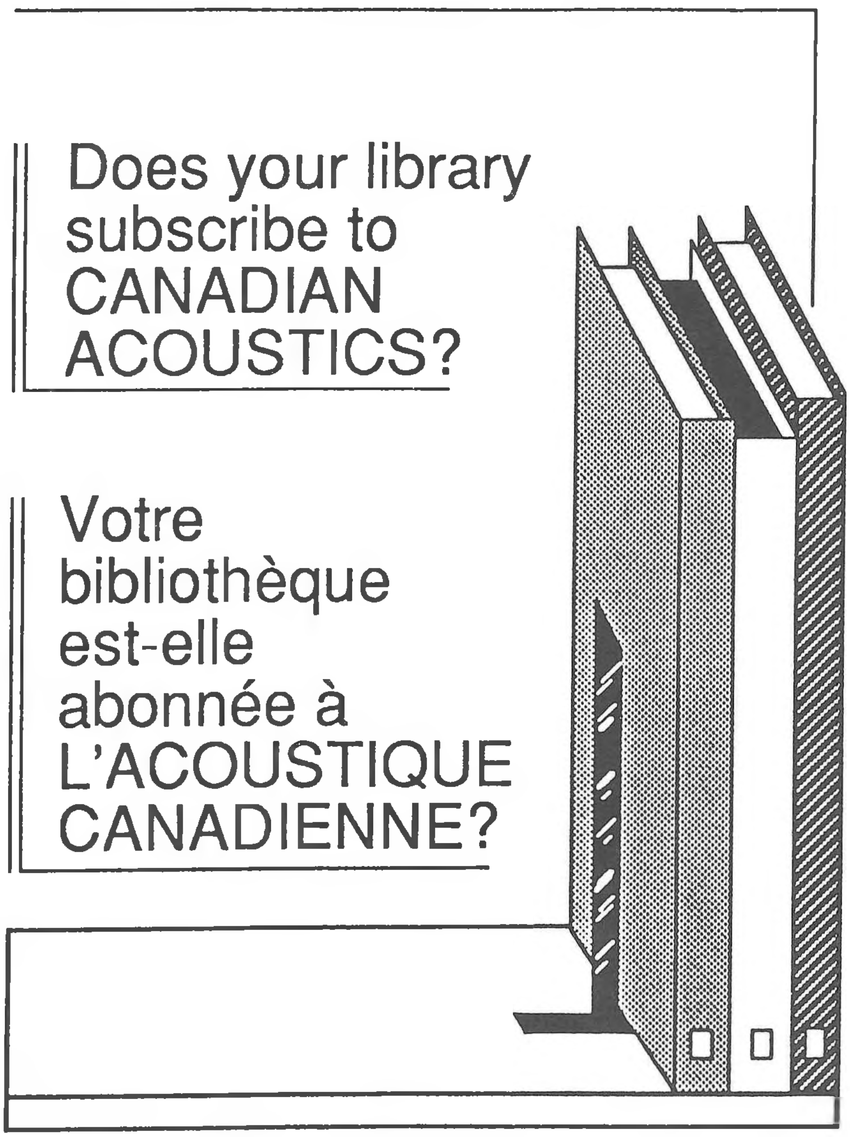
ASTM Standards Guide

ASTM is offering "A Guide to Standards". This 129 page publication is available for $12. Contact: ASTM, 1916 Race Street, Philadelphia, PA 19103.

PEOPLE IN THE NEWS/LES GENS QUI FONT LA MANCHETTE

Tony Embleton Retires

Tony Embleton, Head of the Acoustics Section of the Division of Physics at the National Research Council, retired June 22 after 37-1/2 years' service. He will move to Toronto where, among other things, he will organize the Inter-Noise '92 Conference.



INVITATION TO ATTEND THE 1990 CAA CONVENTION

The 1990 Annual meeting of the Canadian Acoustical Association will take place at the Holiday Inn Crowne Plaza in Montreal from October 1 to 5, (during the week preceeding the Thanksgiving Day holiday weekend). We are presenting courses and seminars, a technical symposium, exhibitions by suppliers, a welcoming wine & cheese party, the annual CAA General Meeting, student awards for paper presentations and, of course, a banquet. We have made special efforts to make eveyone feel as comfortable as possible, in both official languages, and we invite not only CAA members, but anyone studying or working with any aspect of acoustics, to attend. In addition, we encourage you to bring your spouses along to enjoy the conviviality and charm that is so unique to Montreal.

We have arranged special rates for both the hotel and with Air Canada to minimize your costs. This year, we have reintroduced package convention rates that include lunches, banquet and published proceedings. We are also introducing reduced rates for those who can only attend parts of the convention. Details are listed on the accompanying Registration Form. The schedule of events is attached.

To further enhance your visit, we are introducing a no smoking policy in the seminar and symposium meeting rooms. We will offer a non smoking section at the banquet as well. Finally, we have requested the hotel to make vegetarian meals available on request at all servings, for anyone with special dietary needs.

We do urge you to register as early as possible, to permit us to finalize the detailed booking arrangements for meeting room space in the hotel. To encourage you even further, we will give you a 10% discount for all prepaid registrations received by 27 August.

You will note that, per the fees listed on the Convention Registration Form, it will be to most people's advantage to join the CAA. For your convenience, a CAA application form is also attached. New members who submit their CAA membership fee with the Convention Registration Form will become paid up members to the end of 1991. Membership fees received from delinquent CAA members will have the membership fees applied to the current year only.

COURSES AND SEMINARS, OCTOBER 1 TO 3

Four courses, as listed on the folowing pages, are being offered, two in English and two in French. Printed course notes will be available in both languages (one set of notes per the students' choice, with additional sets at extra cost) for the seminars in Industrial Acoustics, Outdoor Sound Propagation and Noise Control in Buildings.

TECHNICAL SYMPOSIUM, OCTOBER 4 AND 5

We have received 80 papers, consisting of both formal presentations from invited speakers and contributors, and papers of a general interest covering the experiences of the contributors. The symposium sessions are listed in the attached Tentative Schedule of Activities, while the contents of the individual papers are described in the abstracts.

All papers that are submitted by the deadline will be reviewed and published in the ***Proceedings of the Annual Meeting of the Canadian Acoustical Association***. The Proceedings will be distributed at the Symposium and are included in the registration fee. If, however, you are unable to attend the meeting and wish to receive a copy of the Proceedings, please complete the accompanying form and mail it as indicated.

INVITATION AU CONGRES 1990 DE L'ACA

Le congrès annuel 1990 de l'ACA se tiendra à l'Holiday Inn Crowne Plaza à Montréal du 1^{er} octobre au 5 octobre (durant la semaine précédent l'Action de Grâce). Auront lieu des cours et séminaires, un symposium technique, des expositions, une réception vin et fromage de bienvenue, le congrès annuel de l'ACA, la remise des prix étudiants et naturellement, un banquet. Nous avons fait des efforts spéciaux afin que chacun se sente à l'aise autant que possible, dans les deux langues officielles du congrès, et nous invitons, non seulement les membres de l'ACA mais toutes les personnes étudiant et travaillant sur un des aspects de l'acoustique, à participer. En plus, nous vous encourageons à venir avec vos épouses ou époux, découvrir la convivialité et le charme si unique de Montréal.

Nous avons obtenu des taux préférentiels à l'hôtel et avec la compagnie Air Canada pour minimiser vos frais. Cette année, le coût du congrès comprend les repas du midi, le banquet et les comptes rendus. Nous faisons cependant des réductions pour ceux qui ne peuvent participer qu'à une partie du congrès. Les détails sont indiqués sur la feuille d'inscription.

Pour améliorer la participation, nous avons introduit une politique d'interdiction de fumer dans les séminaires et les salles de conférences. Nous offrirons une section non fumeur au banquet. Finalement, nous avons obtenu de l'hôtel que des repas végétariens soient disponibles sur demande à tous les repas pour les personnes qui ont besoin d'une alimentation spéciale.

Nous vous invitons à vous inscrire aussitôt que possible afin de nous permettre de finaliser les détails concernant la réservation définitive des salles de conférences. Pour vous encourager, une réduction de 10% sera appliquée à toute inscription reçue avant le 27 août.

Le calendrier des activités est joint.

Vous remarquerez, par les prix indiqués sur la formule d'inscription, qu'il serait avantageux pour la plupart des gens de devenir membre de l'ACA. Un formulaire d'inscription à l'ACA est d'ailleurs joint. Les nouveaux membres qui s'inscrivent à l'occasion du congrès seront membres jusqu'à la fin de 1991. Par contre, les cotisations en retard de membres de l'ACA, renouvelées au moment du congrès, ne seront valables que pour l'année en cours.

COURS ET SÉMINAIRES, 1 AU 3 OCTOBRE

Quatre cours, décrits dans les pages suivantes, seront offerts, deux en français et deux en anglais. Cependant, les notes seront disponibles dans les deux langues (une série de notes par participant) pour le cours en acoustique industrielle, le séminaire sur la propagation extérieure et le séminaire sur le contrôle du bruit dans les bâtiments. Des coûts additionnels seront appliqués pour l'obtention d'une série de notes supplémentaires.

SYMPOSIUM TECHNIQUE, 4 ET 5 OCTOBRE

Nous avons reçu 80 communications invitées ou contribuées. Elles sont organisées en un programme provisoire de 13 sessions. Ce programme est présenté dans son ensemble sous forme d'un tableau de 2 pages et en détail dans la liste complète des communications incluant les résumés.

Tous les textes complets de communication soumis avant la date limite seront arbitrés et publiés dans les **Actes du Congrès Annuel de l'Association Canadienne d'Acoustique**. Ces actes seront distribués lors du congrès et leur coût est inclus dans le montant de l'inscription. Si, cependant, vous êtes dans l'impossibilité de venir au congrès et vous souhaitez recevoir une copie des actes, veuillez remplir la fiche correspondante et l'envoyer à l'adresse indiquée.

DISCOUNT AIR FARES WITH AIR CANADA

Air Canada is offering special discount air fares for travel to and from the convention. The following minimum discounts will apply:

In Canada	15% discount for 7 day advance booking
In the U.S.	25% discount, no restrictions
	35% discount for 7 day advance booking
Air cargo	25% discount, for exhibitors (US or Canada)

All other standard airline features are retained, such as promotional and excursion fares and Aeroplan points, when requesting these special convention discounts. You can even "cash in" Aeroplan points for tickets. A $20.00 penalty fee will apply if a reservation is cancelled, though reservation changes can be made without charge.

Have your travel agent request the **Canadian Acoustical Association Convention Rate, File No. 90-0984**, or reserve directly with Air Canada at 1-800-361-7585.

HOTEL RESERVATIONS

The Holiday Inn has reserved blocks of rooms at the special rate of $100.00 (non-taxable) for those attending this event. In addition, there will be no extra charge for companions for the first twenty double occupancy rooms each night, and a $10.00 double occupancy fee thereafter. To assure the best possible rates, please fill in and mail the enclosed hotel registration card directly to the Holiday Inn. If you have to cancel for any reason, there will be no penalty as long as you cancel prior to 6:00 PM EST on your scheduled arrival date. You can reserve at the last minute using the hotel's international reservation line (1-800-HOLIDAY), but they will have no record of the special CAA rates.

ANNUAL GENERAL MEETING

The CAA's AGM will be held on Thursday afternoon, following the symposium presentations. It will be open to members and guests, but only members in good standing may vote on issues.

SOCIAL PROGRAMME

Welcoming Reception: As most of the participants, other than those taking courses, will arrive on Wednesday evening, a welcoming wine and cheese reception is being planned. All attendees, exhibitors and their accompanying persons are invited.

Banquet: Everyone is also invited to attend the banquet on Thursday evening. We are fortunate to have engaged the McGill Swing Band to provide the principal entertainment for the evening. We are anticipating a truly enjoyable social evening. Make every effort to attend and bring a guest along (see Registration Form for additional tickets).

Closing Ceremony and Awards: A closing reception will be held on Friday at the end of the Symposium, where the awards for the best student presentations will be made. Depending on the final number of papers to be presented, this reception might be held either at the Friday lunch or later during the afternoon.

RÉDUCTION SUR LES VOLS AVEC AIR CANADA

Air Canada offre un rabais spécial pour le congrès de l'AAC, sur ses vols à destination de Montréal. Les rabais minimums suivant seront appliqués:

Au Canada	15% pour une réservation au moins 7 jours avant le départ
Aux USA	25% aucune restriction 35% pour une réservation au moins 7 jours avant le départ
Air Cargo	25% pour les exposants (US et Canada)

Toutes les autres particularités standard de la compagnie sont maintenues, tels les promotions sur le prix des billets, les points accumulés, lorsque ces rabais spéciaux sont réclamés. Vous pouvez utiliser vos points accumulés pour payer votre billet. 20,00$ de frais seront appliqués si la réservation est annulée, bien que des changements de réservation seront fait sans frais.

RÉSERVATION À L'HOTEL

L'Holiday Inn a réservé un ensemble de chambres au taux spécial de 100,00$ (non taxable) pour ceux qui participent à l'événement. Il n'y aura pas de frais supplémentaires pour les vingt premières réservations de chambres doubles pour chacune des nuits. Pour les suivantes, des frais de 10,00$ seront ajoutés pour une chambre double. Afin de vous assurer du meilleur taux possible, remplissez et postez, le plus tôt possible, directement à l'Holiday Inn votre carte de réservation. Si vous devez annuler pour une raison quelconque, il n'y aura aucun frais d'imposé, si l'annulation est faite avant 18h00 heure de l'est, de votre date d'arrivée. Vous pouvez aussi réserver à la dernière minute en utilisant la ligne internationale de réservation de l'hôtel (1-800-HOLIDAY), mais il n'y aura alors aucun tarif préférentiel d'accordé.

RENCONTRE GÉNÉRALE ANNUELLE

La rencontre générale annuelle de l'ACA se tiendra le jeudi après-midi, après les présentations du symposium. Elle sera ouverte aux membres et aux invités, mais seuls les membres en règle auront le droit de vote.

PROGRAMME SOCIAL

Réception de bienvenue: Comme la plupart des participants, autres que ceux qui ont assisté aux cours, arriveront le mercredi après-midi, une réception vin et fromage aura lieu. Tous les participants, les exposants et les personnes les accompagnant sont invités.

Banquet: Tout le monde est aussi invité à participer au banquet le jeudi soir. Nous avons la chance d'avoir le McGill Swing Band pour l'animer. Nous pouvons assurément anticiper une très agréable soirée. Faites tous les efforts pour participer et venez avec un invité (voir la formule d'inscription pour les billets additionnels).

Cérémonie de clôture et remise des prix: Une réception de clôture où les prix pour les meilleures présentations étudiantes seront remis sera tenue le vendredi après midi, à la fin du congrès.

TENTATIVE SCHEDULE OF ACTIVITIES - *PROGRAMME PROVISOIRE DES ACTIVITES*

Monday, October 1 — *Lundi, 1er Octobre*

	Gouverneur I	Gouverneur II	Ambassadeur A	Ambassadeur B	Diplomate
0900 à 1630		*Cours en acoustique industrielle (français)*			

Tuesday, October 2 — *Mardi, 2 Octobre*

	Gouverneur I	Gouverneur II	Ambassadeur A	Ambassadeur B	Diplomate
0900 to 1630		Industrial Acoustics Course (French)			

Wednesday, October 3 — *Mercredi, 3 Octobre*

	Gouverneur I 275	Gouverneur II	Ambassadeur A	Ambassadeur B	Diplomate
0900	*Séminaire sur la propagation du son à l'extérieur (français)*	*Cours en acoustique industrielle (français)*	Numerical Techniques Seminar (English)	Noise Control in Buildings Seminar (English)	Exhibits; *Exposition* (1000 to/ *à* 1700)
1200	Lunch (in Ambassadeur C); *Repas (dans la salle Ambassadeur C)*				
1315 to/ *à* 1630	Outdoor Sound Propagation Seminar (French)	Industrial Acoustics Course (French)	*Séminaire sur les techniques numériques (anglais)*	*Séminaire sur le côntrole du bruit dans les bâtiments (anglais)*	
1930 to/ *à* 2130				Wine & Cheese Reception; *Réception avec vins et fromage*	

TENTATIVE SCHEDULE OF ACTIVITIES - *PROGRAMME PROVISOIRE DES ACTIVITES*

Thursday, October 4 *Jeudi, 4 Octobre*

	Gouverneur I	Gouverneur II	Gouverneur III	Ambassadeur [B] or/ *ou* [C]	Diplomate
0845	Plenary - Opening remarks; *Session plénière d'ouverture*				Exhibits; *Exposition* (0830 to/ *à* 1800)
0900	Industrial Acoustics; *Acoustique industrielle*	Vibration & Structural Radiation; *Vibration et rayonnement des structures*	Hearing and Speech Perception; *Audition et perception de la parole*		
0920					
0940					
1000	Diagnostics				
1020	Refreshment Break; *Pause rafraîchissements*				
1040	Diagnostics; *Diagnostiques*	Vibration & Structural Radiation; *Vibration et rayonnement des structures*	Hearing and Speech Perception; *Audition et perception de la parole*		
1100					
1120	Measure-ments; *Mesures*				
1140					
1200				Lunch; *Repas* [B]	
1320	Measure-ments; *Mesures*	*Vibration et rayonnement des structures*	Physical Acoustics; *Acoustique physique*		
1340					
1400					
1420	Perception of Auditory Warnings	Outdoor Sound Propagation;			
1440					
1500	Refreshment Break; *Pause rafraîchissements*				
1520	Perception of Auditory Warnings; *Perception des signaux avertisseurs*	*Propogation sonore à l'extérieur*	Numerical Techniques; *Techniques numériques*		
1540					
1600		Architectural Acoustics; *Acoustique architecturale*			
1620					
1640					
1700	Annual General Meeting; *Assemblée générale annuele*				
1800				Cash Bar; *Bar payant* [C]	
1900				Banquet; *Banquet* [C]	

TENTATIVE SCHEDULE OF ACTIVITIES - *PROGRAMME PROVISOIRE DES ACTIVITES*

Friday, October 5 — *Vendredi, 5 Octobre*

	Gouverneur I	Gouverneur II	Gouverneur III	Ambassadeur B	Diplomate
0840		Digital Audio Technology; *Technologie audio-numérique*			
0900	Architectural Acoustics; *Acoustique architecturale*		Underwater Acoustics; *Acoustique sous-marine*		
0920					
0940					
1000					
1020	Refreshment Break; *Pause rafraîchissements*				
1040	Architectural Acoustics; *Acoustique architecturale*	Digital Audio Technology; *Technologie audio-numérique*	Underwater Acoustics; *Acoustique sous-marine*		
1100					
1120					Exhibits; *Exposition*
1140					
1200				Lunch; *Repas*	
1320	Architectural Acoustics; *Acoustique architecturale*	Musical Perception; *Perception musicale*			
1340					
1400					
1420	Refreshment Break; *Pause rafraîchissements*				
1440	Closing Ceremony & Awards; *Cérémonie de clôture et prix*				

REGISTRATION FORM - CAA CONVENTION 1990

Name: ______________________ Company: ______________________

Address: ______________________

Postal Code: ____________ Phone: ______________________

COURSES AND SEMINARS Notes & one lunch included.	CAA Member	Non-CAA Member	Student* CAA Member	Student* Non-Member	Enter Amount
Building Acoustics (NRC), 3 Oct., in English	$175	$200	$50	$60	______
Numerical Techniques in Acoustics, 3 Oct., in English	$100	$125	-	-	______
Industrial Acoustics, 1, 2, & 3 Oct., in French	$775	$800	-	-	______
Outdoor Sound Propagation, 3 Oct., in French	$215	$240	$110	$120	______
SYMPOSIUM (4 & 5 Oct.)					
Registration, 2 days, includes 2 lunches & banquet	$175	$200	-	-	______
Registration, 2 days, includes 2 lunches, no banquet	$145	$170	$50	$60	______
Registration, 1 day only, includes lunch, no banquet	$75	$95	$30	$35	______
Additional banquet tickets, by advance payment only ($50 at door)			Number ____	X $45	______

Banquet seating preferred: ____ Non-smoking ____ Smoking ____ No preference

Special meals required: ____ Vegetarian ____ Other (attach note)

TOTAL: ______

DISCOUNT FOR EARLY REGISTRATION

Less 10% discount if received by 27 August 1990 LESS: ______

NET TOTAL: ______

CAA ANNUAL MEMBERSHIP

Regular membership: $35 Full-time student membership: $10* ______

TOTAL AMOUNT OF CHEQUE ENCLOSED: ______

* Special rates for full-time students only; submit proof with registration.

Please make cheques payable to **CAA CONVENTION 1990** and forward with this form to:

Chantal Laroche, Ph.D. Phone: 514-343-7301 FAX: 514-343-5740
Treasurer CAA 90
Groupe d'Acoustique de l'Université de Montréal
P.O. Box 6128, Station A
Montréal, QC H3C 3J7

FORMULAIRE D'INSCRIPTION - CONGRÈS ACA 1990

Nom: ______________________ Compagnie: ______________________

Adresse: ____

Code postal: ______________ Téléphone: ______________________

COURS ET SÉMINAIRES Notes de cours et un repas inclus (midi).	Membre ACA	Non-Membre ACA	Étudiant* membre ACA	Étudiant* non-membre ACA	Mettre le montant
Acoustique du bâtiment (CNR), 3 oct., en anglais	175 $	200 $	50 $	60 $	________
Techniques numériques en acoustique 3 oct., en anglais	100 $	125 $	-	-	________
Acoustique industrielle 1, 2 et 3 oct., en français	775 $	800 $	-	-	________
Propagation sonore à l'extérieur 3 oct., en français	215 $	240 $	110 $	120 $	________
SYMPOSIUM (4 et 5 oct.)					
Inscription, 2 jours 2 repas inclus (midi) et banquet	175 $	200 $	-	-	________
Inscription, 2 jours 2 repas inclus (midi), sans banquet	145 $	170 $	50 $	60 $	________
Inscription, une journée seulement 1 repas inclus (midi), sans banquet	75 $	95 $	30 $	35 $	________
Coupons de banquet additionnels, paiement d'avance (sinon $50 à la porte)			Nombre: ________	x 45 $	________

Préférences pour les tables du banquet: _____ Non-fumeur _____ Fumeur _____ Sans préférence
Demande de repas spéciaux: _____ Végétarien _____ Autre (joindre description)

TOTAL: ________

RÉDUCTION POUR INSCRIPTION D'AVANCE

Moins 10% pour paiement reçu avant le 27 août 1990 MOINS: ________

TOTAL NET: ________

COTISATION POUR DEVENIR MEMBRE ACA

Membre: 35 $ Membre étudiant à temps complet: 10 $* ________

MONTANT TOTAL DU CHÈQUE JOINT: ________

* Taux spécial pour étudiant à temps complet seulement; joindre un certificat avec cette inscription.

Faire un chèque à l'ordre de **1990 CONFERENCE ACA** et l'envoyer avec cette feuille à:

Chantal Laroche, Ph.D. Téléphone: (514) 343-7301 FAX: (514) 343-5740
Trésorière ACA 90
Groupe d'Acoustique de l'Université de Montréal
C.P. 6128, Succursale A
Montréal (Québec)
H3C 3J7

PROCEEDINGS OF THE CANADIAN ACOUSTICAL ANNUAL MEETING 1990

Please send a copy of the Proceedings of the October 1990 Meeting of the Canadian Acoustical Association.

Enclosed is a cheque for $13.00 (CAA members) or $17.00 (non-members), made payable to the **CAA CONVENTION 1990**. Add $2.00 for US mailings and $3.00 for oversea mail. Address this request to:

ACTES DU CONGRES ANNUEL DE L'ASSOCIATION CANADIENNE D'ACOUSTIQUE 1990

S'il vous plait, envoyez une copie des Actes du Congrès Annuel de l'Association Canadienne d'Acoustique 1990.

Trouvez ci-joint un chèque de 13,00$ (membres de l'ACA) ou 17,00$ (non-membres) payable à l'ordre de ***1990 CONFERENCE ACA****. Ajoutez 2,00$ pour le courrier US et 3,00$ pour outre-mer. Addressez cette requete à:*

Dr. Frédéric Laville
Université de Sherbrooke
Génie mécanique
Sherbrooke, QC, Canada
J1K 2R1

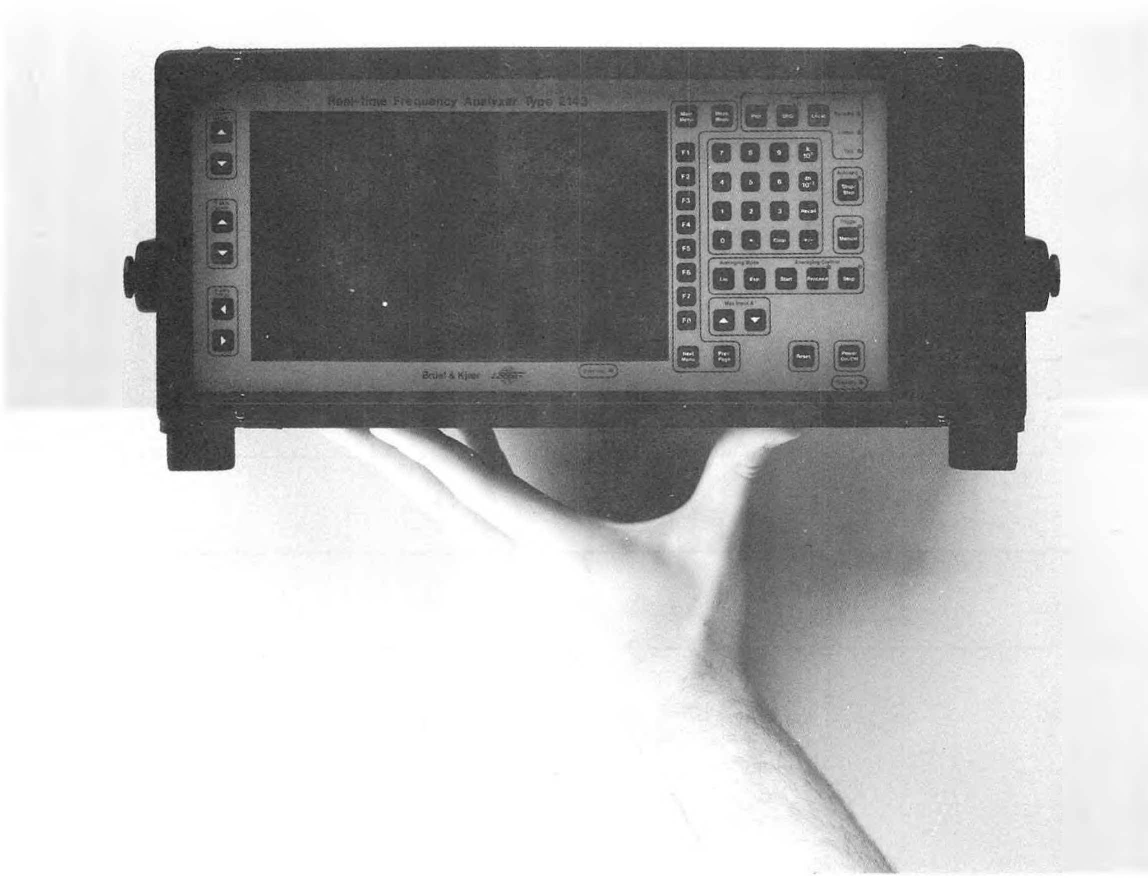
Nom
Name ______________________________

Adresse
Address ______________________________

____

____

We're li



You asked for a lab-quality, precision, real-time analyzer which is truly portable – so we built you one.

ASSOCIATION CANADIENNE D'ACOUSTIQUE

CANADIAN ACOUSTICAL ASSOCIATION

SEMAINE DE L'ACOUSTIQUE 1990 / ACOUSTICS WEEK 1990

COURS ET SÉMINAIRES / COURSES AND SEMINARS

HOLIDAY INN CROWNE PLAZA
420 SHERBROOKE W.
MONTRÉAL, QUÉBEC

1 - 2 - 3 Oct. 1990

- COURS EN ACOUSTIQUE INDUSTRIELLE
- SÉMINAIRE SUR LA PROPAGATION DU SON A L'EXTÉRIEUR
- SEMINAR ON NOISE CONTROL IN BUILDINGS
- SEMINAR ON NUMERICAL TECHNIQUES IN ACOUSTICS

CONTENU DÉTAILLÉ / DETAILED CONTENT

Consult the following pages

Consultez les pages suivantes

INSCRIPTION / REGISTRATION

Fill in the general registration form for the Acoustics Week 1990.

Remplissez la fiche d'inscription générale pour la Semaine de l'Acoustique 1990.

COURS EN ACOUSTIQUE INDUSTRIELLE

(EN FRANÇAIS / IN FRENCH)

Ce cours de trois jours s'adresse aux ingénieurs et technologues qui font face à des problèmes:

- de contrôle du bruit en usine (loi sur la S.S.T.)
- de nuisance sonore sur des produits manufacturés.

ORIGINALITÉS DU COURS:

- Une large place sera faite aux démonstrations
- Les participants recevront en plus des notes de cours, une disquette contenant plusieurs logiciels de base.
- Une formation moderne qui vise à relier théorie et pratique.

CONTENU

1 - INTRODUCTION

Historique, Orthographe et acoustique, Branches de l'acoustique, Un son: une description.

2 - ACOUSTIQUE PHYSIOLOGIQUE

L'oreille et ses caractéristiques, Acquisition de la surdité, Les normes, Les protecteurs auditifs.

3 - DESCRIPTION ET DÉFINITION DES PRINCIPAUX PARAMÈTRES ET PHÉNOMÈNES ACOUSTIQUES

Nature des ondes sonores, Célérité, Fréquence, Longueur d'onde, Paramètres fondamentaux (pression, puissance, intensité, directivité), Manipulation en amplitude (décibels), Manipulation en fréquence (bande étroite, bande tiers d'octave, bande d'octave), Types de sources sonores et ondes correspondantes, Types de champs sonores, Principaux phénomènes acoustique (absorption, réflexion, transmission, diffraction, diffusion, rayonnement).

4 - ÉQUATIONS ET PARAMÈTRES FONDAMENTAUX

Équation d'onde, Équation d'Helmholtz, Ondes planes et sphériques (pression, vitesse, intensité, impédance).

5 - RÉFLEXION ET MATÉRIAUX ABSORBANTS

Réflexion sous incidence normale sur une surface d'impédance finie, Réflexion sous incidence oblique sur une surface d'impédance finie, Réflexion avec effet d'épaisseur, Modèles d'impédance.

6 - PROPAGATION DANS LES CONDUITS ET LES LOCAUX

Approche statistique, Approche géométrique, Approche modale.

7 - TRANSMISSION

Transmission du son par une paroi (méthode approchée, méthode classique).

8 - VIBRATIONS ET RAYONNEMENT ACOUSTIQUE

Rappel sur les vibrations, Facteur de rayonnement.

9 - TECHNIQUES EXPÉRIMENTALES

Mesure de l'impédance et de l'absorption des matériaux, Identification et puissance des sources de bruit par intensimétrie.

10 - TECHNIQUES CLASSIQUES DE RÉDUCTION DU BRUIT ET ANALYSES DE CAS

Réduction du bruit par absorption, par affaiblissement, par encoffrement, par traitement du local, par planification assistée par ordinateur, par réduction du rayonnement, par amortissement, par réduction des vibrations ou des impacts, par l'utilisation de silencieux, par maintenance préventive.

11 - GESTION DU CONTROLE DU BRUIT

Politiques d'achats, Choix de l'équipement de mesure (appareils et logiciels), Utilisation des consultants, Importance et moyens en recherche et développement.

Le cours sera complété par des démonstrations et des exercices dirigés.

DATE: 1-2-3 octobre 1990, 9:00 À 16:30

COUT: $800 incluant le dîner du mercredi et les notes de cours (français ou anglais). Diverses réductions applicables (voir fiche d'inscription). MAXIMUM 25 PLACES

DONNÉ PAR: Jean Nicolas, Professeur titulaire, Université de Sherbrooke.
Frédéric Laville, Ph.D., G.A.U.S., Université de Sherbrooke.
Yvan Champoux, Professeur agrégé, Université de Sherbrooke.
Alain Berry, M.Sc.A., G.A.U.S., Université de Sherbrooke.

INFORMATIONS SUPPLÉMENTAIRES: Jean Nicolas
Tél.: (819) 821-7157
FAX: (819) 821-7903

SÉMINAIRE SUR LA PROPAGATION DU SON A L'EXTÉRIEUR

(EN FRANÇAIS / IN FRENCH)

Ce séminaire d'une journée s'adresse aux intervenants en environnement sonore. Il vise à apprendre à connaître et caractériser les principaux phénomènes en propagation du son à l'extérieur.

CONTENU

1 - PROPAGATION DIRECTE

Ondes planes, Ondes sphériques, Ondes cylindriques.

2 - PROPAGATION EN PRÉSENCE DU SOL

Caractérisation du sol, Effet des types de sols (herbe, terre, asphalte, neige), Effet de surfaces mixtes (pelouse-asphalte).

3 - DIFFRACTION PAR UN ÉCRAN

Diffraction pure, Diffraction et effet de sol, Effet des dimensions de l'écran et des positions de la source et du receveur, Cas des écrans absorbants.

4 - EFFETS ATMOSPHÉRIQUES

Définition de la réfraction, Effet d'un gradient de température, Effet d'un gradient de vent, Gradient généralisé (vent + température).

5 - TURBULENCE

6 - ÉTUDES DE CAS

DATE: 3 octobre 1990, 9:00 à 16:30

COUT: 240$ incluant le dîner et les notes de cours (anglais ou français).
Diverses réductions applicables (voir fiche d'inscription)

DONNÉ PAR: GILLES DAIGLE, Ph.D., Conseil National de la Recherche
JEAN NICOLAS, Professeur titulaire, Université de Sherbrooke
ANDRÉ L'ESPÉRANCE, M.Sc.A., G.A.U.S., Université de Sherbrooke

INFORMATIONS SUPPLÉMENTAIRES: Jean NICOLAS
Tél.: (819) 821-7157
FAX: (819) 821-7903

SEMINAR ON NOISE CONTROL IN BUILDINGS

(IN ENGLISH / EN ANGLAIS)

This one-day seminar will be an updated version of the 1985 Building Science Insight Seminars. It will be of interest to architects, designers and others in the construction industry needing a general understanding of noise control in buildings. It is not intended for those with professional expertise in building acoustics.

CONTENT

1. NOISE CONTROL IN ROOMS

   Including special problems for speech, open plan offices and mechanical system noise.

2. SOUND TRANSMISSION

   Including noise reduction by typical wall and floor construction and special problems with doors and windows.

3. BUILDING ACOUSTICS IN PRACTICE

   Including footstep noise control, plumbing noise and the combination of all factors in design of complete buildings.

- Each lecture will start from basic concepts and provide an overview of the topic from a practical point of view, with minimal mathematical content.
- There will be open discussion periods where the participants can pursue their specific interest.

DATE: 3 october 1990, 9:00 to 16:30

COST: $ 200 including lunch and lecture notes (in French or English). Special rates available (see registration form).

GIVEN BY: The Institute for Research in Construction (IRC), National Research Council, Canada

Speakers: A.A.C. Warnock
J.D. Quirt
J.S. Bradley

INFORMATION: J.D. Quirt
Tel.: (613) 993-2305
FAX: (613) 954-5984

SEMINAR ON NUMERICAL TECHNIQUES IN ACOUSTICS

(IN ENGLISH / EN ANGLAIS)

A one-day seminar on the theory and practice of acoustic modelling using the finite element method and the boundary element method. The presentations will be complemented by hands-on demonstrations.

CONTENT

1 - FUNDAMENTAL THEORIES OF NUMERICAL MODELS IN ACOUSTICS AND ELASTO-ACOUSTICS
Underlying assumptions, Methods available and their range of application.

2 - BASIC CONCEPTS FOR APPLYING NUMERICAL METHODS IN ACOUSTICS
Methodology, Fluid-structure coupling, Link between acoustic modelling and structural modelling, Absorbent materials, Wave sources, Kind of results obtained, Correlation with measurements and using test data, Full description of examples.

3 - ACOUSTIC FINITE ELEMENT METHOD (Interior problems)
Fundamental theory (fluid and porous media), Applications.

4 - ACOUSTIC BOUNDARY ELEMENT METHOD (Interior and exterior problems)
Direct collocation method, Indirect variational method, Applications.

5 - ELASTO-ACOUSTIC COUPLING
Homogeneous: Structural FE + Acoustic FE (interior problem), Direct, modal and non-modal approaches
Heterogeneous: Structural FE + acoustic BE (interior and exterior problems), Direct and modal approaches.
Applications.

6 - FUTURE TRENDS IN METHODS AND TECHNIQUES
Including wave envelope elements.

DATE: 3 october 1990, 9:00 to 16:30

COST: $ 125 including lunch and lecture notes.
Special rates available (see registration form).

GIVEN BY: Dynamics Engineering Inc.
St-Louis, MO

Speakers: Jean-Pierre Goyette, Ph.D., Research Manager Invited professor at University of Louvain (Belgium)
Pierre M. Guisset, Sysnoise Product Manager.

INFORMATION: Hans Wynendaele
Tel.: (314) 429-2150
FAX: (314) 427-6051

TECHNICAL PROGRAM

ACOUSTICS WEEK IN CANADA 1990

SEMAINE DE L'ACOUSTIQUE CANADIENNE 1990

Holiday Inn Crowne Plaza, Montreal, Quebec, 4-5 Oct. 1990

THURSDAY, 4 OCTOBER, 1990

8:45 **OPENING REMARKS / OUVERTURE DU SYMPOSIUM** — **Room: Gouv. 2**

Frédéric Laville,
Technical Program Chair / Président programme technique
GAUS, Génie mécanique, Université de Sherbrooke
Sherbrooke, Québec, J1K 2R1

9:00 **SESSION A** — **Room: Gouv. 2**
VIBRATIONS AND STRUCTURAL RADIATION / VIBRATIONS ET RAYONNEMENT DES STRUCTURES

Jean Nicolas, Organizer and Chair / Organisateur et Président
GAUS, Génie mécanique, Université de Sherbrooke
Sherbrooke, Québec, J1K 2R1

9:00

A1. Remedial measures for traffic vibrations from roads founded on clay. M.O. Alhunaidi and J.H. Rainer (Institute for Research in Construction, National Research Council, Ottawa (Ontario) KlA 0R6).

Several remedial measures are usually suggested to reduce traffic-induced building vibrations, amont them: periodic maintenance to provide a smooth road surface, traffic flow control, weight control, speed control, improvement of road/subbase structure, screening of vibration by trenches or stiff obstacles, soil improvement, etc. Some of these measures may be readily discarded for being impractical or not cost effective. In addition, the suitability of any one or a combination of these measures is site specific. The objective of this study is to investigate the major factors that influence the levels of traffic-induced vibrations with special emphasis on the role of pavement/subbase structure. The investigation consists of: (i) Controlled field tests to investigate the effects of vehicle speed, vehicle weight, vehicle type, and road surface condition, (ii) Computer simulations using the finite element method to investigate the role of pavement/subbase characteristics. The effectiveness of vibrations screening by concrete walls, and the improvement of the clay soil under the road were briefly investigated. The results show that improving the road structure by increasing its stiffness and mass it not effective for reducing traffic-induced vibrations. On the other hand, soil improvement under the road to a depth of several metres would result in significant reduction of vibration amplitudes. It is also demonstrated that discrete irregularities in the road surface such as unleveled catchbasins, cracks, and ripples are major factors that increase vibration levels. For the site under consideration, elimination of irregularities together with the enforcement of a 50 km/h speed limit would bring down traffic-induced vibrations to an acceptable limit. [This study was conducted for Service de génie, Ville de Hull, Quebec, with partial funding from the Quebec Ministry of Transportation and the National Research Council].

9:20

A2. Evaluation of measurement limits of transducer mountings in the ground. M.O. Al-Hunaidi and J.H. Rainer (Institute for Research in Construction, National Research Council, Ottawa (Ontario) KlA 0R6).

Measurements transducers, which are generally very small size, are usually mounted on larger objects, e.g. a stake or a plate, to provide sufficient coupling to the ground. Contrary to expectations, however, proper coupling to the ground may not always be achieved. Kinematic and inertial effects also occur due to the geometry and mass of the mounting device, respectively. Consequently the measurement system supported by the ground will form a resonant system that may be incapable of faithfully transmitting the free field motion. The distortion of ground vibration measurements by different methods for mounting transducers in the ground is investigated experimentally. The following mountings are considered: (i) Tapered stake having cruciform cross-section; (ii) Wood plate attached to the ground with threaded thin rods; and (iii) Embedded aluminum box of density equivalent to that of soil. The frequency range over which acceptable measurements of ground vibrations can be made is determined for each of these mountings using frequency response tests. These tests are performed by lightly impacting the mounting with a small instrumented hammer. The impact force and the response of the mounting were recorded and analyzed on a two-channel frequency analyzer. Tests were performed at two sites: stiff clay and fine loose sand. Results show that the frequency limit for acceptable accuracy was about 200 Hz for the plate and stake mountings, whereas that for the embedded box mounting was about 120 Hz. The plate and stake mountings were found more convenient to use than the embedded box mounting. [This work was partially supported by a contract from the Ontario Ministry of the Environment].

9:40

A3. Vibro-acoustic behavior of a cylindrical shell elastically coupled to a cylindrical mass. Éric Rébillard (G.A.U.S., Mechanical Engineering Department, Université de Sherbrooke, Sherbrooke (Québec) JlK 2Rl).

The basic model for sound radiation from many aeronautical or submarine structures is often an empty cylindrical shell. Empty shells are usually considered in the literature [J. Sound Vib. 131(3), 397-415, (1989)] because of the limitations imposed by the employed method. However, real structures always carry added mass (engines, passengers...). The case investigated in this work is a finite cylindrical baffled shell containing a cylindrical mass. The longitudinal axes of the shell and the mass are assumed to coincide at the static equilibrium position. These elements are joined by several radially-oriented tension springs located at different angular positions in several longitudinal cross-sections. Mechanical forces can be applied on the shell and on the mass. An analytical formulation based on a variational principle is used to solve the problem. The coupling effect between the shell and the mass is considered together with the external fluid loading. Main results are available through mechanical, vibrational and acoustical parameters (mechanical impedances and quadratic velocities of the shell and the mass, radiated power and radiation efficiency). Numerical results will be presented to give a better understanding of the effect of an added mass on the acoustic radiation of the structure.

10:00

A4. Characteristics of train-induced ground vibrations. J. Hans Rainer, Gerry Pernica and M. Osama Al-Hunaidi (Institute for Research in Construction, National Research Council of Canada, Montreal Road, Ottawa (Ontario) KlA 0R6).

Characteristics of train-induced ground vibrations are reported for three sites in Southern Ontario and one site near Kamloops, British Columbia. Train-induced ground vibrations at each site are characterized by: a) one-third octave band spectra near the track, and b) attenuation curves for one-third octave bands with distance in metres from the track. An attenuation curve for each site is also presented by converting distance in metres to distance in wavelengths for each one-third octave frequency.

Characteristics at each site are related to ground conditions (surface profile, soil depth, soil properties) and are compared to those presented by other investigators and to existing design guidelines for train-induced ground vibrations.

The effects of resonant response in neighbouring single-storey, residential homes at the site in British Columbia are presented. Conclusions are drawn on methods of assessing resonant effects in residential structures at other sites. Needed work in the areas of standards, measurement procedures and prediction techniques is outlined. [Work partially supported by the Ontario Ministry of the Environment and by Transport Canada].

10:20
Refreshment break

10:40

A5. Coupling effects between a mass-spring-type source and a plane radiator. Dominique Trentin, Frederic Laville, and Alain Berry (GAUS, Mechanical Engineering, University of Sherbrooke, Sherbrooke (Quebec) JlK 2Rl, Canada).

Structural acoustic radiation usually involves a mechanical source of vibrations (electric motor, internal combustion engine...) attached to a large, thin structure (radiator). The coupling effect between the source and the structure is very important because, in general, it is at the junction that the mechanical source can be isolated. A theoretical analysis of the problem is presented. The lumped source, simulating a motor with a suspension, is composed of a mass, springs and dampers and with one single attachment point to a baffled, thin, rectangular, plane structure where stiffeners and point masses can be added. A quadripole approach for the source and a variational approach for the motion of the structure enable to calculate the force input into the structure in a varety of configurations. Then, the kinetic energy of the structure and the radiated sound from the structure can be derived. Numerical results are presented for the particular application of optimal suspension design for mass-spring-type sources.

11:00

A6. Random vibration of a hysteretic oscillator. Qiang Liu and Huw G. Davies (Department of Mechanical Engineering, University of New Brunswick, Fredericton, N.B. E3B 5A3).

This paper discusses the response of a nonlinear oscillator with hysteretic restoring force to random white noise excitation. The oscillator is described by the third order system:

$$\ddot{x} + c\,\dot{x} + \varepsilon x + (1-\varepsilon)\, z\left(x, \dot{x}\right) = h\,W(t)$$

$$\dot{z} = \left\{A\,\dot{x} - \nu\left[\alpha\left|\dot{x}\right|\left|z\right|^{n-1} z - \beta\left|z^{n}\right|\dot{x}\right]\right\} / \eta$$

The analysis is based on a non-Gaussian closure approximation involving a truncated series of Hermite polynomials. A computer code has been developed to handle the general third order case, and appears to agree well with what few results are available in special cases. The program gives a fairly complete package of statistical response analysis for both the stationary and non-stationary cases, including response statistics, joint probability density functions, correlations and spectra, and subsequently derived statistics such as mean crossing rates. It is thought that the ability to generate the spectrum of the nonlinear response is very useful for engineering applications. (Work supported by NSERC.)

11:20

A7. Vibration analysis of truncated conical thin shell structures. B. Wang and C.W.S. To (Department of Mechanical Engineering, The University of Western Ontario, London, Ontario, N6A 5B9)

Axisymmetrical thin shell finite elements have wide applications because of their simplicity and economy. However, the finite element method and classical shell theory seem to offer conflicting requirements which give rise to difficulties in finding an adequate representation. Consequently, individual axisymmetrical shell finite element has to be extensively tested before it is allowed to be used in the analysis and design process.

This paper presents results of a series of tests performed on a two nodes, four degree-of-freedom (DOF) per node, axisymmetrical truncated conical thin shell finite element. The focus of the tests on the element is to examine its usefulness and validity for vibration analysis of truncated conical thin shell structures. Explicit mass and stiffness matrices of this element have previously been derived and verified by the authors using a symbolic algebra package, MACSYMA. It was reported by Ross that with four point Gaussian integration the above element provided good results. On the other hand, data obtained in the present investigation using the derived explicit element mass and stiffness matrices are unsatisfactory when the conicity or half vertex angle is relatively large. Thus, the truncated conical shell structures are idealized as a series of cylindrical shell elements. This approach gives results in excellent agreement with those available in the literature. It is more efficient to use as it requires no numerical integration for the computation of element mass and stiffness matrices. Theoretically, it satisfies Love's first approximation for the strain-displacement relation at the element level and therefore, it is free from shear locking for a wide range of geometrical dimensions.

11:40

A8. PC-based software for the acoustic radiation from a plate excited through a suspension system. André Côté, Frédéric Laville and Alain Berry (GAUS, Department of Mechanical Engineering, University of Sherbrooke, Sherbrooke, Quebec, J1K 2R1).

Many cases of structural radiation from machiner involve a source generating a force transmitted to a radiating structure through a spring like attachement. In a paper presented by Dominique Trentin et al. at this conference, the case of a force acting on a mass spring damper attached to a "semi-complexe" planar structure is presented. The "semi-complexe" planar structure (rectangular plate with general boundary conditions, stiffners and point masses) leads to a solution by a variational approach using a polynomial base. Whereas the variational approach does not use as much computer time as finite element - boundary element approaches, it still uses enough computing time to make a PC implementation not very practical. Consequently, to develop a PC-based software, the planar structure was limited to cases for which eigenfunctions have analytical expressions: a rectangular plate with simply supported or freely guided edges. The expressions for acoustic radiation previously derived in the case of the polynomial base were rederived in the case of the trigonometric eigenfunction base. The resulting software is presented [Work supported by NSERC and VENMAR].

1:20

A9. La mesure des propriétés mécaniques dynamiques des matériaux viscoélastiques. Marc Tardif (Département de génie mécanique, École Polytechnique).

La méthode de la poutre d'Oberst (norme ASTM E756-83) demeure l'une des plus utilisées pour caractériser les propriétés d'amortissement des matériaux viscoélastiques, même si elle est aujourd'hui désuète tant au niveau théorique qu'expérimental. Pour son remplacement, l'auteur propose une nouvelle méthode d'essai permettant de déterminer le module élastique E et le facteur de perte η soient les deux composantes du module d'Young complexe E*, l'une des principales caractéristiques dynamiques des matériaux viscoélastiques.

2:00

A10. Control of C.B.C. Headquarters Building Noise Intrusion from ground borne excitation. B. Howe and D.L. Allen (Vibron Limited, 1720 Meyerside Drive, Mississauga, Ontario, L5T 1A3).

The new C.B.C. Headquarters Building in Toronto is located next to a planned future subway. It was determined that subway generated ground borne excitation would be transmitted to the building structure to create an intrusive noise in many of the 128 studios within the building. To control structurally radiated noise, in the noise sensitive studios, a building foundation vibration isolation system was designed. Prediction of the noise intrusion and the design of vibration isolators will be presented. The Quality Control Testing, installation and details for controlling vibration bridging will be discussed.

2:20

A11. Coupling effects between a cylindrical shell and a plate. L. Cheng and J. Nicolas (GAUS, Mechanical Engineering Department, University of Sherbrooke, Sherbrooke, Quebec, J1K 2R1).

This work considers the natural frequencies and mode shapes of a circular cylindrical shell elastically coupled to a vibrating plate at one end. Translation and rotation springs are introduced at the edges of the shell, the plate, and their interface. A variational approach is adopted by using the normal modes of a simply supported shell and the polynomial basis for the shell and plate, respectively. This model has the advantage of being very general for different combinations of springs, enabling one to simulate both the classical and complicated edge conditions encountered in practice. It can also be easily extended to vibroacoustic problems. Numerical results are presented related to the natural frequencies of the shell and the plate with various edge conditions. Wherever possible, the results obtained are compared with the existing values in the literature and very good agreement is shown to exist [S. Azimi, J. Sound Vib. 120(1), 19-35 (1988)]. Then, several results are given for the case in which the shell is rigidly connected to the plate, showing the coupling phenomena between two subsystems.

9:00 SESSION B — Room: Gouv. 1
ACOUSTIQUE INDUSTRIELLE / INDUSTRIAL ACOUSTICS

René Benoit, Président / Chair
Centre d'Expertise Acoustique
5104 boul. Bourque, Suite 107, Rock Forest, Québec, J1N 1K7

9:00

B1. Contrôle du bruit d'accélération produit lors du rivetage, à l'aide d'une bouterolle creuse contenant du mercure. M. Amram, Génie physique (École Polytechnique de Montréal, C.P. 6079, Succursale "A", Montréal (Québec) H3C 3A7).

Dans l'industrie aéronautique, les riveteuses sont surtout utilisées pour le rivetage de panneaux ou d'ailes d'avions, que l'on exécute par écrasement des rivets en arrière de la tôle rivetée à l'aide d'un bélier ("buckingbar") et l'enfoncement de "hi-loks", qui se présentent comme des boulons à têtes plates forcées dans des orifices et ultérieurement retenant la tôle à la structure à l'aide d'écrous. Le bruit d'impact périodique (de période 40 millisecondes ou f=25Hz) provient à la fois du bruit d'accélération dû à l'arrêt brusque de la bouterolle lors du choc, et du bruit généré par la réverbération ou tintement ("ringing") de la riveuse et du panneau rigide heurté. Nous avons développé une nouvelle bouterolle creuse, contenant du mercure qui semble réduire principalement (de l'ordre de 4 dBA) le bruit d'accélération lui-même (qui est maximum dans l'axe de la frappe) par dissipation thermique, associée à la turbulence générée dans la cavité contenant le mercure, de l'énergie vibratoire due aux chocs.

9:20

B2. Réduction du bruit des équipements de type "Gessner" pour la finition des tissus. René Benoit, ing., M.Sc.A. (Centre d'Expertise Acoustique, 5104 boulevard Bourque, Suite 107, Rock Forest, Québec, J1N 1K7).

Lorsque la machine de modèle Gessner et son système d'aspiration de poussière fonctionnent, les niveaux de bruit dans la zone de circulation varient de 92 dBA à 101 dBA. A lui seul le système de dépoussiérage est responsable des niveaux les plus élevés dans certaines zones et est particulièrement marqué par la présence d'une bande de fréquence prédominante dans le 1/3 d'octave 250 Hz.

Parmis les aspects contraignants du problème, il faut souligner la nécessité de maintenir l'aménagement initial des équipements et la variabilité des conditions de fonctionnement dont les effets sur les niveaux de bruit ont été mis en évidence par l'étude.

Un enclos partiel a été développé pour le "Gessner" en particulier de même qu'un silencieux d'entrée et un silencieux de sortie adaptés spécifiquement en fonction des exigences imposées par les caractéristiques du dépoussiéreur et de son aménagement.

A la suite de la mise en place des solutions, les mesures ont révélées que pour des conditions de fonctionnement identique, les réductions du bruit varient de 6 dBA à 15 dBA. Les réductions de bruit sur le dépoussiéreur étant les plus marquées.

Par ailleurs, l'étude a également permis de mettre en évidence que l'usine aurait eu avantage de faire appel aux experts en acoustique avant de procéder à l'installation de cette machine récemment acquise. En effet, ce type d'équipement est reconnu bruyant, mais un aménagement plus approprié et l'application des solutions lors de la mise en place initiale des machines auraient permis d'obtenir d'aussi bon si non de meilleurs résultats à des coûts nettement minimes.

9:40

B3. Enclos sur mesure pour les équipements industriels. Vick J. Chvojka (ACOUVIB Experts-Conseils, 2217 Guénette, Ville St-Laurent (Québec) H4R 2E9).

Sur la demande de la Cie Domtar, 2 cabines acoustiques pour les raffineurs ont été développées afin de remplacer les enclos précédents acoustiquement inefficaces. L'environnement acide et très humide ainsi que le mode d'opération restreint ont aidé à prédéterminer tout paramètre considéré dans le design tel que l'efficacité acoustique, le drainage, la corrosion, l'espace limité, les contraintes thermiques, l'accumulation de la pâte, l'entretien régulier, les réparations imprévues, le niveau d'accessibilité immédiat et rapide, la facilité du montage et du démontage. La conception d'un style Ikea facile à monter sur place penche sur un cadre inventé. La conception des panneaux acoustiques basée sur les expertises et diagnostics a été ajustée sur les modèles mathématiques afin d'offrir une atténuation particulière dans la bande de fréquences prédominantes. Les résultats de mesure "in situ" après l'installation démontrent une réduction du bruit de 20 dBA en dépassant l'objectif prérequis.

10:00 SESSION C — Room: Gouv. 1
DIAGNOSTICS / DIAGNOSTIQUE

G. Krishnappa, Chair / Président
Engine Lab., National Res. Council Canada, Ottawa, K1A 0R6

10:00

C1. Développement d'un outil informatique pour l'étude paramétrique de sources et de leurs influences sur les niveaux de bruit. Henri Campagna et Pierre Canetto (Campagna & Varenne Canada, 5104 boulevard Bourque, Bureau 107, Rock Forest, Québec, J1N 2K7).

Cette conférence traite de la mise en place d'un outil informatique facilitant l'étude de la réduction du bruit par l'analyse des sources le générant. Cet outil informatique permet la détermination automatique de ces sources et l'analyse de l'influence de certains paramètres sur les niveaux sonores générés par ces sources.

Dans un premier temps, l'expert liste les phénomènes physiques cinématiquement attendus sur la machine, et les manifestations spectrales correspondantes. Ensuite, des mesures vibratoires et acoustiques, effectuées par analyse spectrale, sont réalisées sur la machine étudiée et archivées dans une banque de données. Cette banque de données est munie d'outils informatisés permettant:

- de déterminer automatiquement les émergences spectrales à chaque mesure. La confrontation de ces émergences mesurées et de la liste des manifestations spectrales attendues établie au préalable permet d'identifier les sources générant les niveaux sonores les plus élevés.

- de tracer l'évolution des niveaux de ces émergences spectrales en fonction de la valeur des paramètres archivés lors de l'acquisition. Ceci permet de déterminer l'influence de ceux-ci sur les niveaux de bruit générés par chaque source.

Le conférencier présente ensuite une application de cette méthodologie, réalisée à l'aide de la Banque de Données Expérimentales DIAMANT, sur une étude de réduction de bruit effectuée sur un lave-vaisselle.

10:20
Refreshment break

10:40

C2. Identification of structure-borne propagation with help of health monitoring system. Vick J. Chvojka (ACOUVIB Experts-Conseils, 2217 Guénette, Ville St-Laurent (Quebec) H4R 2E9).

A very commun problem in building acoustics is rather complex sound propagation through the structures so called structure-borne noise. The health monitoring system was adapted to supply noise and vibration diagnostics in order to determine the noise propagation originated by mechanical equipment and propagated through the building to the living area. Data were collected at predetermined strategical components and the spectrograms computerized to identify the principal sources and their propagation paths with help of correlation techniques. Finally, the results from an acoustical model allowed to engineer the custom noise control which reached the acoustical goal with help of efficient and economic solution.

11:00

C3. Noise and vibration diagnostics on a new Corrado G-60. Vick J. Chvojka (ACOUVIB Experts-Conseils, 2217 Guénette, Ville St-Laurent (Quebec) H4R 2E9).

Such as revealed by the german manufacturer, several years were spent on research and development carried by the team of Dr. Klaus-Dietrich Emmenthal in order to bring the competitive muscles to a new sports's car by using several inventions. The pure curiosity instigated the study of the engineering effort invested to the conception in terms of noise and vibration control. The field testings were undertaken with a motor running from 1000 to 5000 rpms corresponding to the speed from 40 km/h to environ 200 km/h at the 5th gear. The expertise includes the sound propagation from the motor to the cockpit and the modal analysis of vibration transmitted from the motor to the body. The results affirmed a strong degree of the pertinent engineering involved.

11:20 SESSION D MEASUREMENTS / MESURES Room: Gouv. 1

Phat N'Guyen, Chair / Président
Decibel Consultants Inc., 250 Hymus, Pointe-Claire, Québec, H9R 1G8

11:20

D1. Digital filters from a users viewpoint. John H. Carey (Larson Davis Laboratories, 1681 W. 820 N. Provo, Utah USA 84601).

Recent developments in highspeed array processor chip technology have resulted in the enhanced use of digital signal processing (DSP) techniques in the instruments used for the measurement and analysis of sound and vibration signals. Although the FFT technique for narrowband frequency analysis is familiar to many of us, the use of digital technology to realize octave and fractional octave filters will have a significant impact on the both purchasers and users of such instruments. This presentation will not be overly concerned with the theory behind the digital filter, but rather on how they impact the user directly. This technology, which can now produce nearly ideal bandpass filters comparable to analog 28 pole filters, has made necessary the development of totally new standards such as ANSI S1.11-1986. Furthermore, they have made possible lightweight, battery operated instruments containing more analysis power than several of the previous generation benchtop units. The user can now have at his fingertips both FFT and fractional octave analysis, typically including 1/1, 1/3, 1/12 and 1/24 octave bandwidths, augmented with such powerful tools as acoustic intensity analysis, in a single instrument. Coupled with the fact that the analysis capabilities of such instruments can be modified by simply adding or changing the coding of the math algoriths, this represents the beginning of an exciting, possibly bewildering, period in sound/vibration analysis.

11:40

D2. Residual pressure intensity index and performance evaluation of instruments to measure sound intensity. G. Krishnappa, V.J. Chiu and G.R. Matthews (Engine Lab., National Res. Council Canada, Ottawa, K1A 0R6).

Residual pressure intensity index measurements and performance evaluation of sound intensity probes and analyzers are discussed. The residual pressure intensity index was determined separately for the analyzers using identical electrical input signals, and for probe and analyzer combinations using identical sound-pressure inputs. Both FFT and digital frequency analyzers were examined in the investigations. The results show that the residual pressure intensity index depends on the input signal levels, and any phase compensation scheme should be considered in relation to these measurements. Performance of the probes was examined using a gating technique in a large enclosed space. The measured sound intensity levels using the sound intensity probe were compared with the levels derived from sound-pressure measurements from a single standard microphone. The results are in agreement with the predicted performance. Further discussions in the paper include the directivity of the probes and phase compensation schemes.

1:20

D3. DCC Digitizer Method: A new high precision method for measurements of TOF and phase with fast A/D converters. Marek Roland-Mieszkowski (School of Human Communication Disorders, Dalhousie University, 5599 Fenwick Street, Halifax (Nova Scotia) B3H lR2).

A new high precision Double Cross-Correlation (DCC) method was developed for the measurement of the Time of Flight (TOF) of an acoustic pulse. This technique utilized A/D conversion of both transmitted and received pulses, either into single channel A/D or double channel A/D. Following RAM storage, a cross-correlation of transmitted and received pulses was performed. Also, a TOF was calculated. The advantages of the DCC method are: removal of time jitter in the transmitted pulse; removal of clock jitter in the transmitted and received pulses; and its relative insensitivity to noise in the transmitted and the received pulses. This in turn leads to unprecedented precision of TOF measurement - error can be much smaller then the time interval between adjacent samples in the A/D converter. For example, precision of +/- 2 ns in a single-shot TOF measurement was achieved for 2.25 MHz ultrasonic pulse with a single channel 32 MHz A/D converter. This is better by a factor of 4 to 100 in comparison to any alternative method of TOF measurement. A final advantage of the DCC method is its ease of implementation in any existing experimental environment, for measurement of TOF and phase difference of acoustical, laser, and electrical etc. signals.

1:40

D4. Recent development in some acoustical standards. George S.K. Wong (Institute of National Measurement Standards, National Research Council Canada, Ottawa, Ontario, K1A 0R6).

The aim of the presentation is to provide up-to-date information on the development of some International and National acoustical instrument and measurement standards that may have profound effect on Canadian noise control regulations. The program of revision for IEC Publication 651: Sound Level Meters and IEC Publication 804: Integrating-averaging Sound Level Meters will be discussed together with IEC draft documents on Personal Sound Exposure Meters, Octave-band and Fractional-octave-band Filters and Microphone Calibration.

The draft document, under preparation by Working Group 30 of ISO/TC43/SC1, entitled "Frequency weighting "A" for noise measurements" will be discussed. The subject document has far reaching implications since its aim is to modify the design goal of the A-weighting.

A brief summary will be given on the instrument standards program of the ASA Standards Committee S1: Acoustics, accredited by the American National Standards Institute for the development of ANSI standards on acoustics.

2:00

D5. A computer simulation for the two-microphone acoustic intensity evaluation of sound power. Frédéric Laville, Jean-Luc Agnan, and Jean Nicolas (Groupe d'Acoustique de l'Université de Sherbrooke, Département de Génie Mécanique, Université de Sherbrooke, Sherbrooke, Québec, J1K 2R1).

Work has been done for several years on the standardization of sound power determination using acoustic intensity measurements. The validation of the standards through testing is difficult because of the large number of measurement conditions to be tested. To help overcome this problem, a computer code simulating the measurement has been developed. Whereas past attempts have been limited to special cases, the developed code is intended to handle cases that integrate more of the industrial reality. The measured noise sources as well as the extraneous noise sources are modeled by any number of monopoles for which the user specifies their quantity, source strength, location, relative phase, and degree of coherence. This approach offers computational simplicity as well as the possibility to model realistic radiation patterns such as plate radiation. This simulation is used to determine the relative importance of the various essor sources in sound power evaluation, which is useful for the definition of measurement strategies and for the validation of measurement standards.

9:00 SESSION E Room: Gouv. 3
HEARING AND SPEECH PERCEPTION / AUDITION ET PERCEPTION DE LA PAROLE

Sharon M. Abel, Chair / Présidente
Hearing Research Laboratory
Ste. 843, Samuel Lunenfeld Research Institute, Mount Sinai Hospital
600 University Ave. Toronto, Ontario, M5G 1X5

9:00

E1. The effect of level-dependent hearing protectors on auditory perception: I. Normal Listeners. Sharon M. Abel, Ellen M. Krever and Christian Giguere (Hearing Research Laboratory, Ste. 843, Samuel Lunenfeld Research Institute. Mount Sinai Hospital, 600 University Ave., Toronto, Ontario, M5G lX5).

Two groups of twenty normal-hearing listeners, aged 20 to 35 and 40 to 60 years, participated in an experiment, which compared the effects of conventional level-independent (E-A-R 3000 and BILSOM 2315) and newly-marketed level-dependent (E-A-R 9000 and BILSOM 2390) hearing protective devices on hearing and speech perception. The measurements included detection thresholds for one-third octave noise bands centred at 0.5, 1, 2 and 4 kHz, consonant discrimination and word recognition, in quiet and in a background of 75 dB SPL-cable swager noise. The level of the speech was held constant at 80 dB SPL. The results indicated that, relative to unoccluded listening, signal detection in noise generally remained the same or was slightly enhanced when the muffs were worn. The exception was the BILSOM 2390 at 4 kHz. Speech intelligibility in quiet was close to 100% for both occluded and protected listening. The scores decreased in noise, although for three of the muffs, the E-A-R 3000, the E-A-R 9000 and the BILSOM 2315, performance improved relative to the unoccluded condition. Aging had no effect. [Work supported by the Ontario Ministry of Labour and Health and Welfare Canada).

9:20

E2. Identification of the /R-W/Contrast by normally developing children. Laurie K. Fitzgerald and Elzbieta B. Slawinski (Department of Psychology, The University of Calgary (Alberta) T2N lN4).

The purpose of the present study was to examine the development of the categorical perception of /r/ and /w/. In an attempt to extend earlier research which focused primarily on isolated age groups, four age groups were recruited for subjects in the study: adults, and three, four, and five year old children. The experimental paradigm involved a two-choice, forced choice identification task. The stimuli employed in the identification task were acoustic tokens of a 7-step adult male /r-w/ synthetic continuum varying in F2 and F3 onset frequencies and F2 and F3 transition durations. Percent identification data was computed and transformed to yield measures of

phonemic boundaries. The significant shifting and increasing steepness of phonemic boundaries. The significant shifting and increasing steepness of phonemic boundaries as a function of age was supportive of the hypothesized progressive development in the proficiency of phonemic perception ($\underline{F}(3,36) = 4.61$, $\underline{p} < .0079$). Results were discussed in terms of clinical implications and consistency with previous research.

9:40

E3. Sound attenuation from a combination of a plug and a muff. Alberto Behar (Ontario Hydro, Health & Safety Division, 757 McKay Rd, Pickering (Ontario) LlW 3C8).

It is generally accepted, that the total attenuation when wearing a muff on top of a plug, is 5 dB higher that the highest of the individual attenuations of each of the protectors. A recent paper by A. Damongeaot et al [A. Damongeot, R. Lataye and A. Kusy, Applied Acoustics 28, 169-175 (1989)], lists results from 32 laboratory measurements of attenuations resulting from wearing simultaneously a muff and a plug, performed at 5 different laboratories. The resulting mean attenuation was 7 dB. However attenuation values ranged from 0.6 to 12 dB, defying the validity of the 5 dB rule. In this paper, several attempts for a general rule for predicting the combined attenuation have been postulated, non with success. The conclusion is, that combination of protectors should not be used unless the resulting attenuation is known from previous measurements.

10:00

E4. Acoustic characteristics of the /r/ sound and its substitutions produced by normally developed preschool children. Elzbieta B. Slawinski (Psychology Department, The University of Calgary, 2500 University Dr., Calgary (Alberta) T2N 1N4.

In spite of many studies, it is not clear why the sound /r/ is mastered so late in the speech development of English speaking children, nor why it is so often substituted by /w/. The present study examined patterns of articulation for sonorant /r/ and its substitutions in different word contexts. The subject population consisted of 20 normally developing children (33 to 52 months of age).

Production tests involved the identification and naming of 30 presented objects. Acoustical analysis performed on 560 words revealed, that children produce a variety of /r/ substitutions, which can be assigned to four significantly distinctive groups. Information was obtained concerning formant frequencies of F2 and F3, transition rates and durations. Analysis also revealed that /r/ substitutions were context dependent and correlated with the perceptual development of a child.

10:20
Refreshment break

10:40

E5. Oreille: un modèle d'audition pour des applications en temps réel. B. Paillard, J. Soumagne, P. Mabilleau, S. Morissette (Département de génie électrique Faculté des sciences appliquées, Université de Sherbrooke, Sherbrooke (Québec) JlK 2Rl).

Cette communication décrit un modèle d'audition qui a été développé spécifiquement pour des applications en temps réel. Par exemple, il est bien adapté à des applications en codage perceptuel où l'on essaie de tirer parti des propriétés de perception de l'oreille pour le codage des signaux audio.

Comparé à des modèles développés par d'autres groupes, une caractéristique importante de celui-ci est la très grande résolution des espaces, tant fréquenciel (20 000 composantes de 0 à 20 kHz) que basilaire (2500 composantes de 0 à 2500 Mel).

Les hypothèses qui sont à la base de ce modèle sont usuelles. Par exemple, la linéarité des phénomènes mécaniques dans l'oreille interne, ainsi que le temps de réponse "assez long" des détecteurs de la membrane basilaire ont été supposés. De plus, certaines approximations très simples ont été faites, qui permettent sa mise en oeuvre en temps réel sur des signaux de haute qualité (44 Ke/s) dans les limites de performances des processeurs de signaux actuels.

Malgré des approximations, le modèle prédit avec une très bonne précision les résultats de toutes les expériences de psychoacoustique qui ont été simulées jusqu'à présent. Par exemple, il prédit aussi bien (+- 3 dB) les seuils de masquage pour du bruit masqué par une tonalité, ou pour une tonalité masquée par du bruit, vérifiant ainsi quantitativement l'assymétrie de masquage entre bruit et tonalités, décrite par plusieurs auteurs ([1], [2], [3]). Il prédit aussi remarquablement bien des phénomènes auditifs macroscopiques tels que les bandes critiques, et ceci bien que les espaces tant fréquenciel que basilaire, soient très finement discrétisés (quasi-continus).

11:00

E6. Computer-enhanced Teaching of Speech Acoustics. Margaret F. Cheesman and L. Whitney Allsop (Hearing Health Care Research Unit, Department of Communicative Disorders, University of Western Ontario, London, Ontario, N6G 1H1).

The reduced costs, increased computational power, and sophisticated software tools that have become available in recent years challenge those involved in acoustics education to develop educational programs to allow students to experience basic phenomena and to explore advanced topics. The acoustics component of the speech science course at UWO has been enhanced by developing a series of computer-based teaching modules that combine text instruction, visual-displays using computer graphics, animation, audio output, and audio input. Two modules will be discussed, as examples of alternative approaches. In the first, students use a general-purpose system to explore a particular topic; for this module, the computer-based speech research system "CSRE" [Jamieson, Nearey, and Ramji, Canadian Acoustics, 17, 23-35, (1989)] is used and students conduct acoustical analyses of aspects of their own speech within scheduled laboratory sessions. In the second approach, a structured-learning module was developed using a hypercard analog (GUIDE, 1988) which runs on IBM/PC-compatible computers to introduce students to topics in resonance, with a particular focus on vocal-tract resonance. Using this approach, students can explore each topic in the detail they require -- skipping familiar or less interesting topics and exploring others in depth, as required. Because these and other modules run on mass-produced and widely-available hardware, and do not require costly software, a complete student workstation can be developed for approximately Cdn$5,000. [Work supported by the Faculty of Applied Health Sciences and by the Academic Development Fund, University of Western Ontario].

11:20

E7. NIH Consensus Development Conference on Noise and Hearing Loss: An Informal Report. Edgar A.G. Shaw, Researcher Emeritus (Division of Physics, National Research Council, Ottawa, Ontario, K1A 0R6.

This conference was held in Bethesda, Md., U.S.A. January 22-24, 1990 and was sponsored by the U.S. National Institute on Deafness and Other Communication Disorders and the NIH Office on Medical Applications of Research. Twenty-one speakers presented invited papers under four headings: (1) the characteristics of noise-related hearing loss, (2) acoustic parameters of hazardous noise exposure, (3) individual and age-specific susceptibility, and (4) prevention strategies. The presentations were made before a public audience and the 15 members of the Consensus Panel who were then required to prepare a draft statement in response to five questions: What is noise-related hearing loss? What sounds can damage hearing? What factors, including age, determine an individual's susceptibility to noise-related hearing loss? What can be done to prevent noise-related hearing loss? What are the directions for future research? On the final day of the conference, the panel statement was presented to the conference audience for comments and questions in preparation for publication.

2:20 SESSION F — Room: Gouv. 2
OUTDOOR SOUND PROPAGATION / PROPAGATION SONORE À L'EXTÉRIEUR

Jean-Gabriel Migneron, Organisateur et Président / Organizer and Chair
Laboratoire d'acoustique et Centre de recherches en aménagement et en développement (CRAD), 1624 pavillon Félix-Antoine-Savard, Université Laval, Ste-Foy, Québec, G1K 7P4

2:20

F1. Le logiciel "IMPACT" et la modélisation de l'environnement sonore au voisinage des infrastructures industrielles. Dominique Leclerc, Pierre Lemieux et Jean-Grabriel Migneron (Laboratoire d'acoustique et Centre de recherches en aménagement et en développement (CRAD), 1624 pavillon Félix-Antoine-Savard, Université Laval, Ste-Foy, Québec, G1K 7P4).

Le logiciel "IMPACT" a été développé à l'Université Laval au cous des années 80 (en Turbo Pascal depuis 1985). Il permet le calcul du niveau du bruit dû à des voies routières en divers points de l'espace, quelle que soit la position géométrique et la forme des voies considérées. En plus de la dispersion et de l'effet de sol, le programme identifie tous les effets d'écran, naturels ou dus à des dispositifs de protection et les compile ensuite, avec les réflexions et les diffractions correspondantes, pour chacun des segments élémentaires de voie. Le logiciel opérant intégralement en trois dimensions, il est également possible de produire une interpolation dans un plan vertical. pour la production des documents cartographiques, "IMPACT" est muni d'un générateur permettant l'échange de données avec différents logiciels de dessin assisté (Autocad, Microstation, etc.). En 1989, le logiciel s'est vu adjoindre une routine d'entrée des données applicable à n'importe quelle source de bruit industrielle, de dimensions, puissance, composition et directivité données.

2:40

F2. Precise modelisation of the insertion loss of parallel noise barriers on ground. Raymond Panneton, André L'Espérance (GAUS, Mechanical Engineering Department, University of Sherbrooke, Sherbrooke, Quebec, J1K 2R1).

Most of the computer codes actually used to predict the traffic noise do not specifically consider important acoustical phenomena like the ground effect, the diffraction over absorbent barrier and/or the multiple reflections in the case of parallel barriers.

To evaluate these phenomena, a computer code was developed using a precise theory of sound propagation over finite ground impedance [T.W.F. Embleton et al., J. Acoust. Soc. Am. 59 (1983)] and an appropriate diffraction solution which can take into account the effect of absorbent layer on barrier [A. L'Espérance et al., J. Acoust. Soc. Am. 86(3) (1989)]. To evaluate the contribution of multiple reflections in the case of parallel barriers, the algorithm can consider the image-source contributions through an order of N reflections.

The model was validated with experimental measurements and with results found in literature. Some comparisons with STAMINA, a typical computer code used by practitioner, were done to point out the limitation of this type of model.

3:00
Refreshment break

3:20

F3. Modelisation of the long range outdoor sound propagation via a geometrical ray model. A. L'Espérance, J. Nicolas (GAUS, Mechanical Engineering Department, University of Sherbrooke, Sherbrooke, Quebec, J1K 2R1) and G. Daigle (Division de Physique, Centre National de Recherche du Canada, Ottawa, Ontario, K1A 0R6).

For short range sound propagation problem the acoustic energy reaches a remote receiver via a straight direct ray and a ground-reflected ray and the total pressure at the receiver can be precisely computed considering the geometrical spreading, the atmospheric absorption and the ground effect. [J.E. Piercy & al., J. Acoust. Soc. Am. 61(6) 1403 (1977)]. For long range sound propagation problem, additional affects have to be considered, mainly the refraction due to temperature and wind gradients which curve the rays, and the turbulence which destroys the coherence between the rays.

To evaluate the effect of refraction, a constant linear sound speed gradient is assumed. This assumption allows an analytical determination of the curved rays and it also permits the determination of additional reflected rays that may appear in presence of positive gradients, or of the position of the shadow zone in presence of negative gradients. The total sound pressure at the receiver is computed by summing up the contribution from all the rays existing between the source and the receiver and, if the receiver is in the shadow zone, the diffraction solution of Berry is used [A. Berry, G.A. Daigle, J. Acoust. Soc. Am. 83(6), 2042-2058 (1988)]. The comparisons between theoretical and experimental results show the accuracy of the proposed model.

3:40

F4. Évaluation in-situ de la réduction du bruit d'un nouveau revêtement asphaltique. René Benoit, Centre d'Expertise Acoustique, 5104 boulevard Bourque, Suite 107, Rock Forest, Québec, J1N 1K7).

Un nouveau revêtement asphaltique de type poreux a été mis en place sur un tronçon d'autoroute en milieu urbain dans le but d'en vérifier les différentes caractéristiques dont l'effet possible sur la réduction du bruit pour les riverains.

L'évaluation objective des performances acoustiques d'un revêtement d'asphalte requiert des conditions de mesure où de nombreux paramètres doivent être contrôlés. Malgré l'impossibilité de contrôler tous ces paramètres, les mesures effectuées avant et après la pose du nouveau revêtement ont permis de mettre en relief des différences significatives entre les deux revêtements.

Des mesures du niveau équivalent (Leq) ont été effectuées sur des périodes de 60 à 180 minutes pour trois points de mesures principaux. Huit autres points de mesures secondaires ont également été utilisés pour des relevés de 15 minutes. Le contenu spectrale résultant du trafic routier avant et après la pose du revêtement a été évalué. Le débit et la composition du trafic ont par ailleurs été relevés pendant chaque période mesure.

Outre une réduction du bruit de 3 à 5 dBA, l'analyse des résultats et des observations fait ressortir, entre autres, que la réduction du bruit des autos est la plus marquée et que ce sont les bruits aigus au-dessus de 800 Hz qui diminuent le plus alors que les sons plus graves demeurent sensiblement les mêmes.

2:20 SESSION G Room: Gouv. 1

PERCEPTION OF AUDITORY WARNINGS / PERCEPTION DES SIGNAUX AVERTISSEURS

Chantal Laroche, Organizer and Chair / Organisatrice et Présidente
Groupe d'Acoustique de l'Université de Montréal
C.P. 6128, Succ. A, Montréal, Québec, H3C 3J7

2:20

G1. The validity of a computerezed model to predict the detection of warning sounds by workers with noise-induced hearing loss. Maryse Comeau, Chantal Laroche, Hung Tran Quoc and Raymond Hétu (Groupe d'acoustique de l'Université de Montréal, C.P. 6128, Succ. A, Montréal, Québec, H3C 3J7)

A computerized model has been developped to predict the detection of warning sounds by workers who suffer from noise-induced hearing loss. This model takes into account the auditory sensitivity and frequency selectivity. More precisely, the masked threshold of a sound in a noise is calculated for subjects with hearing loss of cochlear origin according to the critical bandwiths proposed by Pick, Evans and Wilson (in Psychophysics and Physiology of hearing. Ed.: E.F. Evans, J.P. Wilson, London, Academic Press, 273-281, (1977). The predicted values had to be validated. They were then compared to experimental data available in different papers on the masked thresholds of subjects with different degrees of cochlear hearing loss. These comparisons have permitted to improve the predictions of the original model. A "user-friendly" version of the program will soon be available. This practical tool will allow safer warning sounds to be designed. (Work supported by IRSST).

2:40

G2. The Psychoacoustic Determinants of Urgency in Auditory Warnings. Judy Edworthy & Sarah Loxley (Department of Psychology, Polytechnic South West, Plymouth, United Kingdom).

Many spectral, temporal and melodic parameters affect the perceived urgency of sound, and this relationship between psychoacoustic quality and psychological urgency could be exploited in auditory warning design. Situations of low urgency could be signalled by warnings with low urgency whilst high urgency situations could be signalled by high urgency sounds. In order to do this, the effects of individual sound parameters on perceived urgency and the interactions between them must be measured. A series of experiments are reported in which the perceived urgency of individual sound parameters are shown by both ranking and rating judgements. The results show clear and consistent effects for many spectral, temporal and melodic parameters; individual sound parameters such as amplitude envelope, harmonic content, speed and melodic structure all affect the perceived urgency of auditory stimuli in a consistent way. A test of the results was carried out whereby a set of warnings was generated and their urgency rank ordering predicted. This ordering was confirmed on experimental testing. These results show how the perceived urgency of auditory warnings might be manipulated in both design and use.

3:00
Refreshment break

3:20

G3. The Design and Evaluation of Trend Monitoring Sounds. Judy Edworthy & Sarah Loxley (Department of Psychology, Polytechnic South West, Plymouth, United Kingdom).

In high workload environments such as operating rooms and helicopter cockpits, it is often useful to provide auditory feedback on the status of various parameters via sound. When the value of a parameter increases then this could be conveyed through a change in the sound; when the value decreases, this could be conveyed by a different change in the monitoring sound. Three sets of trend monitoring sounds, called 'trendsons', have been designed and evaluated for helicopter use. Experimental data on perceived urgency and magnitude estimation tasks were used in the development of three trendsons. In each case the trendson consists of five levels of a single sound where each of the levels is acoustically related and clearly identifiable as a version of the prototype sound for that trendson. In a series of experiments the confusions and similarities between and within trendsons was measured. The results show that subjects are able to identify each level of a trendson as belonging to a particular group or sounds (trendson), whilst being able to differentiate between different levels of a single trendson.

3:40

G4. Frequency selectivity in workers with noise-induced hearing loss. Bruno Josserand, Chantal Laroche, Hung Tran Quoc and Raymond Hétu (Groupe d'acoustique de l'Université de Montréal, C.P. 6128, Succ. A, Montréal, Québec, H3C 3J7).

The Groupe d'acoustique de l'Université de Montréal has developped a computerized model which predicts the detectability of warning sounds in noisy workplaces. This original program took into account the auditory sensitivity and frequency selectivity as a function of age. No such program was available to predict detection abilities of workers with noise-induced hearing loss. This is due to the fact that very few data were available on the loss of frequency selectivity as a function of the degree of the degree of noise-induced hearing loss. It is well known that these two impairments influence masked thresholds. Using the notched-noise method, data have been collected on the auditory filter shapes of workers with different degrees of noise-induced hearing loss. Regression analysis has been conducted between the degree of hearing loss and parameters of the auditory filters at 0.5, 1 and 3 kHz. These data in combination with an analysis of the litterature on masked thresholds in subjects with hearing loss of cochlear origin have allowed generalization of the original program to the entire population of workers whose safety depends on the detection of warning sounds. This new program will be presented and the notched-noise method used in this experiment will be discussed. (Work supported by IRSST).

4:00

G5. Safety of back-up alarms used in noisy workplaces. Chantal Laroche (Groupe d'acoustique de l'Université de Montréal, C.P. 6128, Succ. A, Montréal, Québec, H3C 3J7) and André L'Espérance (Groupe d'acoustique de l'Université de Sherbrooke).

Each year, deadly accidents occurs because a back-up alarm is not heard. Such accidents occur despite Government regulations enforced in each Canadien provinces. In order to understand the exact cause of these accidents, the propagation of back-up alarms has been studied at the rear of trucks in open-field conditions. Noise measurements have been conducted with a sound level meter plugged into a digital audio-tape. Analysis of sound pressure levels at different places at the rear of the trucks and of the frequency content of the alarm could explain the cause of some of the accidents. Sound wave cancellation of up to 20dB occurs at some points due to the reflection and diffraction of the pure tone used in back-up alarms. This decrease in the sound level can be crucial in noisy environments, such as contruction sites. These results should be verified with other heavy vehicles. (Work supported by IRSST).

4:20

G6. Analysis of warning sounds used in a steel plant. Stéphane McDuff, Chantal Laroche, Hung Tran Quoc and Raymond Hétu (Groupe d'acoustique de l'Université de Montréal, C.P. 6128, Succ. A, Montréal, Québec, H3C 3J7).

Each year accidents occur in noisy workplaces because a warning sound is not heard. In order to improve safety in noisy workplaces, a computerized model ("Detectsound") was developped to predict the detectability of warning sounds. This model takes into account the loss of auditory sensitivity and frequency selectivity as a function of age and the use of hearing protectors. The model was used to analyse 93 different configurations of warning sounds in a steel plant. In about half of the cases, the warning signals did not meet the recognition criteria for workers aged between 20 and 60. Recommandations have been made in order to improve workers safety. The usefulness of this tool for health and safety personnel will be discussed. (Work supported by IRSST).

4:40

G7. Acoustic parameters that contribute to the perceived urgency of auditory warning signals. K.L. Momtahan and B.W. Tansley (Department of Psychology, Carleton University, Ottawa, Ontario, K1S 5B6).

Two experiments were conducted in order to investigate the effects of varying acoustic parameters on subjects' ratings of perceived urgency. Subjects in Experiment 1 were presented with two 3-second windows of sound and asked to judge which of the two sounded more urgent. The sound parameters investigated were interpulse interval length, amplitude modulation, number of harmonics, spectral tilt, pitch, frequency modulation, frequency glides, envelope shape, and pitch steps. Some of the most promising parameters of Experiment 1 were incorporated into Experiment 2 where the urgent and non-urgent forms of six sound parameters were combined. The sound parameters investigated in Experiment 2 were interpulse interval length, number of harmonics, spectral tilt, pitch, frequency glide, and loudness. Results of Experiment 1 were often surprising but consistent across subjects. All the parameters of Experiment 2 were found to influence subjects' ratings of urgency but to varying degrees. The import of these results in the design of auditory warning signals will be discussed. (Work supported by NSERC).

3:20 SESSION H Room: Gouv. 3
NUMERICAL TECHNIQUES / TECHNIQUES NUMÉRIQUES

Ken Fyfe, Organizer and Chair / Organisateur et Président
Department of Mechanical Engineering, Katholieke University of Leuven, Leuven, Belgium

3:20

H1. Shape design optimization using the constituent matrix method of acoustic finite element analysis. Robert J. Bernhard (Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907 U.S.A.).

In this paper, the constituent matrix method of assembling acoustic finite element matrices will be discussed. The method utilizes classical finite element approximations of the Helmholtz equation except that the shape variables of the problem are isolated in the mapping which traditionally takes place in evaluating the finite element matrices. Thus, the finite element model is written explicitly in terms of geometric variables, which describe the shape of the acoustic space, and so-called constituent stiffness and mass matrices. Shape design sensitivity derivatives can be computed from this form of the model. The resulting sensitivity information is useful for design optimization problems and probabilistic design methods. Also, modal models can be written in terms of the shape variables and modal constituent matrices. Application of the method will be illustrated for muffler, reverberation room and automobile interior shape optimization example problems.

3:40

H2. Finite element and boundary element techniques to solve acoustic problems. J.P. Coyette (Dynamic Engineering, Ambachtenlaan 21, Leuven, Belgium).

This paper reviews modelling techniques to solve acoustic problems in the frequency domain. Finite element (FE) and boundary element (BE) methods will be presented as powerful tools to solve Helmholtz equation with various boundary conditions (pressure, normal velocity and impedance constraints are considered). Both interior (bounded) and exterior (unbounded) are addressed. Emphasis will be made on extension of FE methodology to handle unbounded domains. Recently developed "wave envelope" infinite elements will be shown to effectively handle the radiation boundary condition in infinite space. Boundary element methods (both direct/indirect approaches) will be presented and compared. Special attention will be devoted to performance of asymptotic formulations (plane wave approximation) valid at high frequencies. Presentation of all methods will be supported by numerous examples solved with SYSNOISE package (General Purpose Program for acoustic and elasto-acoustic modelling).

4:00

H3. The use of acoustic streamlines and reciprocity methods in automotive design sensitivity studies. K.R. Fyfe, L. Cremers (Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta) and P. Sas (Department of Mechanical Engineering, Katholieke University of Leuven, Leuven, Belgium).

A wide variety of numerical acoustic modelling tools exist for forced response and eigenmode analysis of automobile enclosures. However, design tools based on these calculational procedures are not readily available. In this work, innovative analysis procedures have been developed to enable the designer to make intelligent design choices in geometry studies. Through the use of so-called acoustic streamline functions and reciprocity techniques, procedures have been developed which enable quick prediction of the effect of inserting barriers in an acoustic cavity and which areas of the boundary are most sensitive to external input. Examples are given from numerical and experimental tests which demonstrate these concepts.

4:20

H4. A cubic isoparametric hermitian finite element for duct component acoustics with flow. David C. Stredulinsky (Defence Research Establishment Atlantic, P.O. Box 1012, Dartmouth, Nova Scotia) and Anthony C. Graggs (Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta).

This paper will outline the development of a new acoustic finite element for modelling sound propagation through duct components, including convective flow effects. The new element is compared to the conventional cubic isoparametric element for the acoustic enclosure eigenvalue problem and the incompressible potential flow problem. A finite element model is then developed to study the propagation of sound through duct components with incompressible potential flow at low Mach number. The finite element solution to the flow field is obtained first, and then used in the acoustic model. Higher order acoustic mode boundary conditions are considered in linking finite element models of duct bends and junctions to anechoically terminated straight ducts containing uniform flow. Results for several duct bends and side branch junctions are presented for plane wave and first cross mode propagation with duct width-to-wavelength ratios approaching one. These results indicate that flow, at Mach 0.1 or less, has little effect on the bend and junction transmission losses. This numerical method has been implemented on a desktop computer with 1.5 megabyte of memory.

4:40

H5. Numerical versus Analytical Methods for Structural Radiation. Jean Nicolas, A. Berry (GAUS, Mechanical Engineering Department, University of Sherbrooke, Sherbrooke, Quebec, J1K 2R1).

Amoung the various methods used to simulate the vibroacoustic behavior of structures, the "analytical" and the "numerical" approaches are probably the most powerful. Analytical methods are defined as methods using a discretization of the solution. Numerical methods are defined as methods using a discretization of the governing equations (in differential, integral, or variational form), and they are used for complex structures. Interesting and meaningful comparisons between these two approaches have been made possible because the analytical method has been generalized to the case of planar semicomplex structures. "Semicomplex" means that the plate has any type of boundary conditions, has added masses and stiffeners, and has any type of excitation forces or moment. This has been done by choosing an appropriate basis [Berry et al., J. Acoust. Soc. Am. Suppl. 1 85, S131 (1989)] of the modal expansion. These developments allow us to study structures that are no longer of the "academic type" (a plate simply supported with one single force in the middle), making the comparison with the finite element method more significant. The numerical method used is based on a finite element method for structural vibrations and a boundary element method for radiation in air. The key parameters presented for this comparison are the quadratic velocity, the radiation factor, and the overall sound power.

1:20 SESSION I Room: Gouv. 3
PHYSICAL ACOUSTICS / ACOUSTIQUE PHYSIQUE

David Cheeke, Chair / Président
SIRICON, 1455 boul. de Maisonneuve Ouest, Montréal, Québec, H3G 1M8

1:20

I1. Acoustic augmentation of air jet mixing with a confined hot crossflow. P.J. Vermeulen, P. Grabinski and V. Ramesh (Department of Mechanical Engineering, The University of Calgary, Calgary (Alberta) T2N 1N4).

Previous work on acoustically pulsed free air jets showed that an entrainment increase up to 6 times was possible. Furthermore, a pulsating air jet in a confined cold crossflow was indirectly shown to have significantly increased mixing. This work has now been extended to the mixing of a pulsating jet with a confined hot crossflow, which allowed more direct and superior assessment of mixing by temperature profile measurements. These novel experiments were designed to examine the affects of acoustic driver power and Strouhal number on jet structure, penetration and mixing. Strong changes were produced in the measured temperature profiles resulting in significant increases in mixing, penetration (greater than 100%), and the length to achieve a given mixed state was shortened by at least 70%. The jet-wake region was strongly modified. Inception of saturation in the increase in jet penetration and mixing was demonstrated. The jet response, as determined by penetration and mixing, was optimum at a Strouhal number of 0.27. Overall, pulsating the jet flow significantly improved the jet mixing processes in a controllable manner.

1:40

I2. Acoustic methods for determining the acoustical properties of rigid-structure materials. Murray Hodgson (Institute for Research in Construction, National Research Council Canada, Ottawa (Ontario) K1A 0R6) and Roland Woodcock (Département de génie mécanique, Université de Sherbrooke, Sherbrooke (Québec) J1K 2R1).

The prediction of the acoustic performance (impedance, absorption, etc.) of 'rigid-structure' materials requires a knowledge of the material's acoustical properties and a suitable prediction model. Usually these properties are determined by non-acoustic means or are simply estimated. Often they are assumed to be frequency invariant. In this paper, new acoustic methods for determining these properties are proposed. The methods rely on a suitable prediction model and on measurements of the acoustic surface impedance of the materials backed by various impedances. They are first illustrated for the case of fibrous materials and the determination of their flow resistivities. Then their extension to the general case of any rigid-structure material described by the Zwicker and Kosten four-parameter (flow resistivity, porosity, compressivility, structure factor) model is discussed and illustrated for fibrous materials.

2:00

I3. Effects of temperature and mean flow on the acoustic characteristics and performance of muffler systems. C.W.S. To and C.H. Xiao (Department of Mechanical Engineering, University of Western Ontario, London, Ontario, N6A 5B9).

Harmful acoustic pulsations always exist in the exhaust piping systems of automobiles, helicopters, tanks, and oil as well as gas compressor piping systems. To provide a more realistic analysis and design of mufflers or silencers for the above systems, the inclusion of the thermal and flow properties of the fluid inside the systems is a necessity as the exhaust pipes and compressor piping systems are always heated. Previous work of Prasad and Crocker has incorporated a linear temperature gradient and flow effect in the derivation of four-pole paramters for a uniform pipe. Application of the four-pole parameters was made on the determination of insertion loss of an expansion chamber on a V-8 automobile engine. No results concerning the thermal as well as flow effects on the acoustic properties such as the acoustic resonant frequencies and mode shapes along the piping system was presented. As the acoustic resonant frequencies and mode shapes are extremely essential in the isolation and identification of the critical location of major acoustic pulsations that may damage the structural integrity of the piping system and in the cases of gas compressor piping systems, operating at high static pressure, it may induce catastrophic structural failure, therefore in this study the thermal and flow effects of the medium inside a particular piping system on its acoustic resonant frequencies and mode shapes as well as performance are considered. It is shown that the flow has an insignificant effect whereas the temperature can drastically change the acoustic properties even for a simple uniform pipe. As the results are obtained with the digital computer package, PASAPS there is no limitation on the form of temperature gradient. In other words, any practical temperature gradient can be included in the analysis and design of silencers or mufflers.

2:20

14. New pseudo-macroscopic approach for the characterization of poro-elastic materials. Roland Woodcock (GAUS, Département de génie mécanique, Université de Sherbrooke, Sherbrooke, Québec, J1K 2R1) and Murray Hodgson (Institute for Research in Construction, National Research Council, Ottawa, Ontario, K1A 0R1).

A model for predicting the acoustic characteristics (surface impedance, absorption, transmission loss) of "generalized multi-layer systems" is under study. This model is based on the theory of quadripoles, exploiting electro-acoustic analogies. Two types of interface conditions are relevant to multi-layer systems: (1) simple fluid-fluid conditions as in the case fo "fluid-type" materials (eg. fibrous materials); (2) complex mixed (solid/fluid/poro-elastic medium) conditions as in the case of poro-elastic materials. A new pseudo-macroscopic model (PMAPEM) for characterizing poro-elastic materials has been developed. The effect of the structure is taken into account, the structure being viewed globally. The resulting eight-parameter model takes the form of transfer matricies. It is shown how to determine all of the parameters using an acoustic technique. The validity of the model is illustrated for the cases of the surface impedances of several multi-layer systems.

2:40

15. The physics model of thyristors interferences with radios and other communication equipments. Ming-Fu Yang and Fei Xue and Yi-Pei Lu (No. 357 Xun Yang New Village, Shi Quan Road, Shanghai 200061, People's Republic of China).

With the increasing use of thyristors in civil electric installations such as lamp controllers, electric fan controller and electric heat controllers, the thyristor interference in the middle frequency ($f < 20$ MHz) range is repugant and serious hampers the using of thyristors in civil electric installations. This paper introduces for the first time a physics model of thyristors which indicates that interference results from the instantaneous pulse that is produced when the thyristor is turned on. Such interference will produce an interference pulse on a nearby antenna and it is received and amplified, which becomes annoying noise. This conclusion is useful in the design of civil electric installations using thyristors so that such installation have greater reliability and better intereference prevention.

4:00 SESSION J Room: Gouv. 2
ARCHITECTURAL ACOUSTICS / ACOUSTIQUE ARCHITECTURALE

Richard Guy, Organizer and Chair / Organisateur et Président
Centre des études sur le bâtiment, Université Concordia
1455 boul. Maisonneuve Ouest, Montréal, Québec, H3G 1M8

4:00

J1. A comparison of Salle Wilfrid Pelletier with other halls. J.S. Bradley (Institute for Research in Construction, National Research Council, Ottawa, Canada, K1A 0R6).

Advanced auditorium acoustics measurements were made in the Salle Wilfrid Pelletier, Place des Arts, Montreal, using the RAMSoft computer measurement program. Measurements were made at the 36 combinations of 3 source positions and 12 receiver positions, both with and without the orchestra shell in place. The hall mean values and the within hall variations of measures of the early decay time, the clarity, the overall strength, and the spacial impression, as well as the conventional reverberation time, were examined and compared to those obtained in other halls. Because this hall is a multi-purpose hall, comparisons are made both with famous concert halls as well as other multi-purpose halls.

4:20

J2. Modélisation de l'intelligibilité dans les locaux réverbérants. Jean-Gabriel Migneron (Laboratoire d'acoustique de l'Université Laval, CRAD 1624 Pavillon Félix Antoine Savard, Cité universitaire, Québec, Québec, G1K 7P4).

Les deux paramètres susceptibles d'influencer l'indice RASTI ("Rapid Speech Transmission Index") sont le niveau du bruit de fond technique et le temps de réverbération, tout particulièrement au tout début de chacune des décroissances de l'énergie acoustique. En fait, dans un local fortement réverbérant, ces deux paramètres affectent la dynamique du signal perçu. Afin de mettre au point une procédure de modélisation convenable de l'intelligibilité pour les nouveaux systèmes de sonorisation dans des locaux fortement réverbérants, il faudrait disposer du temps de réverbération initial EDT, suivant une localisation donnée de la source et avec une directivité similaire à celle des futurs haut-parleurs. Une recherche expérimentale a permis de mettre en évidence l'influence du temps de réverbération initial EDT et, surtout, de la directivité de la source employée, sur l'indice RASTI mesuré (le paramètre EDT -5 dB donnant une meilleure corrélation avec l'indice RASTI que EDT -10 ou -15 dB). On est tout d'abord arrivé à bâtir un modèle informatique susceptible de reproduire convenablement l'intelligibilité existante en utilisant la réponse impulsionnelle relevée directement à travers les haut-parleurs. Ensuite, pour un EDT mesuré (avec une source fortement directive par exemple), ou bien calculé dans l'axe d'un groupe de haut-parleurs, il est possible, à partir des caractéristiques directionnelles prévues et de la réverbération mesurée de simuler l'intelligibilité escomptée sur toute l'aire de dispersion du système de sonorisation.

4:40

J3. Applications of modern room acoustics techniques. John P.M. O'Keefe (Barman Swallow Associates, 1 Greensboro Drive, Suite 401, Rexdale, Ontario, M9W 1C8).

Recent advances in the study of room acoustics are formidable. The modern understanding of the behaviour of sound in rooms now allows for much more freedom and confidence in design. The design of two new rooms will be presented. The first is a 3500 seat Assembly Hall of Jehovah's Witnesses to be used primarily for speech. It features a terraced floor plan to provide early reflected sound throughout the audience. The second room is a 300 seat recital hall at Conrad Grebel College in Waterloo, Ontario. In this room, special attention has been given to platform acoustics using the recent findings of Gade and Naylor. Both designs demonstrate the practical application of modern acoustical research.

FRIDAY, 5 OCTOBER 1990

9:00 SESSION J — Room: Gouv. 2
ARCHITECTURAL ACOUSTICS (continued)
ACOUSTIQUE ARCHITECTURALE (suite)

9:00

J4. Propagation sonore à travers des portes-fenêtres. Vick J. Chvojka (ACOUVIB Experts-Conseils, 2217 Guénette, Ville St-Laurent (Québec) H4R 2E9).

Les fenêtres constituent généralement une faiblesse majeure dans l'enveloppe du bâtiment face à l'isolement acoustique. Dans le cadre de notre recherche, une étude du comportement acoustique des portes-fenêtres sur le milieu immédiat a été entreprise "in situ". Ceci afin de répondre à la performance réelle des portes vitrées à la basse fréquence telles que soumises au bruit environnemental dans un milieu urbain. Pour accomplir cette tâche, une source stationnaire omnidirectionnelle "Isophon" développée par l'auteur a été utilisée. Les résultats démontrent la propagation sonore sur les cartes isophoniques avec le spécimen ouvert et fermé ainsi que l'atténuation franchie.

9:20

J5. Analogue scale modelling technique for architectural acoustics. Vick J. Chvojka (ACOUVIB Experts-Conseils, 2217 Guénette, Ville St-Laurent (Québec) H4R 2E9) and tomas Rozsival (ALP - Acoustics Laboratory of Prague, Plzenska 66, Prague 5, Czechoslovakia).

The Analogue Scale Modelling facilities developed in early seventieth has proved a very efficient tool to any architectural design, being verified on hundreds of soundcrafted projects in room and environmental fields. The various measuring techniques used to simulate a natural source, have the same basis in commun, frequency transformation adjusted with a scale factor of the analogue model, in order to provide with the same acoustical properties as the real situation. Customizing of the acoustical design at the earlier conception stage brings the sound quality and cost balanced control for new or rebuilt projects. During the decades the engineering gradually progressed to the details allowing to optimize any acoustically important element or parameter before its final implantation. The study is scoped at the engineering for room acoustics, illustrated on some projects i.e. The Palace of Culture with a look at the impulse technique used to optimize the sound energy density distribution.

9:40

J6. Omnidirectional sound system "Isophon". Vick J. Chvojka (ACOUVIB Experts-Conseils, 2217 Guénette, Montreal (Quebec) H4R 2E9).

However the frequency response criteria (20 Hz - 20 kHz) have been quite easily fulfilled by professional sound systems, the radiation pattern remained still a predominant factor difficult to control especially at high frequencies. New system "Isophon" developed in 1988 by the author achieves its omnispherical properties with help of properly adapted acoustical means resulting with a revolutionary design. The prototype tested on a sphere within the anechoic facility of the Ecole Polytechnique of Montreal attested its unique sound quality within the audible frequency range. Among new assets to the architectural acoustics, one may note the Field Testing and Sound Enhancement Facilities applied to Concert halls, Theatres, Cinemas, Auditoriums, Recording Studios, Disco Clubs, Stadiums, Amphitheaters and the Buildings. [Acknowledgement to Dr. G. Ostiguy, Ecole Polytechnique].

10:00

J7. Evidence of diffuse surface reflections in rooms. Murray Hodgson (Institute for Research in Construction, National Research Council, Ottawa, Ontario, K1A 0R6).

In order to determine how to predict accurately the reverberation time (RT) and sound propagation (SP - the variation of steady-state level with distance from a source) in rooms, predictions have been compared with measurements for an empty scale-model room and in various nominally empty factories. In the case of rooms with disproportionate dimensions, predictions by the method of images, which accounts for room shape but assumes specular surface reflection, were found to deviate in a consistent way from experiment. The RT is always too high; the short-distance SP tends to be slightly low and the large-distance SP is always too high. This result suggests that diffuse surface reflections were occurring. To test this hypothesis, further predictions were made using a ray-tracing model that accounts for diffuse surface reflections. It is found that excellent prediction accuracy is obtained as follows: a) scale model - if all surfaces are 10-40% diffusely reflecting; b) real factories - if the celling and walls are 70-90% diffusely reflecting.

10:20
Refreshment break

10:40

J8. Sound Emission from Residential Ventilation Fans. J.D. Quirt (Acoustics Section, Institute for Research in Construction, National Research Council Canada, Ottawa, K1A 0R6).

A CSA standard has been developed for laboratory testing of residential ventilation fans to provide ratings of their air-handling and sound emission. A study is underway to evaluate these laboratory test methods, and to assess teh relationship between the laboratory ratings and actual field performance. This paper describes the acoustics part of that study - laboratory measurements (conforming to requirements of the CSA C260 draft standard) of sound power emission of 11 ventilation units, and subsequent field measurements on the same fans when installed in homes. The laboratory tests were structured to verify that the method is practicable and to evaluate factors likely to affect reproducibility of the test method. The field tests were included to demonstrate the relationship between sound power ratings and the resulting sound pressure in practical application. [Work supported by a consortium of interested parties, including the Research Division of Canada Mortgage and Housing Corporation.]

11:00

J9. Sound transmission loss measurements through light-weight porous concrete blocks. A.C.C. Warnock (National Research Council Canada, Montreal Road, Ottawa, K1A 0R6).

Concrete blocks vary in porosity quite widely. The more porous the block, the more important it is to seal the face to achieve good sound transmission loss. This paper gives the results of some measurements made on extremely porous wood-fibre aggregate blocks. The porosity can be used to advantage if the blocks are plastered. Adding drywall on studs on the unplastered side results in a cavity that is greater than normal; the thickness of the block is added to the nominal cavity depth. This results in a mass-air-mass resonance that is significantly lower than might have been expected and, consequently in increase sound transmission loss and sound transmission class. With correct design, a lightweight 90 mm block system gave a sound transmission class rating slightly higher than a normal-weight 190 mm block wall.

11:20

J10. Sound transmission through wood joist floor/ceiling systems: A study of the effects of soune absorbing materials and changes to the ceiling structure. A.C.C. Warnock (National Research Council Canada, Montreal Road, Ottawa (Ontario) KlA 0R6) and M.J. Morin (MJM Acoustical Consultants Inc., 6555 Côte-des-Neiges, Bureau No. 440, Montreal (Quebec) H3S 2A6).

A wood joist floor system was constructed in the Acoustics Laboratory at NRC. Measurements of airborne and impact sound transmission were made for different types and amounts of sound absorbing material in the cavity. Different makes of resilient metal channels were installed and methods of improving an unsatisfactory floor were examined. Over twenty floor systems were measured. The study was funded by Canada Mortgage and Housing. This paper will give a summary of the results obtained.

11:40

J11. Reduction of plumbing noise in lightweight construction. A.C.C. Warnock (National Research Council Canada, Montreal Road, Ottawa (Ontario) KlA 0R6) and M.J. Morin (MJM Acoustical Consultants Inc., 6555 Côte-des-Neiges, Bureau No. 440, Montreal (Quebec) H3S 2A6).

Noise from plumbing fixtures can be a source of great annoyance in single-family and multi-family homes. Noise-control articles and textbooks usually recommend the use of resilient supports for pipes and other fixtures as a means of controlling noise. A study recently completed at NRC examined the changes in noise level produced by different types of pipe, methods of mounting pipes, different wall types, and the addition of sound absorbing materials in walls. Noise sources used included an ISO standard plumbing noise source, a toilet, a sink and five common bathroom faucets. Foam rubber supports were found to be the most effective of the resilient materials tested, providing reductions in A-weighted noise levels of around 20 dB. The study was funded by Canada Mortgage and Housing. This paper will give a summary of the results obtained.

1:20

J12. Loudspeakers and Rooms - An Unfriendly Alliance. Floyd E. Toole (Institute for Microstructural Sciences, National Research Council, Ottawa, K1A 0R6).

The loudspeaker, listening room and the listener comprise a system within which recorded stereo signals are decoded. Sound reproduction technology has reached the stage where loudspeakers and rooms must be treated together if variations in sound quality and stereo imaging rare to be controlled. The enclosure in front of the diaphragm is a major factor in what we hear, and it presents many more problems than the one behind it. This paper reviews the major physical and perceptual variables involved in loudspeaker/listener/room interactions, and discusses some of the methods available for reducing the variability in these complex systems.

1:40

J13. Noise and Vibration Control in the C.B.C. Broadcast Centre (Part 1). Tom Paige, P. Eng. (Vibron Limited, 1720 Meyerside Drive, Mississauga, Ontario, L5T 1A3).

The C.B.C. Broadcast Centre, currently under construction in downtown Toronto, contains more than 200 sound sensitive spaces for radio and television broadcast production, including 3 large television studios located on the roof-top. This paper is an overview of acoustical design concerns relating to this unique self-contained facility which features many novel contruction concepts for controlling noise and vibration from internal and external sources. Areas to be discussed include acoustic isolation of studios and control rooms, control of structure borne sound and vibration and noise control for mechanical and electrical systems. Acoustic isolation for critical areas such as set construction carpentry shops, truck loading facilities and service elevators will also be discussed.

2:00

J14. Noise and Vibration Control in the C.B.C. Broadcast Centre (Part 2). Tom Paige, P. Eng. (Vibron Limited, 1720 Meyerside Drive, Mississauga, Ontario, L5T 1A3).

This paper is a continuation of the previous paper

8:40 SESSION K Room: Gouv. 2
DIGITAL AUDIO TECHNOLOGY / TECHNOLOGIE AUDIO-NUMÉRIQUE

Wieslaw Woszczyk, Organizer and Chair / Organisateur et Président
Faculty of Music, Strathcona Music Building, McGill University,
555 Sherbrooke Street West, Montreal, Quebec, H3A 1E3

8:40

K1. Recent experience with digital audio technology in radio production and broadcasting within the CBC. Stephen B. Lyman (Canadian Broadcasting Corp., 7925 Côte St-Luc, Montreal (Quebec) H4W lR5).

The Radio division of the Canadian Broadcasting Corporation has recently been experimenting with both the production and transmission of digital audio material. This paper will examine the initial design goals for the digital production studio, its final design, and the problems encountered in realizing the design. It will summarize the lessons learned during several months of the studio's operation, and draw conclusions from them. The last section of the paper will give a brief description of the Digital Audio Broadcasting (DAB) system that was developed by the Centre Commun d'Études de Télédiffusion et Télécommunications (CCETT) and the Institut für Rundfunktechnick (IRT), and used in a series of tests that included digital material produced in the studio just described. Some preliminary conclusions from the as yet incomplete transmission experiments will be reported.

9:00

K2. Computer Systems for Music, Audio, and Acoustics. Bruce Pennycook (Faculty of Music, McGill University, Montreal, Quebec).

Many new and extremely powerful signal processing devices have recently become available to developers of computer systems for music synthesis, audio recording and processing and acoustics research and development. Digital signal processing chips from Motorola, Texas Instruments, AMD, AT&T, and Fujitsu, combined with high-precision audio signal convertors have simplified the problem of developing real-time hardware and software for all types of audio applications from telephony to professional audio.

This paper will present a brief overview of kinds of computer systems available to the audio community with a focus on low-cost solutions for personal computers applications. Next, three different types of computer systems will be described which all use essentially the same signal processing hardware and audio conversion mechanisms:

- 16 Channel Disk-Based Digital Recorder

This system is being developed by the authors for CVDS, Inc. in Montreal. The system is capable of recording, playing, editing and processing up to 16 channels of 16-bit, 48 KHz. audio. Unlike other systems currently available, this device will also handle multiple sampling rates and word sizes simultaneously. Up to 71.2 GByte disk drives from a single device are supported.

- Multi-Channel Audio Monitoring

Under a research and development agreement with the National Research Council and the Canadian Audio Research Consortium, a signal processing card for the PC/AT has been developed which is capable of more than 60 million floating point calculations per second (megaflops). Up to four of these devices plus a specially designed multi-channel fiber optic link to external conversion hardware can be installed in one PC/AT (DOS or UNIX) which will deliver more the 250 megaflops distributed over 8,30 Mhz. TMS320C30 signal processors. These devices will be used for research and development into adaptive speaker arrays and monitoring systems by the CARC members.

- Speech Recognition and Neural Networks

Under a research and development contract with Dr. Martin Taylor, Defense and Civil Institute of Environmental Medicine (Toronto), a set of parallel processing devices are being designed to provide real-time models of the ear (cochlear filter models) and to provide an array of independent processors for distributed neural-network audio processing (the speech recognizer). This system uses 9, TMS320C30 dsp's and the fiber-optic networking standard interface, FDDI. A SUN/3 (VME) computer is required.

9:20

K3. Distortion for wideband operation of slightly nonlinear audio systems. D. Preis and R. Gregg (Department of Electrical Engineering, Tufts University, Medford, Massachusetts 02155, USA).

Audio systems typically operate over a bandwidth of 1000 to 1, namely, 20 Hz to 20 kHz. Under test such systems are normally excited by very narrowband signals, such as, for example, one or a few sine waves that are quite unlike wideband program material. One question considered in this paper is how much greater is the distortion for typical wideband operation than that for narrowband test signals? A second question addressed is how can nonlinear distortion be distinguished from the true signal since both simultaneously occupy the same wideband? Finally, results from actual measurements as well as those from computer simulations are presented for systems exhibiting soft clipping, hard clipping and slewing. The notion of a signal-to-distorsion ratio, as opposed to percent distortion, is introduced. Practical measurement procedures using digital signal processing are discussed.

10:00

K4. Perceptual Digital Coding of Audio Signals - A Review. James D. Johnston (Signal Processing Research Dept., AT&T Laboratories, Murray Hill, New Jersey, U.S.A.).

10:20
Refreshment break

10:40

K5. Electro-acoustic measurements using micro-computer generated ML sequences (a user perspective). Timothy Hewlings (Resonance TJL Inc., 5475 Royalmount Ave., Suite 107, Town of Mount-Royal, Quebec, H4P 1J3).

Recently, micro-computer based systems for calculating impulse response (IR) have become available. These systems use pseudo-random binary sequences (Maximum-Length Sequences) which are cross-correlated to obtain the IR. Post-processing by computer can yield a great deal of useful information in room acoustics. The use of one such system is discussed in the context of recording studio control room design and measurement. Also discussed are various uses in parameters of large auditoria.

11:00

K6. Filter banks for music analysis and enhancement. WF McGee and Paul Merkley (University of Ottawa, Ottawa, Ontario, K1N 6N5).

New developments of digital signal processor technology and algorithms allow the implementation of filter-bank-based logarithmic-frequency spectrum analyzers. For example, a bank of 88 filters tuned to piano frequencies allows real-time transcription of music. Also, logarithmic analysis/synthesis filter-banks in which the output is a delayed version of the input with no amplitude distortion permits music enhancement as follows. The input is analyzed into a number of frequency bands. Weaker signals are dynamically attenuated. Then a modified signal is resynthesized by passage though a similar filter bank. A demonstration of the facility for supressing weak noise will be presented.

11:20

K7. Digital Data Compression and Data Reduction/Compression algorithms: efficient information storage and/or transmission in the digital format. Marek Roland-Mieszkowski (School of Human Communication Disorders, Dalhousie University, 5599 Fenwick Street, Halifax (Nova Scotia) B3H 1R2.

In recent years digital technology, for data storage and transmission, has become very popular. This popularity has resulted in a dramatic increase in the demand for Data Compression (DC) and Data Reduction/Compression (DR/C) methods. Higher speeds of microprocessors and the emergence of Digital Signal Processing (DSP) chips have permitted real time applications of even complex algorithms. However, a large portion of the scientific and engineering community is still not aware of the existence of these very efficient DC and DR/C algorithms. In particular, many commercial devices currently on the market still use a "brute force" coding approach like Pulse Code Modulation (PCM). This approach is an ineffective way of using storage devices and transmission channels. For example, to store 1 hour of PCM-coded CD-quality audio signal, 635 MBytes of memory are needed, while with DC algorithms one can reduce this number by a factor between 2 to 10. Current developments and trends in DC and DR/C algorithms will be discussed.

9:00 SESSION L — Room: Gouv. 3
UNDERWATER ACOUSTICS / ACOUSTIQUE SOUS-MARINE

Jacques Yves Guigné, Organizer and Chair / Organisateur et Président
NORCO Limited, Newfoundland Oceans Research and Development Corporation, P.O. Box 8333, St. John's, Newfourndland, A1B 3T2

9:00

L1. A numerical technique for the prediction of acoustic radiation from submerged structures. D.P. Brennan and M.W. Chernuka (Martec Limited, 5670 Spring Garden Road, Halifax (Nova Scotia) B3J 1H6.

The program AVAST which utilizes an iterative technique to predict the acoustic radiation characteristics of an elastic three-dimensional structure, vibrating in either an infinite or half-space fluid medium is described. AVAST combines both the finite element method for the structure and the boundary integral technique for the fluid. The finite element method is used to define the mechanical mobility matrix relationship between excitation forces (in a particular direction and at a particular frequency) and structural velocities at fluid-structure interface nodes. The boundary integral technique is used to generate a system of equations relating surface velocities to fluid acoustic pressures.

Although initially unknown, the surface pressures are first approximated using a plane wave impedance condition. This satisfies the requirements of the mobility relationship and provides a reasonable estimate for the surface velocities. These surface velocities are then used as boundary conditions for the discrete forms of the Helmholtz integral exterior equations, supplies the analyst with a unique set of surface pressures which can be compared to those provided by the plane wave idealization. If the new pressures fail to match the original ones by more than permitted by the convergence criterion (controlled by the analyst), then the updated pressures are used to compute a new set of surface velocities and the process is repeated until convergence is attained.

The simulation of a right circular cylinder is provided to illustrate the potential of this technique.

9:20

L2. Bottom loss in areas with ice-rafted sediments. Francine Desharnais (Defence Research Establishment Atlantic, P.O. Box 1012, Dartmouth, NS, B2Y 3Z7).

Bottom loss vs grazing angle data was obtained for a location in Baffin Bay. The analysis showed bottom losses decreasing with frequency, for frequencies from 20 to 630 Hz. This feature fits the hypothesis of the presence of ice-rafted sediments, which could be modelled by adding a thin layer of high-impedance material at the sediment surface. Other areas of the North Atlantic Ocean have shown similar features in their bottom loss curves and sediment configuration. The validity of the thin-layer approximation is discussed for areas where ice-rafting is dominant, and the possibility of turbidity currents creating the same phenomenon is considered.

9:40

L3. Shot Propagation from the Arctic Basin. R. Del Huston, Gary H. Brooke, and Jon Thorliefson (Defence Research Establishment Pacific, FMO Victoria, B.C., V0S 1B0).

Shot experiments provide a means of measuring dispersion and mode excitation. The Arctic Ocean, with its rough ice canopy, variable bottom geoacoustics and bathymetry, contains many complex acoustic environments with interesting modal propagation characteristics. At three deep water sites a series of explosive charges were detonated at three different depths. The signals were recorded with a nine element vertical array located on the continental shelf. Sonograms were used to determine the dispersive properties and depth-dependent nature of the modes. Time-dependent frequency components observed in the data were formed in the deep water environment and were only slightly modified by the shallow (500 m) waveguide at the vertical array. Dispersive effects were sufficient to separate the lower order water modes. The depth dependance of these modes is computed by mode fitting with theoritical shapes.

10:00

L4. Directional response of a vector intensity hydrophone array. Jacques Yves Guigné and Ian Atkinson (NORDCO Limited, Newfoundland Oceans Research and Development Corporation, P.O. Box 8333, St. John's, Newfoundland, A1B 3T2).

The objective of the testing was to determine the directional response of a three dimensional hydrophone array used in an intensity mode. This was achieved by measuring the x, y, and z components of intensity emitted under water from a stationary source, while rotating the array about its z-axis. The resulting intensity curves show the expected cosine patterns with minima spaced precisely 90° apart. For comparison, theoretical curves were plotted alongside the measurements. There are accurate one-to-one correspondences.

The advantages of the vector intensity approach are in its signal-to-noise ratio, 1° directivity at low frequencies (eg. 1 KHz), incoherent noise suppression, and sound intensity mapping of dominant energy paths. Future work will be on beamforming with this intensity array. Simple algorithms can be applied using the approach to identify sound patterns in the water such as for automatic event detection and for spatial and temporal signal decomposition.

10:20
Refreshment break

10:40

L5. Measuring the Source Level of Wind Generated Ambient Noise in the Ocean. James W. Cornish (University of Victoria, Victoria, BC) and N. Ross Chapman (DREP, FMO, Victoria, BC, V0S 1B0).

Measurements of the source level of wind-generated ambient noise at low frequencies (10-350 Hz) are presented in this paper. The data were obtained using a vertical line array deployed in the deep-water sound channel at various sites in the North-East Pacific. The array response was steered vertically upward to measure the locally generated sea surface noise and eliminate the effect of distant shipping noise. The beamforming was carried out with a frequency-domain beamforming algorithm using a spatial Kaiser-Bessel window to reduce side-lobe levels. The beam power levels obtained were referenced to a source level at the sea surface using a simple propagation model. An analysis of the relation between the measured surface source levels and measured wind speed data is presented and compared with theoretical models of noise generation. The results suggest that the noise level is strongly influenced by the presence of breaking waves in the ocean and is dependent on local wind speed. the source levels are compared with measurements reported in the literature.

11:00

L6. Some new explanations on the mechanism of underwater sound generation by rainfall. Frédéric Laville (Groupe d'Acoustique de l'Université de Sherbrooke, Département de Génie Mécanique, Université de Sherbrooke, Sherbrooke, Québec, J1K 2R1) Grayson D. Abbott, and Matthew J. Miller (Creare Incorporated, P.O. Box 71, Hanover, NH 03755).

Although using underwater sound to measure the rate of rainfall is a promising technique, conflicting models have been proposed for the spectral contributions of the two rainfall sound sources (raindrop impacts on the water surface and air bubble resonances) and correlating rainfall rate to spectral level has proven difficult. In order to resolve these problems, high speed data acquisition and processing of underwater sounds recorded in a lake under real rain and artificial raindrop conditions were used. The two rainfall sound sources have been identified in the time domain and their respective contributions to the long term spectrum have been determined: bubble resonances were found responsible for the spectral peak around 13 to 15 kHz and raindrop impacts were found responsible for a broad band spectrum with a negative slope. The poor correlation reported in literature between the rainfall rate and the level at 13-15 kHz is now explained by the sensitivity of bubble generation to raindrop distribution and surface conditions. The better correlation obtained outside this frequency range is explained by the systematic occurence of raindrop impacts.

11:20

DISCUSSION. Moderator / Animateur: David Chapman (Defense Research Establishment Atlantic, P.O. Box 1012, Dartmouth, NS, B2Y 3Z7).

1:20 SESSION M Room: Gouv. 1
MUSIC PERCEPTION / PERCEPTION MUSICALE

Lola L. Cuddy, Chair / Présidente
Queen's University at Kingston

1:20

M1. Exploring the internal representation of key with a modified probe-tone task. Bradley Frankland & Annabel J. Cohen (Dept. of Psychology, Dalhousie University).

Sixty-one subjects were presented on each trial with an ascending or descending C-major scale followed by a probe-tone (one of 13 chromatic notes) and were asked to judge whether or not the probe fit the preceding context in a forced-choice reaction time task. For each probe, the proportion of good fit responses was considered as a measure of the current level of activation of the representation of the pitch of the probe tone prompted by the preceding musical key. Thus, for each subject the ratings of all 13 × 2 probes provided a profile of the internal representation of key for that subject. Cluster analyses of the profiles revealed three major subgroups accomodating approximately two-thirds of the subjects. The groups could be interpreted in terms of various weightings on triadic, diatonic and proximity relations, dimensions earlier pointed out by Krumhansl and Shepard (1979). Differences in profiles were also observed for ascending and descending scales. Reaction times reflected certain hierarchical and proximity effects and were consistent with the rule that very good and poor fits (highly certain responses) led to fast response times and moderate fits (uncertain responses) led to slow response times.

1:40

M2. Probing Musical Perception. W.F. Thompson (Atkinson college, York University) and Lola L. Cuddy (Queen's University at Kingston).

In a typical application of the probe-tone procedure, listeners are asked to rate the goodness-of-fit of each of the 12 tones of the chromatic scale to a musical context. The set of 12 ratings is called a probe-tone profile, after Krumhansl and Kessler (1982). A variety of analytical techniques is available to recover systematic response patterns contained in a profile - multidimentional scaling, Fourier analysis, and multiple regression.

In this presentation, we further explore the effectiveness of the technique of multiple regression. Through this technique, we assessed the separate influences on probe-tone ratings of acoustical features of the stimulus and cognitive or knowledge-based factors. Both musically trained and untrained listeners were found to be sensitive to the influences identified. Examples will be provided from profiles recently collected for different musical contexts - scales, intervals, chords, and chord sequences.

2:00

M3. Tonal closure in the cerebral hemispheres of both musicians and nonmusicians. Isabelle Peretz, Lise Gagnon, and Sylvie Hebert (Dept. of Psychology, University of Montreal).

We explored the neuropsychological concomitant of our claim (Peretz & Morais, 1989) that tonal organization of pitch might be subserved by modular organization, thus be implemented with a fixed architecture in the brain of all Western listeners. The present study represents an initial step in that direction by searching for a common cerebral hemispheric locus in professional musicians and nonmusicians. We adapted the tone profile technique used by Cuddy & Badertscher (1987) to the measurement of ear-asymmetries. We tested twenty nonmusicians and twenty musicians, who were strongly right-handed and who exhibited evidence of processing speech in the left-hemisphere. On each trial, the subjects heard a sequential tone pattern based on a major triad followed by a probe-tone; they were required to judge as quickly as possible whether or not the probe "fitted" with the key of the pattern. Both musicians and nonmusicians were found to display a right-ear advantage for tonal interpretation of the pitches: they were shorter for the tonic and the dominant than for any other diatonic tones. Thus, the present results indicate a left-hemispheric locus for the processes devoted to the tonal interpretation of pitch; these processes would be fixed for all listeners exposed to the same idiom.

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