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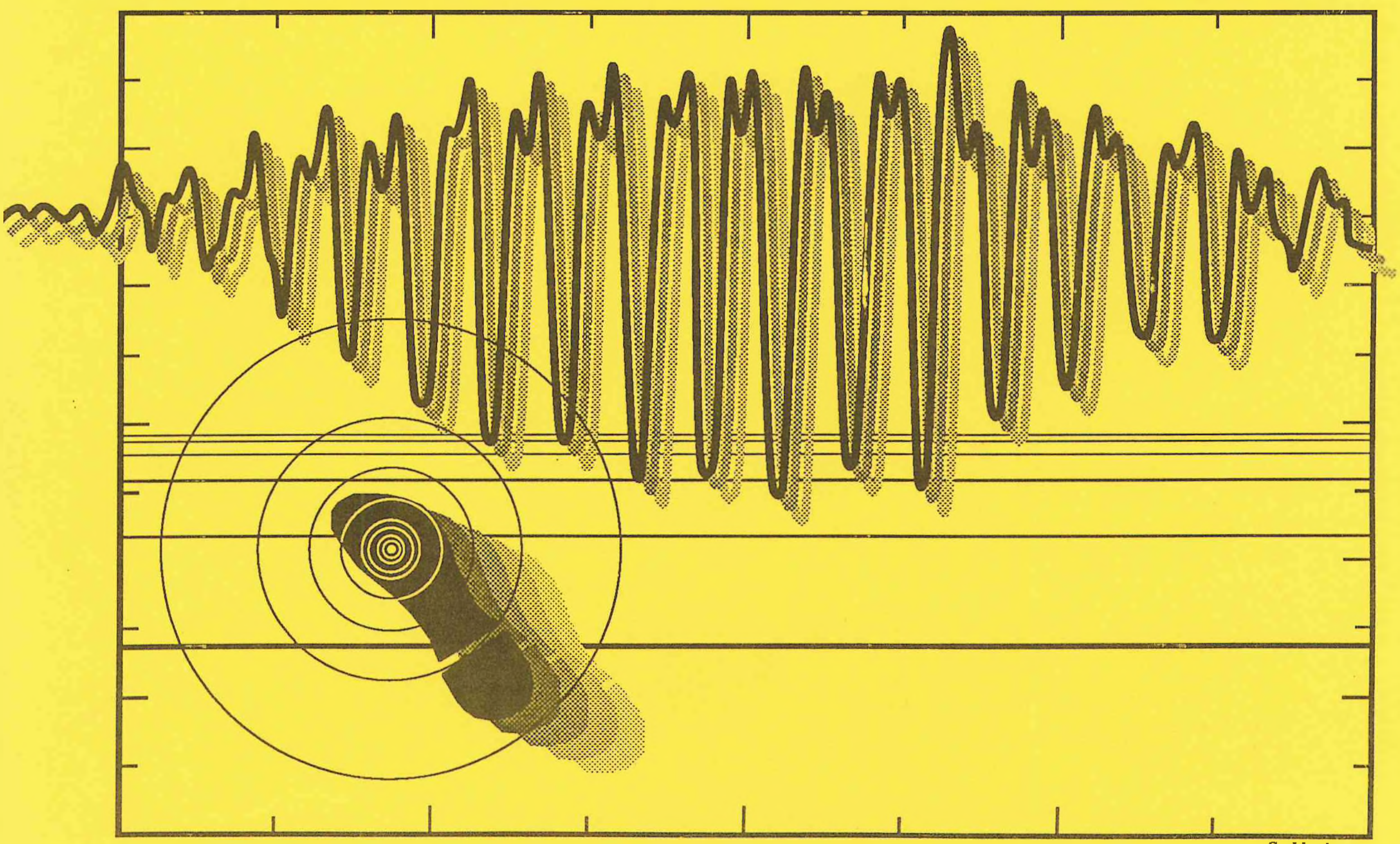

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ACOUSTIQUE CANADIENNE publie des articles arbitrés et des informations sur tous les domaines du son et des vibrations. Les manuscrits seront inédits ou bien des aperçus, ainsi que des notes techniques, rédigés en françcais ou en anglais. Deux copies seront soumis au rédacteur en chef (articles en anglais), ou au rédacteur (articles en français). La forme et la préparation des manuscrits exigées pour reproduction se trouveront dans le premier numéro de chaque volume.

EDITORIAL

In just three months the 12th ICA will be held in Toronto (24–31 July). ICA Congresses are held in a different country every three years. They are by far the most significant international acoustical conferences, and this time it will be here in Canada. What a unique opportunity to meet others and to hear first-hand the results of research studies from colleagues around the world. In addition, there are associated meetings of a more specialized nature in three other Canadian cities. These are: "Underwater Acoustics," Halifax (16–18 July); "Speech Recognition," Montreal (21–22 July); and "Acoustics and Theatre Planning for the Performing Arts," Vancouver (4–6 August). Plan to be involved: don't miss this rare chance to get a good dose of acoustics.

For more information on the ICA, there is an article in this issue by Fritz Ingerslev that explains how the ICA relates to other international acoustical activities. Finally there is a report by Edgar Shaw, the chairman of the 12th ICA, concerning plans for this summer's ICA.

canadian acoustics will do its part by presenting all attendees at the ICA meeting with a copy of our July issue. We are trying hard to make it one of our best issues yet. If you are a potential advertiser, don't miss our July issue with its much greater circulation.

Now that you have your paper submitted to the ICA, it is time to consider writing a complete version of it for publication in **canadian acoustics**. Many of the excellent papers presented at the CAA meeting in Ottawa last fall have still not been published. If it was worth doing the original work, it must be worth the extra effort to create a written record of your efforts so that others don't have to repeat your work. Why not start today?

We have had a good response to our survey of Canadian acoustical consultants, and will publish the results in our next issue. If you haven't responded you have only a few days left to ensure that you are included.

See you in Toronto!

EDITORIAL

Il reste à peine trois mois avant le 12e Congrès international d'acoustique qui se tiendra au 24 au 31 juillet à Toronto. Le secrétariat a reçu quelques 600 communications d'une trentaine de pays. Ces communications ont été regroupées en 15 sessions structurées, 64 sessions de contributions particulières ainsi que 7 conférences plénières. Les contributions seront publiées dans le compte rendu du Congrès alors que l'horaire des présentations, accompagné des résumés, se trouvera dans le programme. Au moment où j'écris cet éditorial la troisième et dernière circulaire est chez l'imprimeur et sera postée d'ici quelques jours. Cette circulaire contient l'information sur d'hébergement, les formulaires d'inscription, un programme provisoire ainsi que des renseignements généraux et touristiques. On trouvera aussi quelques détails sur les congrès associés à l'ICA. Ces derniers portent sur l'acoustique sous-marine (Halifax, due 16 au 18 juillet), la reconnaissance de la parole (Montréal, les 21 et 22 juillet) et l'acoustique des salles de spectacle et l'agencement théâtral (Vancouver, du 4 au 6 août).

Cette année, exceptionnellement, l'ICA prend la place du congrès annuel de l'association. Nous profiterons donc d'un forum international pour présenter les résultats de nos travaux.

Un rapport plus détaillé de la plume d'Edgar Shaw est publié dans ce numéro. En plus, nous reproduisons un article de Fritz Ingerslev, ex-secrétaire de la Commission internationale d'acoustique, qui situe l'ICA par rapport aux autres activités internationales en acoustique.

A l'occasion de l'ICA, nous comptons publier un numéro spécial. En effet, le prochain numéro sera composé d'articles sur invitations et des copies seront distribuées à tous les participants à l'ICA. Avis aux annonceurs!

Notre enquête sur les activités de génie conseil en acoustique au Canada a suscité un bon intérêt. Nous publierons les résultats de cette enquête dans le prochain numéro. Il reste encore quelques jours pour répondre si vous ne l'avez déjà fait.

A NON-CONTACTING OPTICAL DISPLACEMENT TRANSDUCER

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ABSTRACT

A non-contacting optical system is described which can measure not only absolute displacements like comparable, more traditional transducers but also relative displacements. It can be cheap and, even under normal lighting conditions, operated non-intrusively at some distance from a test object which need not be reflective. Several examples are presented to illustrate the system's versatility in applications involving frequencies below 100 Hz.

RÉSUMÉ

Une méthode optique pour mesurer les déplacements dans un système est discuter. Les mesures peuvent être fait a une distance du système et il n'y a aucun contact avec le système. Un environnement sombre n'est pas nécessaire et la méthode donne non seulement des résultats absolus mais aussi relatives. Plusieurs applications sont inclu qui démontre la flexibilité de la méthode pour mesurer les déplacements en bas de 100 Hz.

1. INTRODUCTION

A non-contacting transducer, unlike an accelerometer, does not have to be placed on a vibrating object to determine the dynamic characteristics. This feature is particularly useful for lightweight objects whose behaviour would be influenced by the additional weight of a contacting probe. However, conventional non-contacting transducers like lasers or capacitive probes are either quite expensive or have to be located very close to the vibrating object [1]. Furthermore, they are only able to measure absolute displacements. A non-contacting optical transducer will be described which largely overcomes these disadvantages. Four examples of its use will be presented to portray various applications.

2.PRINCIPLE OF OPERATION AND EXPERIMENTAL IMPLEMENTATION

The principle of measuring an absolute displacement with the optical transducer is illustrated in Figure 1(a). A light source is used to form a slit of light on the opening created between the object, vibrating about an equilibrium position, and a stationary reference post. The additional iris and collimator in Figure 1(a) are optional components which may be introduced to improve the unifomity of this slit of light. If uniform, light passing through the opening will fluctuate by an amount which is proportional to the movement of the vibrating object. Such fluctuations can be determined by using a biconvex lens to focus the transmitted light on a photocell and measuring the photocell's amplified electrical output on an oscilloscope. However, it is beneficial to place the photocell not quite at the biconvex lens' focal point so that the light image is formed over the photocell's entire surface. This precaution alleviates the consequences of slight misalignments between the the optical components. Furthermore, if a displacement is needed at more than one location of the vibrating object, as in a modal analysis, openings first formed at the different locations with the object at rest should be preferably identical. Then the initial light transmissions associated with each location will be the same so that the gain of the optical system will be constant. Finally, if the reference post itself was to move then the same procedures may still be used to determine the vibrating object's displacement relative to the post.

The first embodiment of the optical transducer was made from availible components and is shown in Figure 1(b). The light source was a small, high intensity bulb with an internal coil and the iris and collimator were absent. Reasonable accuracy was obtained providing peak-to-peak absolute or relative displacements were smaller than 1.0 mm. Larger displacements would need better and more costly components. The following components were purchased primarily from Ealing Scientific Limited† :

1. A very high intensity halogen light bulb, Type 28-8407.
2. An iris with a 2mm opening, Type 22-8601, to transmit only the most homogeneous centre section of the light source.
3. A collimator, Type 28-8506, with a focal length of 95 mm to transpose diverging light into parallel rays. (The inclusion of a collimator made sure that the sensitivity of the optical transducer did not change when the distances between the collimator to opening and opening to biconvex lens were varied. However, the distances between the source and iris, iris and collimator and biconvex lens and photocell must then be kept constant.)

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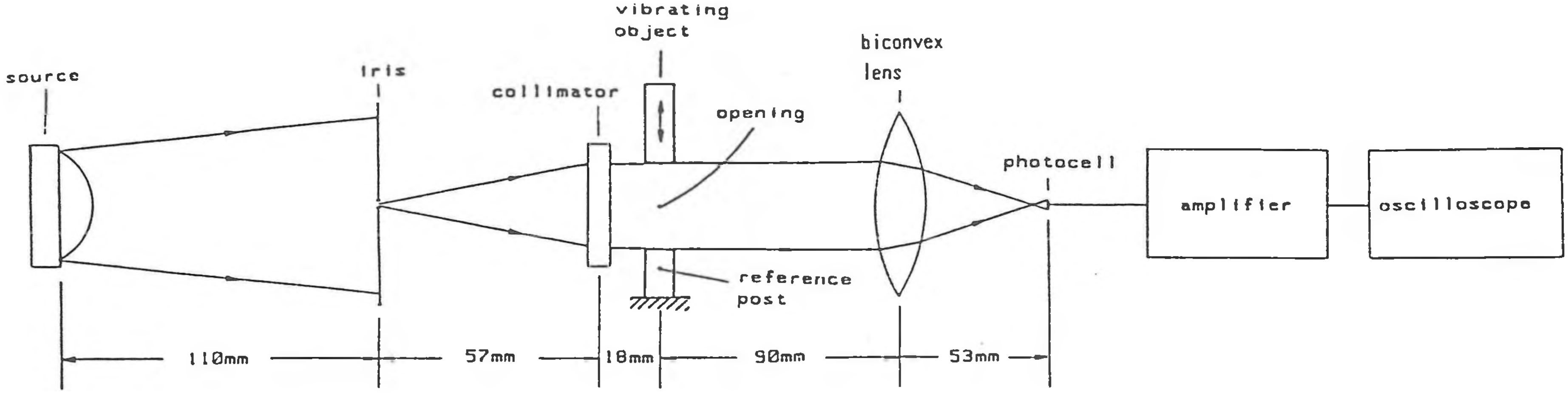
Ealing Scientific Limited
6010 Vanden Abeele, Saint-Laurent, Quebec, Canada H4S 1R9.



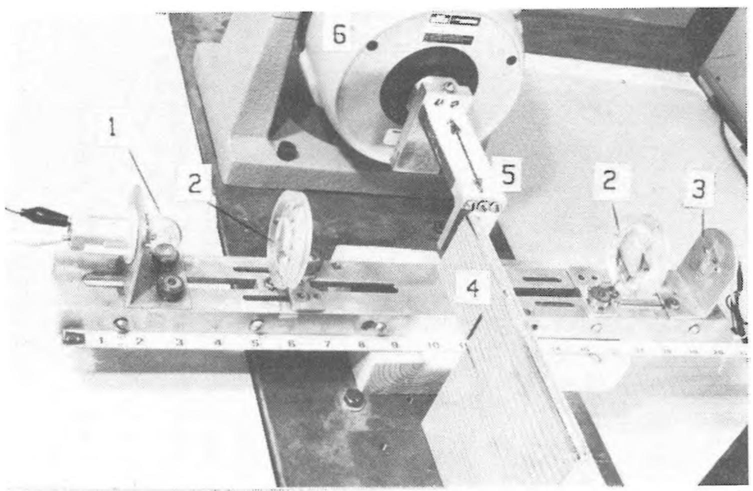


Figure 1. Showing (a) a general arrangement and (b) the components of the $50 system.

(1)Light source (2)biconvex lens (3) photocell (4)stationary reference post (5)vibrating bracket (6)electromagnetic shaker.

(b)

4. A good quality biconvex lens, Type 23-8972, with a focal length of 50 mm to better focus the light on the photocell,MRD Type 3055 [5].

These additions brought the total cost of the optical components from $50 to under $1500 and extended the working displacement range approximately five times.

The sensitivity and linearity of the upgraded optical system were found from comparisons with reference absolute displacements measured independently by using a Wayne Kerr MEI capacitive probe and meter. Easily detectible displacements with various amplitudes and frequencies were created by firmly securing a solid metal bracket to an electromagnetic shaker controlled by a power amplifier and a sinewave generator. An opening was formed between the bracket and an adjacent stationary post in a similar fashion to that shown in Figure 1(b).Signals from both tranducer systems were displayed simultaneously on a Tektronix 7313 storage oscilloscope to facilitate calculation of the upgraded system's sensitivity. Percentage deviations+ from 24 mV/mm, the average sensitivity in the frequency range 1 to 100 Hz, are presented in Figure 2. The greatest deviations of 11 % from the linear abscissa of this figure happen, regardless of the peak absolute displacement, at frequencies above 40 Hz. They were caused by resonances of the structure supporting the optical components. Experiments also indicated that linearity was reasonably preserved when the bracket's displacement was changing the size of the opening (between the bracket and post) by 4% to 30%.

3.TYPICAL APPLICATIONS

3.1 Bilinear Hysteretic Oscillator

The upgraded optical system was used, as illustrated in Figure 3, to measure the absolute displacement history of an experimental bilinear hysteretic oscillator. In addition, the displacement was processed electronically in a feedback loop to give the required bilinear hysteretic features. Details may be found in references 2 and 3.

3.2 Modal Analysis

The fundamental mode shape of an inverted brass T-plate, standing on two rubber strips, was determined by using the optical system. The plate was excited sinusoidally at its fundamental natural frequency by connecting it through a light spring to an electromagnatic shaker. To avoid interference with

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+

$$\left(\frac{\text{Sensitivity at any one frequency} - \text{Average sensitivity}}{\text{Average sensitivity}}\right) \times 100\%$$

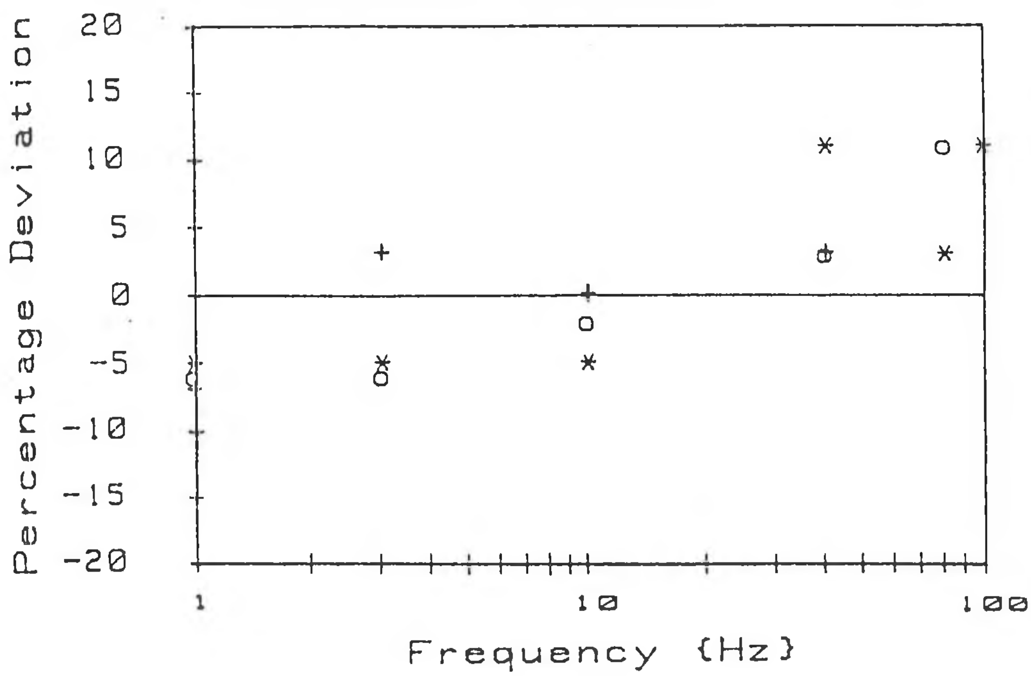
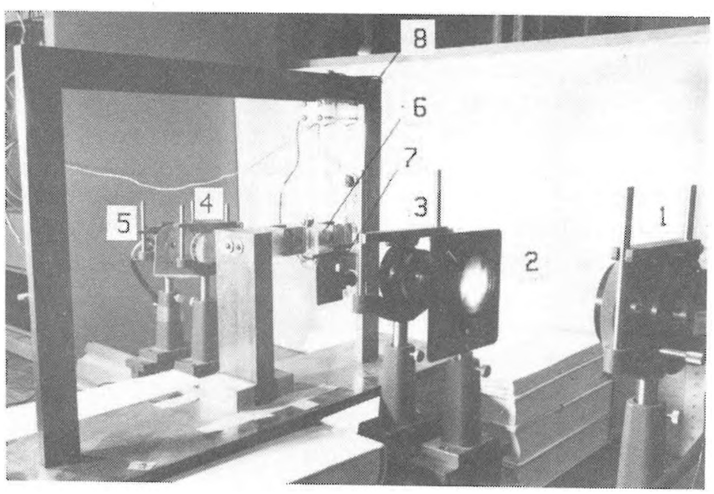


Figure 2. Frequency sensitivity of the upgraded optical system for peak absolute displacements of 1.50 mm (+), 1.00 mm (o) and 0.25 mm (*).



(1)Light source (2) iris (3) collimator (4) biconvex lens (5) photocell (6) vibrating mass (7) opening (8) fixed reference frame.

Figure 3. Measuring the absolute displacement history of a bilinear hysteretic oscillator with the upgraded system.

the metal plate, the elements of the optical system could not be set in a single row as before. Instead, two rows were formed on each side and perpendicular to the plate's vertical component as shown in Figure 4(a). Light was transferred between the rows by employing two off-set but parallel mirrors each positioned at 45° to the plate's vertical component. Absolute deflections and phases at regularly spaced points of the plate were found with the help of a movable cardboard strip appended consecutively to each point. This arrangement may be seen in Figure 4(a) together with the stationary reference post. Reasonable agreement is shown in Figure 4(b) with the mode shape determined conventionally [4] by traversing a Bruel and Kjaer Type 4344 accelerometer across the much heavier plate.

3.3 Vibroimpact Damper

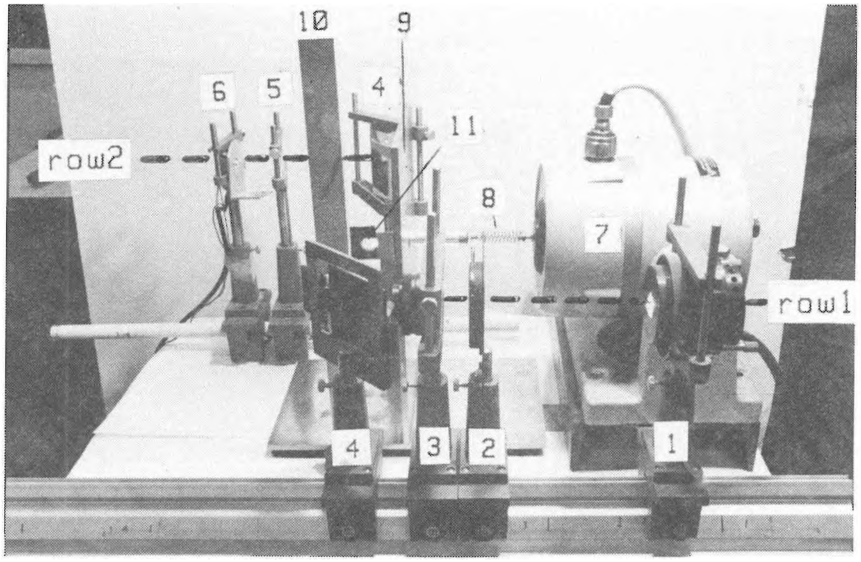
A vibroimpact damper is essentially a rigid mass (m) whose motion, upon collision, opposes and reduces that of a larger resonant mechanical system. It is important, therefore, to know the relative displacement when "tuning" the damper. This measurement was achieved straightforwardly by employing the optical system and stiff, lightweight cards fixed firmly to both the damper and an oscillator representation of a mechanical system to exaggerate their intermediate gap. Typical relative and absolute displacement measurements are presented in Figure 5 together with a schematic of a vibroimpact damper.

3.4 Multi-exposure Photography

The optical system was employed as a trigger for a 35 mm camera when photographing the progressive deformation of a pendulum impacting a rigid wall. The pendulum cut the optical system's light beam just before the collision. Then the sudden change in the electrical output of the system's photocell triggered a stroboscope. By leaving the camera's aperture open, the ensuing stroboscopic light flashes produced multi-exposed photographs around the instant of collision. Resulting photographs like that shown in Figure 6 gave a visual representation of the pendulum's deformation history.

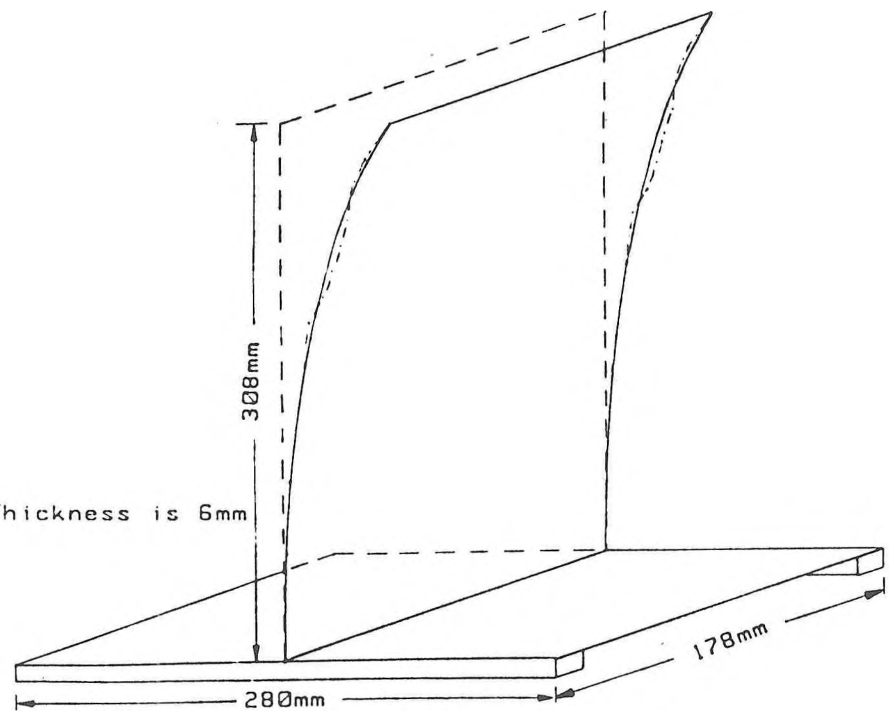
4. CONCLUSIONS

A non-contacting optical system has been developed to accurately measure both absolute and relative displacements below 100 Hz. The system's cost depends upon the peak displacement to be measured but remains very competitive when compared with alternatives. Several typical examples have been presented to illustrate the potentially wide range of the system's applications.



(a)

(1) Light source (2) iris (3) collimator (4) mirror (5) biconvex lens (6) photocell (7) electromagnetic shaker (8) light spring (9) inverted T-plate (10) fixed reference post (11) cardboard strip (secured to the edge of the plate).



(b)

Figure 4. Modal analysis of an inverted T-plate. Illustrating (a) the two row optical set-up and (b) the comparison of the resulting fundamental mode shape (-·-·) with that determined conventionally (———). The dashed lines give the plate's undeformed configuration.

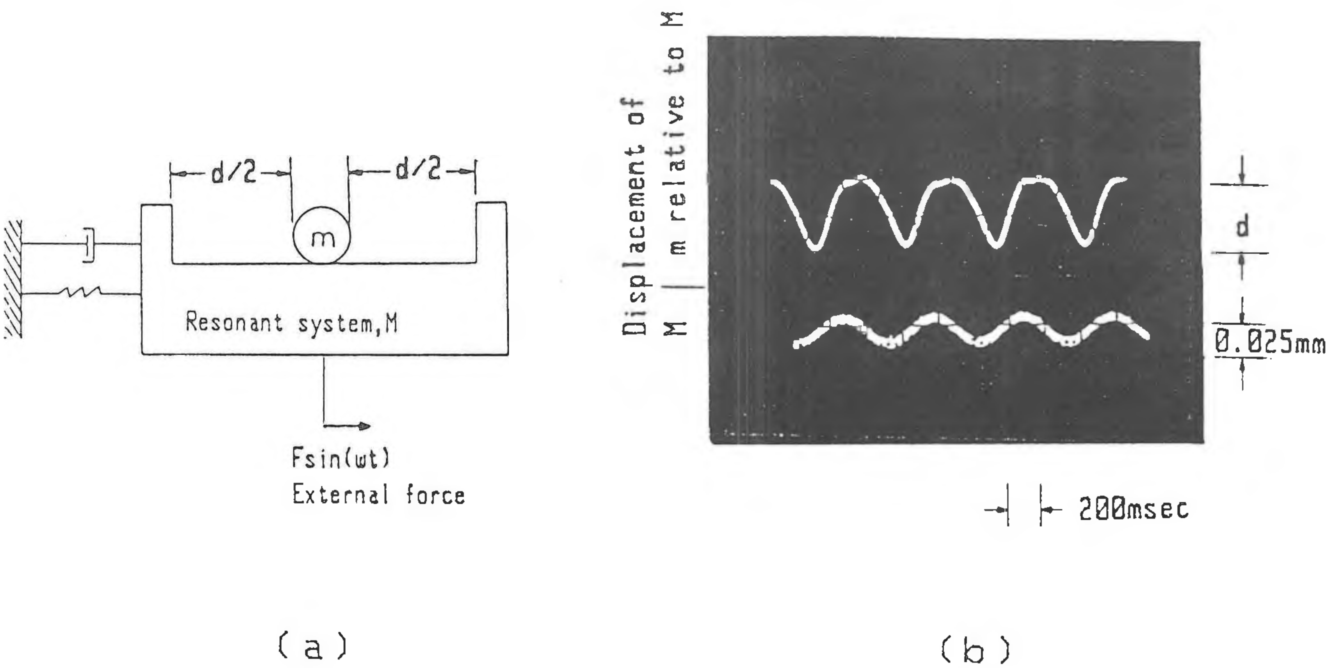


Figure 5. Showing (a) a schematic and (b) the displacement histories of the masses in a vibroimpact system.

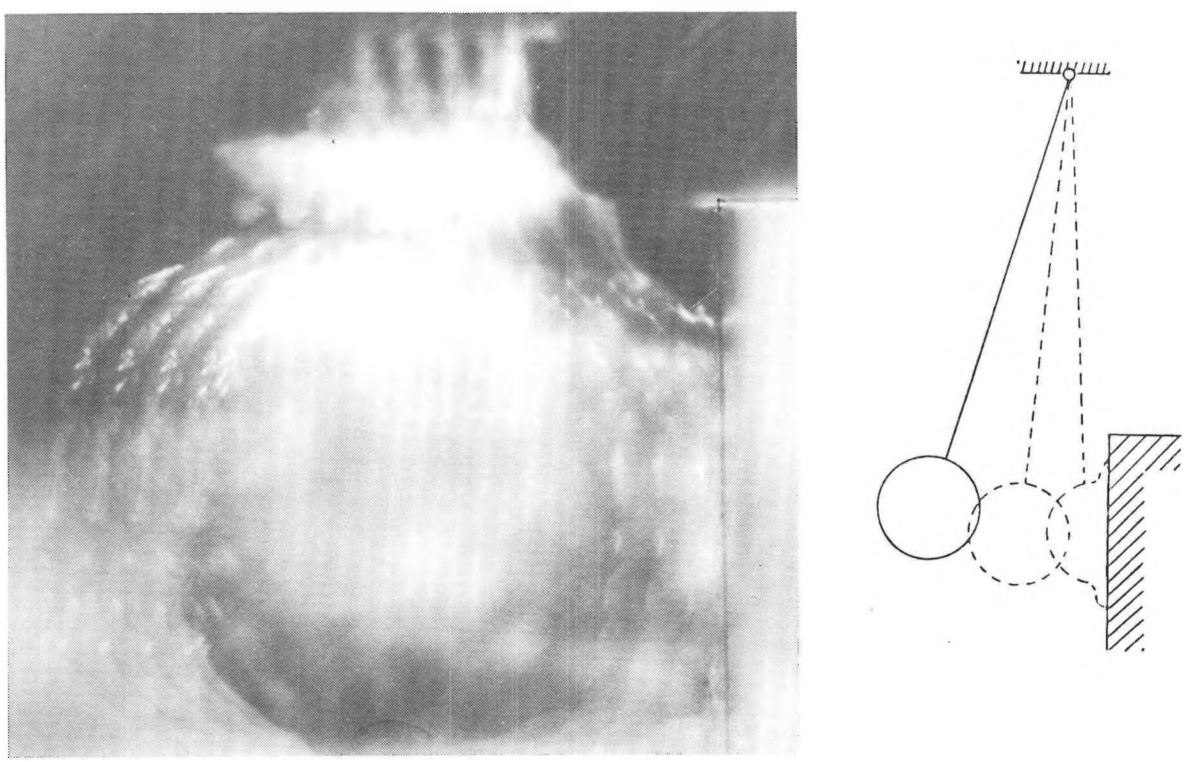


Figure 6. A multi-exposed photograph showing the deformation history of a resilient pendulum. The interval between exposures was 2.4 msec.

5. REFERENCES

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ACKNOWLEDGEMENTS

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VERTICAL DYNAMIC FORCES FROM FOOTSTEPS

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ABSTRACT

Vertical dynamic forces from walking and running were measured by load cells placed between temporary supports and the centre of a 17-m-long floor strip. The measurements showed that the dynamic forces are composed of wave trains of harmonics of the walking or running rate. The significant low frequency contributions are generally contained within the first three to four harmonics.

To represent the contribution of each harmonic to the total dynamic forces, a 'dynamic load factor, α' was defined as the ratio of dynamic force amplitude of the harmonic to the weight of the person. Footstep forces were produced by three male subjects; for walking, the maximum dynamic load factors measured and corresponding frequencies are: α_1 = 0.56 at 2.4 Hz for the first harmonic, α_2 = 0.28 at 5.4 Hz for the second, α_3 = 0.12 at around 7.8 Hz for the third, and α_4 = 0.08 for the fourth harmonic. For running, maximum values of α_1 were 1.45 at 3.0 to 3.5 Hz for the first harmonic, α_2 = 0.4 for the second, α_3 = 0.2 for the third, and α_4 = 0.1 or less for the fourth harmonic.

RÉSUMÉ

Les forces dynamiques verticales du pas de marche et du pas de course ont été mesurées au moyen de cellules extensométriques placées entre des supports temporaires et le centre d'une piste de 17 m. Les mesures ont révélé que les forces dynamiques se composent de trains d'harmoniques de la fréquence du pas. Les contributions importantes à basse fréquence sont généralement associées aux trois ou quatre premières harmoniques.

Pour représenter la contribution de chacune des harmoniques aux forces dynamiques totales, on a défini un "facteur de charge dynamique, α" comme étant le rapport de l'amplitude de la force dynamique de l'harmonique et du poids de la personne. Les forces de pas ont été produites par trois hommes. Au pas de marche, les facteurs de charge dynamique maximaux mesurés et les fréquences correspondantes étaient : α_1 = 0,56 à 2,4 Hz pour la première harmonique, α_2 = 0,28 à 5,4 Hz pour la deuxième, α_3 = 0,12 à 7,8 Hz environ pour la troisième, et α_4 = 0,08 pour la quatrième. Au pas de course, les facteurs maximaux étaient : α_1 = 1,45 entre 3,0 Hz et 3,5 Hz pour la première harmonique, α_2 = 0,4 pour la deuxième, α_3 = 0,2 pour la troisième, et α_4 = 0,1 ou moins pour la quatrième.

INTRODUCTION

Walking and running are two of the most common forms of dynamic excitation produced by occupants in buildings, yet relatively little quantitative data is available about them. To provide some data on this topic, a study of the forces produced by walkers and runners was undertaken at the Division of Building Research of the National Research Council of Canada.

A number of previous studies of forces induced by human activity can be found in Refs. 1 to 4. These studies simulated the forces due to a continuous series of steps by combining duplicates of the force produced by a single step separated by time delays corresponding to the walking rate (3,4). The present investigation measures the dynamic forces produced by a continuous series of steps; possible inaccuracies arising from the creation of sequences consisting of single step pulses are thus avoided.

A knowledge of the forces produced by footsteps is of practical significance: a) in understanding the nature of undesirable floor vibrations produced by occupants; and b) in affording the possibility of predicting during the design stage the probable behaviour of a floor subjected to walking or running. This is of ever-increasing importance since lighter structural systems and longer spans tend to make floors more prone to occupancy-induced vibrations.

TEST PROCEDURE AND ANALYSIS

The forces from walking and running were measured at mid-span of a simply supported floor strip consisting of two open-web joists 914 mm deep, spaced at 1.76 m and spanning 17.04 m. The joists are covered by pre-cast concrete panels of 100 mm thickness, each measuring 2.13 m across and 1.19 m along the floor span. A plan view and elevation are shown in Figure 1.

At centre span under each joist a piezoelectric force transducer was inserted between a temporary support and the bottom chord, and pre-loaded to approximately

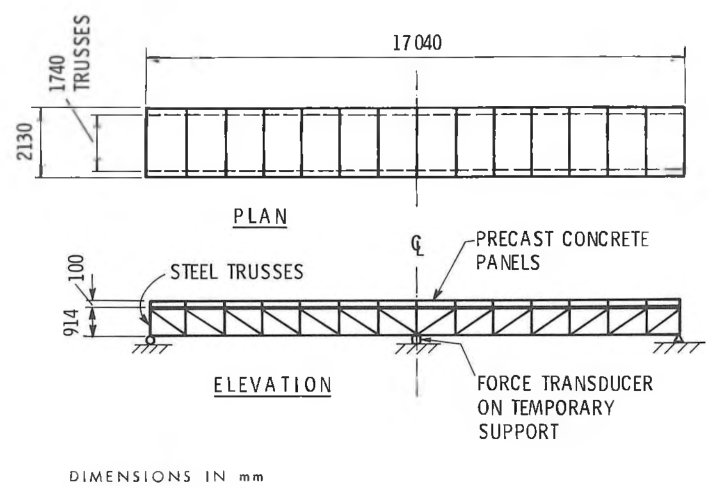

Figure 1. Test floor strip.

4000 N. The signals from the two transducers were added, amplified and recorded. Analysis commenced with high-pass filtering the signals at 0.2 Hz to eliminate the low frequency drift as the subject moved across the floor strip. The signals were then digitized and analyzed on a Fourier analyzer and by Fast Fourier Transform (FFT) routines on a minicomputer. Digital filtering was carried out by 'windowing' in the frequency domain. The peak amplitudes near the middle of the signal train were used as a measure of signal magnitudes (see Figs. 2 and 3).

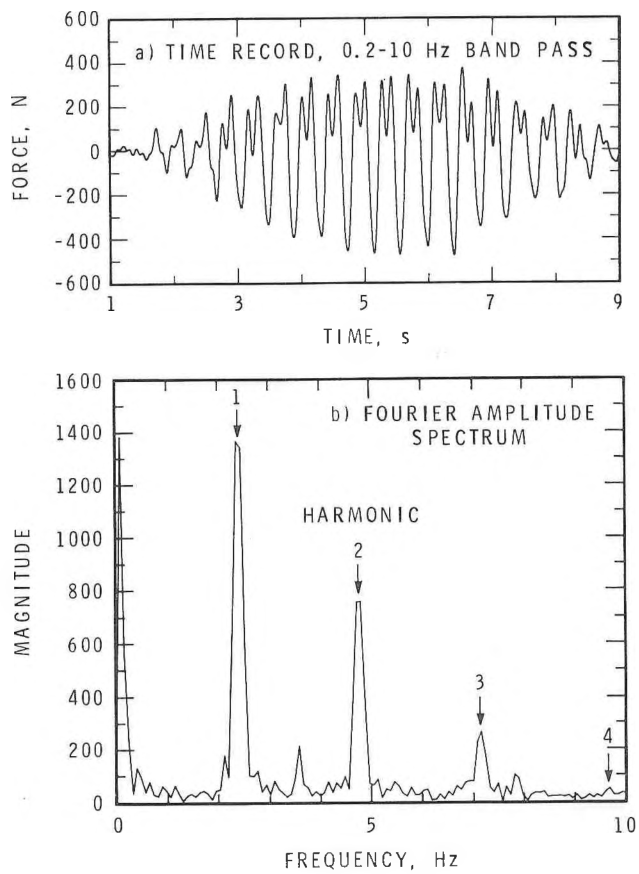

Figure 2. Walking forces at 2.4 steps/second, subject A.

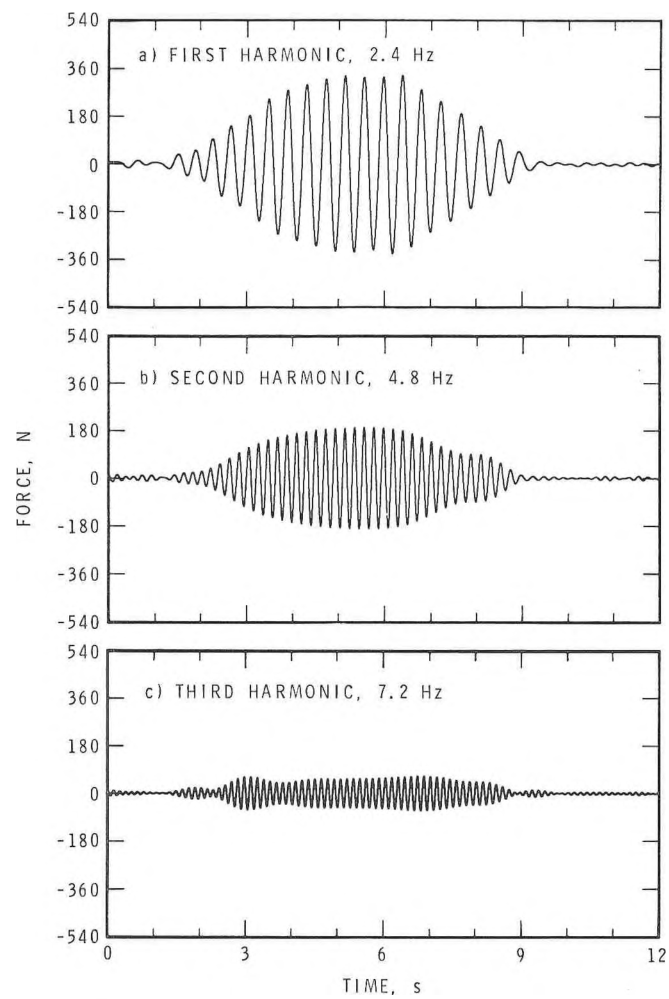

Figure 3. Harmonic components of force from walking at 2.4 steps/second, subject A.

The tests were conducted by playing pre-recorded pulses at the desired walking or running rate through loudspeakers, and requesting the subject to walk or run along the floor strip at the specified rate using a stride of his own choosing. For walk tests in which stride was varied, the subject walked first at his natural stride, and then at a shorter and a longer one.

To compensate for the dynamic amplification effects near the lowest resonance frequency of the supported floor strip, correction factors were determined from 2 to 10 Hz by comparing the load cell output with the known shaker force that was applied at centre span.

Since the lowest resonance frequency of the instrumented floor strip was 12 Hz, the useful results were thus limited to frequencies below about 10 Hz. Above that frequency, the dynamic amplification becomes large and rather sensitive to damping. A frequency range from 0.2 to 10 Hz was considered adequate for present purposes since the majority of problems associated with footsteps have occurred in floors with fundamental frequencies below about 8 Hz (5).

CHARACTERISTICS OF FOOTSTEP FORCES

The distinction between walking and running is that during walking the person always has one foot in contact with the floor or ground, whereas during running, contact is lost. The walking or running frequency in Hz is defined as the rate at which the feet make contact with the floor. Walking and running were performed by three male subjects, whose physical characteristics are given in Table 1.

TABLE 1

Physical Characteristics of Male Test Subjects

Subject	Weight (N)	Height (m)	Age (y)
A	734	1.82	48
B	800	1.78	41
C	690	1.88	23

Walking

A typical time record of walking forces, low-pass filtered at 10 Hz, is shown in Figure 2a. The record contains only the dynamic portion of the induced forces, as the static components have been eliminated by the 0.2 Hz high pass filter. These forces are bounded by a parabolically shaped envelope which is the static influence line for the mid-span support of the floor strip (6). The Fourier amplitude spectrum of this force record is shown in Figure 2b. The spectrum shows that the forces produced by walking consist of distinct frequency components at integer multiples of the walking rate, with spectral amplitudes that decrease with increasing frequency. The first three or four harmonics comprise the main dynamic components of walking forces in the frequency range of interest. As the time record in Figure 2a shows, the forces are periodic, with a repetition rate equal to the walking rate.

Running

The time signatures of forces from running are similar to those for walking, except that the pulses associated with each step are zero during the time the runner is airborne. Nevertheless, the Fourier spectrum of the force record again contains discrete frequency components at integer multiples of the running rate, as shown in Figure 4.

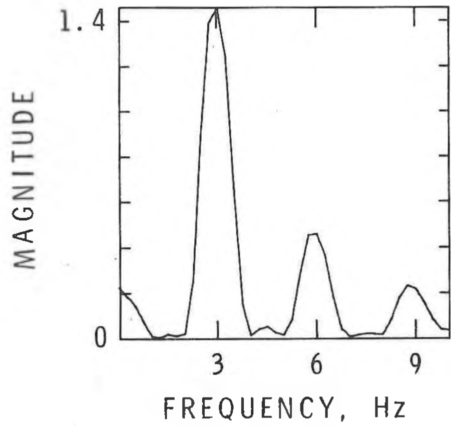

Figure 4. Fourier amplitude spectrum for running at 3.0 steps/second.

MATHEMATICAL REPRESENTATION OF FOOTSTEP FORCES

Walking

The analysis of force records indicates that the walking forces (F(t)) can be represented by the following expression:

$$F(t) = P(1 + \sum_{n=1}^{N} \alpha_n \sin (n2\pi ft + \phi_n)) \quad . \tag{1}$$

Here, P = static weight of subject;
α = Fourier amplitude or Fourier coefficient;
n = order of harmonic of the walking rate (n = 1, 2, 3...);
f = rate of walking in Hz;
t = time variable;
ϕ = relative phase angle;
N = total number of harmonics.

The dynamic component of the walking force in Eq. (1) is represented by the summation term, which is a Fourier series with Fourier coefficients (α_n) at the discrete frequencies (nf). From the analysis of time records, the relative phase angle (ϕ_n) was determined to be about 0°, 90°, and 0° for n = 1, 2, and 3, respectively, for walking rates between 2.0 and 2.4 Hz. The time signatures of the three lowest and most significant harmonics that comprise the walking forces in Figure 2 are presented in Figures 3a, b and c. These were obtained from the time record shown in Figure 2a by digital bandpass filtering in the frequency domain using Fourier transform techniques (7). The centre amplitudes of the harmonics, normalized by the weight (P), then represent the Fourier coefficients (α_n).

Running

Periodic dynamic forces produced by running can also be represented by Eq. (1). However, the relative phase angles of the harmonics are not as clearly defined as those for walking.

VARIATION OF DYNAMIC FORCES WITH STEP FREQUENCY

Walking

The key parameters in Eq. (1) that describe the dynamic force from walking are the Fourier coefficients (α_n) and the walking rate or step frequency (f). In a manner similar to that used in the description of rhythmic forces (8), the Fourier coefficients (α_n) are called 'dynamic load factors,' defined as the ratio of the dynamic force amplitude of each harmonic to the weight of the subject. In this paper, the variation of α with step frequency was studied for walking rates from 1.0 to 3.0 Hz using three different male subjects (A, B and C, Table 1). The results are shown in Figures 5a, b, and c.

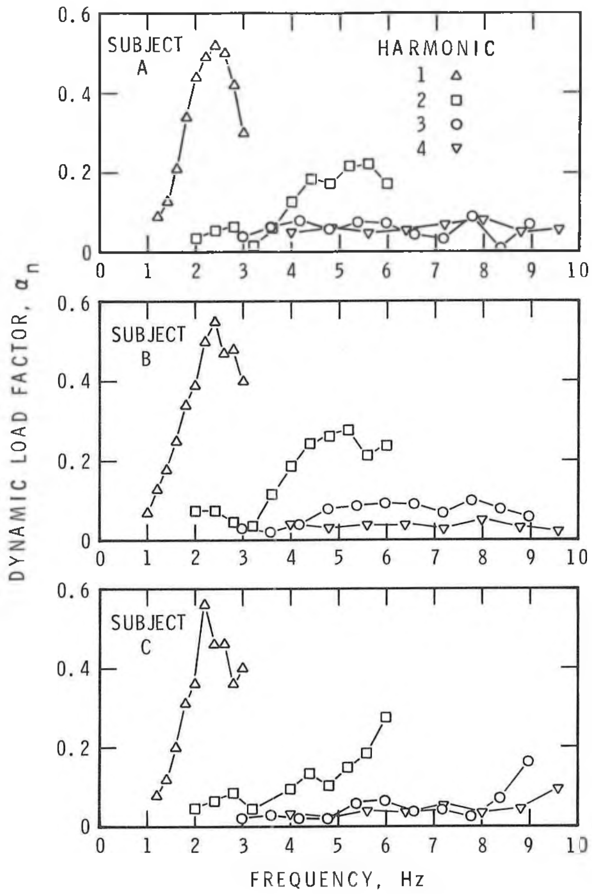

Figure 5. Dynamic load factor for walking.

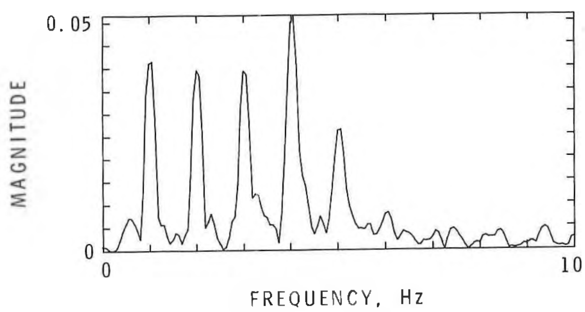

Figure 6. Fourier amplitude spectrum for walking at 1.0 steps/second, subject B.

At very low walking rates (near 1.0 Hz) the first four harmonics have comparable dynamic load factors. Additional higher harmonics are also evident, as shown in Figure 6 by the Fourier amplitude spectrum of a walking record at 1.0 Hz. At higher footstep frequencies the dynamic load factor of the first harmonic (α_1) is the largest and reaches a maximum near 2.4 Hz for all three subjects. For subjects A and B the following can be observed from Figures 5a and b. The maximum dynamic load factors for the second harmonic (α_2) are somewhat less than half the maxima of α_1. This peak occurs at about 5.4 Hz, slightly more than twice the frequency of the maximum for α_1. The dynamic load factors of the third harmonic (α_3) are also somewhat less than half of α_2, with the peak occurring near 7.8 Hz. This is slightly more than three times the frequency of the maximum dynamic load factor for the first harmonic. This shift in frequencies of the maximum dynamic load factors for the second and third harmonics from integer multiples of the frequency at which the maximum (α_1) occurs can be attributed to the fact that higher walking rates produce larger forces during the heel landing and toe push-off phases of impact. The result is a relatively larger proportion of the higher harmonics than at lower walking rates.

The results for subject C (Fig. 5c) differ somewhat from those of subjects A and B (Figs. 5a and b) in that the second and third harmonics do not exhibit the same shape as those for the other two subjects. Subject C shows a relative lack of second and third harmonic components in his walking forces at walking rates between 2 and 2.6 Hz, and the dynamic load factors reach a maximum at frequencies of 6 Hz for the second harmonic and 9 Hz for the third, corresponding to a 3 Hz walking rate. On the other hand, there is good agreement in the variation of α_1 among the three subjects, both in the general shape and the frequency at which the maxima occur. Maximum values of the dynamic load factors among the three test subjects were: $\alpha_1 = 0.56$, $\alpha_2 = 0.28$, $\alpha_3 = 0.12$, and $\alpha_4 = 0.08$. This excludes the extreme values near 9 Hz for subject C.

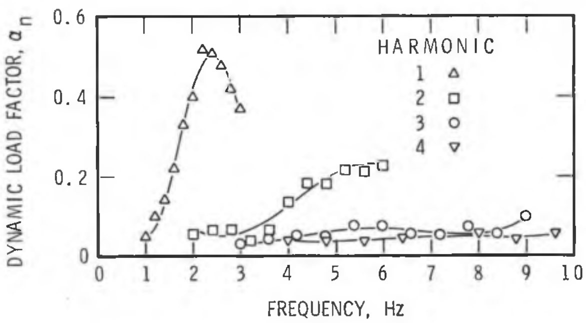

Figure 7. Averaged dynamic load factors for walking, subjects A, B and C.

The data for the three subjects at each frequency were averaged and are plotted in Figure 7; a fourth-degree polynomial curve was fitted to the resulting points. The maximum values for this polynomial fit are: $\alpha_1 = 0.52$ at 2.4 Hz, $\alpha_2 = 0.24$ at 5.6 Hz, $\alpha_3 = 0.06$ at around 6 Hz, and $\alpha_4 = 0.05$ at around 8 Hz. α_3 and α_4 could well be considered constant from about 4 to 9 Hz at the above values. This again ignores the 9 Hz data point, which is strongly influenced by the contribution from subject C.

Variation of α with length of step The variation of α with step length was investigated at the 2 and 2.4 Hz walking rates using subject A. The results are shown in Figure 8. The 0.9 m step length was the natural stride of the walker. For the three step lengths investigated here, the dynamic load factors increase with step length for both the 2 and the 2.4 Hz walking rates.

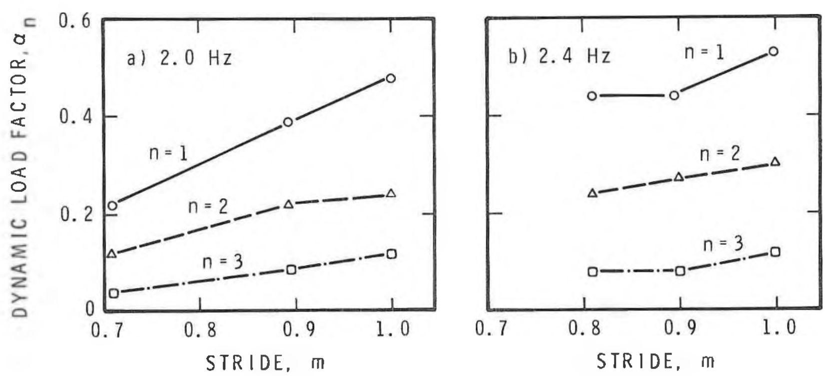

Figure 8. Variation of dynamic load factor with step length and walking rate.

Running

The dynamic load factors (α) for running are plotted against running rate for the three male subjects in Figures 9a, b and c. The results show the first harmonic to be the most significant, increasing monotonically from approximately 0.5 at 1.5 Hz to a maximum of 1.5 at a frequency of 3.6 Hz. Thereafter a gradual decrease in α_1 is indicated. The second harmonic initially decreases from a high of about 0.4 around 3.0 Hz, to a low of 0.1 around 4.0 Hz, and then gradually increases to between 0.35 and 0.47 around 7.0 Hz. The third harmonic remains relatively constant at less than

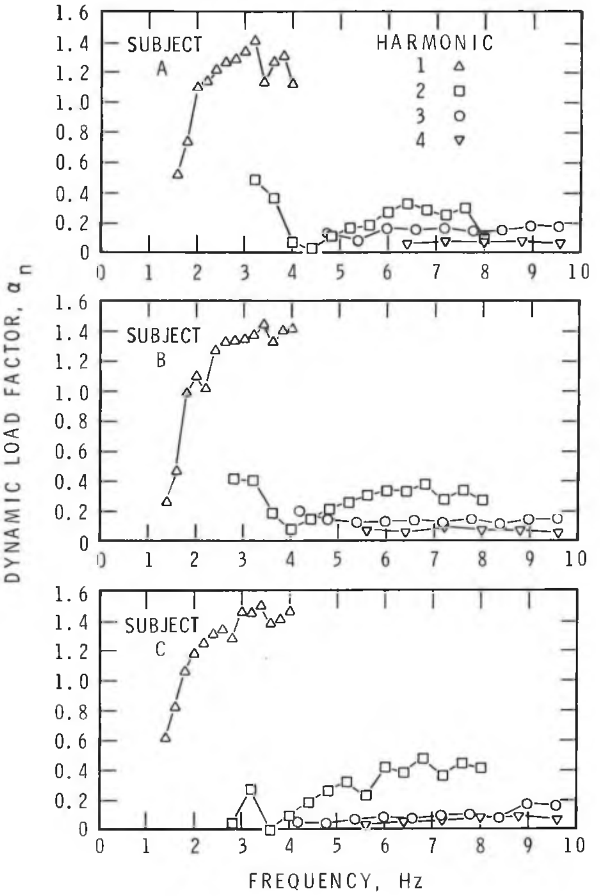

Figure 9. Dynamic load factor for running.

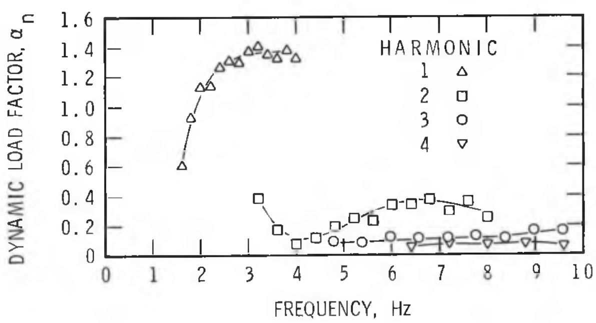

Figure 10. Averaged dynamic load factors for running, subjects A, B and C.

0.2 between 4 and 8 Hz. For the fourth harmonic, the dynamic load factor α is less than 0.09 for all frequencies investigated.

The plot of the averages of the dynamic load factors among the three test subjects is shown in Figure 10. A fourth-degree polynomial fit gives a maximum value of $\alpha_1 = 1.40$ at 3.6 Hz, $\alpha_2 = 0.40$ at 3 Hz and 0.35 at 6.5 Hz; α_3 and α_4 are relatively constant at 0.12 and 0.08, respectively.

A summary of the dynamic load factors for walking and running is presented in Table 2.

DISCUSSION AND SUMMARY

The technique used to measure step forces restricts the useful data to below 12 Hz, the lowest resonance frequency of the test structure. While there are high frequency components present in footsteps, it is the low frequency ones that cause most vibration problems due to walking or running in buildings.

The Fourier series representation of the dynamic components of footstep forces simplifies analytical calculations of dynamic responses of floors and other building components. This permits the treatment of a dynamic process that has so far eluded simple analysis. Not only is the numerical evaluation of the response possible, but a realistic intuitive assessment of the causes of vibration problems from footsteps becomes feasible. It is apparent from the characterization of the spectrum of the forces that a resonant condition can occur when the walking or running rate, or an integer multiple of it, coincides with a natural frequency of the floor. This coincidence can cause a large dynamic response in floors having low damping.

A comparison of dynamic load factors for walking and running shows the following.

1. The maximum dynamic load factor of the first harmonic for running is approximately three times as large as the corresponding α_1 for walking. These maxima occur around 2.4 Hz for walking and between 3.0 and 3.5 Hz for running.

TABLE 2

Maximum Dynamic Load Factors (α) for Walking and Running

		Maximum from subject A, B or C*		Maximum from polynomial fit to averages from subjects A, B, C*	
Activity	Harmonic (n)	Frequency (Hz)	α	Frequency (Hz)	α
Walking	1	2.4	0.56	2.4	0.52
	2	5.2	0.28	5.6	0.24
	3	4.2 - 7.8	0.12	5.8	0.06
	4	8.0	0.08	7.6	0.05
Running	1	3.6	1.50	3.6	1.40
	2	6.8	0.47	3.2	0.40
				6.6	0.35
	3	4.2	0.20	6 - 8	0.12
	4	7 - 9	0.09	7 - 9	0.08

*Except for values corresponding to 9.0 Hz and above.

2. The ratio of the dynamic load factors of the first to the second harmonic (α_1/α_2) is considerably larger for running than for walking. In absolute terms, however, α_2 for running is slightly higher than for walking but is shifted to a higher frequency. The low point in α_2 occurs around 3.0 Hz for walking and around 4.0 Hz for running.

3. The dynamic load factors for the third and fourth harmonics for running are only slightly larger than those for walking.

The above comparison of dynamic load factors shows that running represents a more severe dynamic loading than walking for all four harmonics. While this is not surprising in a qualitative sense, the data provide the quantitative information to substantiate this widely-held view.

Although the measurements have been taken over a wide frequency range, regular walking occurs generally at or near 2.0 Hz, and recreational running from about 2.4 to 3.2 Hz. Thus the measured maximum force values of the lowest harmonic occur near the most common walking or running rates.

ACKNOWLEDGEMENT

This paper is a contribution of the Division of Building Research (DBR), National Research Council Canada. The measurements were conducted on a test floor designed by D.E. Allen of DBR. The assistance of C. Pilette, H.H. Ireland, E.C. Luctkar, and R. Glazer in performing the tests and analyzing the results is gratefully acknowledged.

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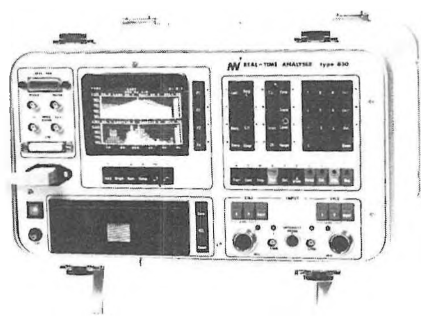

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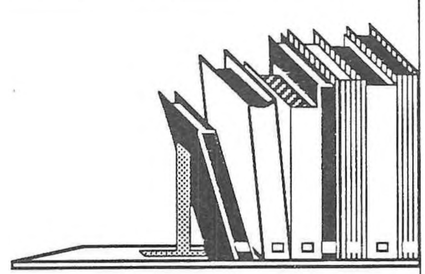

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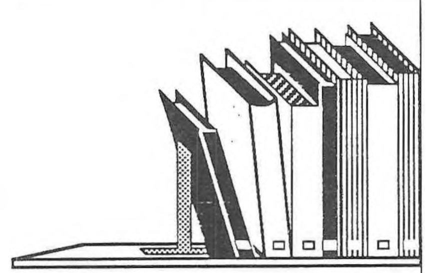

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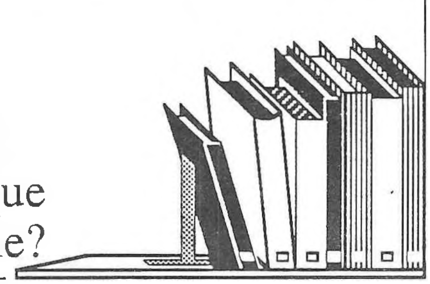

INTERNATIONAL CO-OPERATION IN ACOUSTICS*

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President, International INCE
The Acoustics Laboratory
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I. THE PURPOSE OF INTERNATIONAL CO-OPERATION

Acoustics was, up to the first decades of this century, a branch of physics. The subject acoustics embraced at that time primarily sound and sound waves. Perception of sound through the ear was treated to a minor degree. The increasing interest during the first half of this century in pure and applied acoustics resulted in the establishment of acoustics as an independent discipline. Acoustics rapidly developed to become an important interdisciplinary activity - perhaps to a greater extent than has been the case with any other engineering discipline. Acoustics is today a broad field which treats subjects as for example: Physical Acoustics, Physiological Acoustics, Psychological Acoustics, Speech, Musical Acoustics, Shocks, Vibrations, Electroacoustics, Architectural Acoustics, Room Acoustics, Noise Emission, Noise Immission, Town Planning, Effects of Noise, and Measurement of Noise.

International co-operation in the province of Acoustics comprises the following three important subjects.

Research

It is of great value for research scientists to be informed -- at international meetings - about the latest advances in research all over the world. It is important to get the opportunity to meet colleagues and discuss subjects of common interest. Exchange of information and experience may promote the research carried out by the individual research workers.

Noise Control Engineering

Engineers occupied with noise control are, of course, interested in information about noise control procedures developed in other countries. It is important to pool the knowledge and experience which exist in all countries. The task to carry out a proper noise control programme is so enormous that it is absolutely necessary to take advantage of methods and principles developed in other countries. The individual country cannot afford to solve all problems. International co-operation is, therefore, also of great value for engineers occupied with noise control.

Standardization

An efficient international co-operation in science and engineering implies a proper harmonizing of vocabulary. Co-operation in Acoustics implies, furthermore, a

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proper harmonizing of physical quantities and units. First, but not least, the necessity of the harmonization of methods of measurements used in acoustics should be realized. Harmonizing of vocabulary, physicaql quantities and units, and methods of measurements are objects of international standardization.

II. INTERNATIONAL ORGANIZATIONS ON ACOUSTICS

A number of International Organizations - as well as Regional Organizations - have been established since World War II. Five such International Organizations will be quoted as examples.

II.1 'The International Commission on Acoutics' (ICA)

ICA is a 'special commission' of 'The International Union of Pure and Applied Physics' (UPAP). The purpose of ICA is to advance the science of acoustics throughout the world. ICA was established in 1951. The most important activity of ICA is to sponsor ICA Congresses on Acoustics. ICA Congresses are held every third year. ICA Congresses act as international meeting places with a broad international attendance.

Eleven ICA Congresses have been held so far:

1953	Delft	1971	Budapest
1956	Boston	1974	London
1959	Stuttgart	1977	Madrid
1962	Copenhagen	1980	Sydney
1965	Liège	1983	Paris
1968	Tokyo		

The number of participants have been between 750 and 1600 depending on the location of the congress. The number of papers have been between 250 and 850. Participants came from 25-40 countries. The papers represent nearly every aspect of acoustics. Typical categories of contributions are papers on:

1. Speech communication
2. Physiological acoustics
3. Psychological acoustics
4. Noise
5. Shock and vibration
6. Architectural acoustics
7. Bioacoustics
8. Ultrasonics
9. Underwater sound
10. Physical acoustics
11. Aeroacoustics
12. Musical acoustics
13. Acoustical measurements

Scientists and research workers engaged in the field of Acoustics meet at ICA Congresses and present and discuss the latest results of their work.

A proper understanding of the theory of physics dealing with Acoustics and the effects of sound on human beings is an absolute condition for a satisfactory solution of practical problems in Acoustics, e.g. problems in Architectural Acoustics, Room Acoustics, Underwater Acoustics, Communication, Noise Control, and Shock and Vibration. The participants in ICA Congresses are, therefore, not only scientists and research workers, but also engineers who have a fairly good education in physics and mathematics.

The next ICA Congress will be the 12th International Congress on Acoustics. The congress will be held in Toronto, Canada, 24 July - 1 August 1986.

II.2 'International Commission on Biological Effects of Noise' (ICBEN)

Noise is a problem that millions of individuals feel in such forms as impaired hearing, annoyance, intrusion of privacy, and sleeplessness. The noise exposure in industry causes hearing damage and annoyance. The environmental noise produced by industry or traffic causes annoyance. The noise in our homes produced by neighbours, industrial activities or traffic causes annoyance and sleeplessness. The object of the International Commission on Biological Effects of Noise is to promote research related to the biological effects of noise.

An International Congress on 'Noise as a Public Health Problem' is held once every fifth year. The papers presented at these congresses provide a comprehensive coverage of the complex and extensive biological correlations that exist between man and noise. ICBEN was established in 1968.

The activities at these congresses are organized around eight International Noise Teams, each composed of approximately ten scientists who are renowned for their expertise in the area in which that team works. The eight teams are:

Team 1	Noise-Induced Hearing Loss
Team 2	Noise and Communication
Team 3	Non-Auditory Physiological Effects Induced by Noise
Team 4	Influence of Noise on Performance and Behaviour
Team 5	Noise-Disturbed Sleep
Team 6	Community Response to Noise
Team 7	Noise and Animals
Team 8	Effects of Interaction Between Noise and/or Other Physical and Chemical Agents

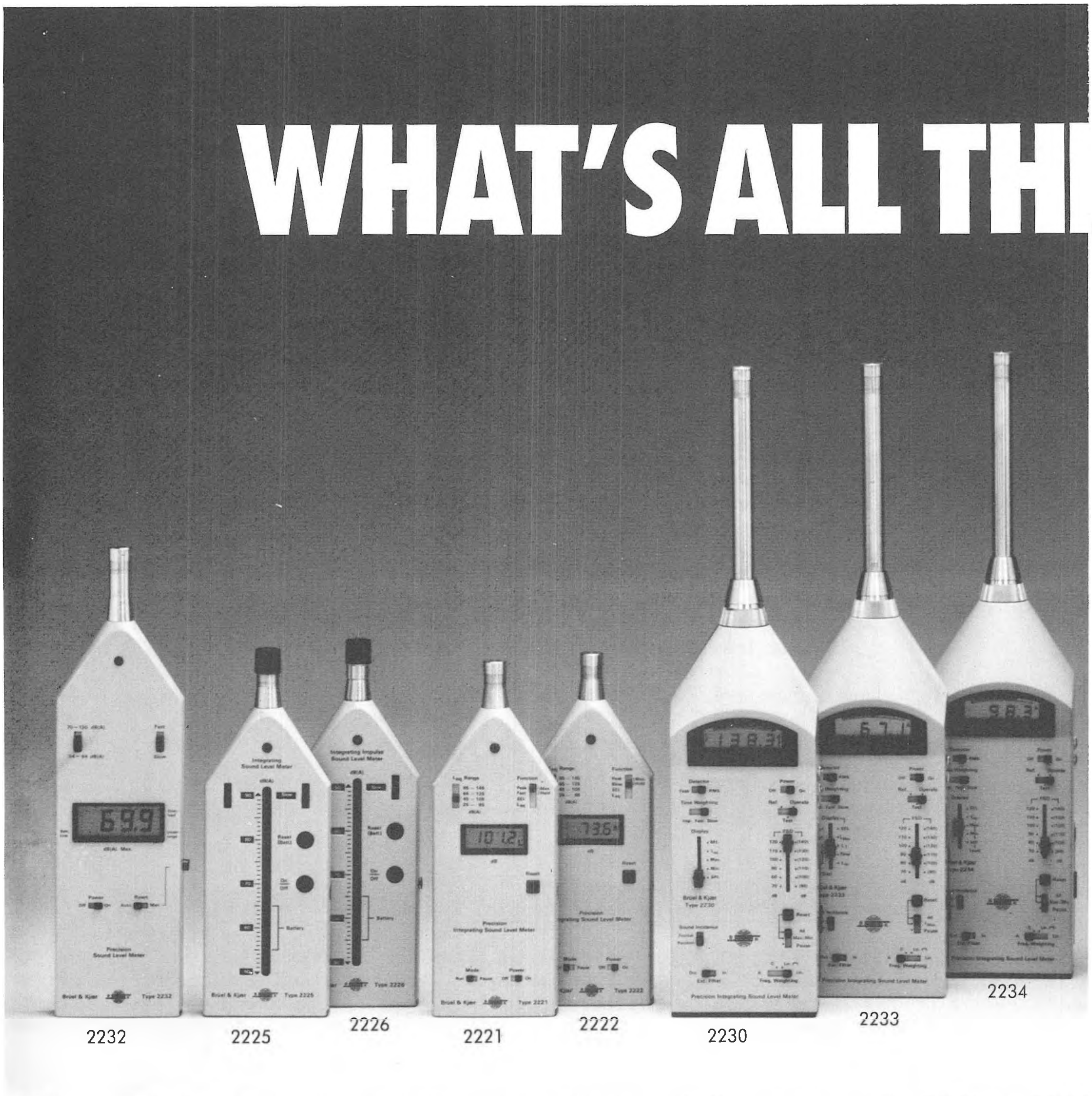
ICBEN Congresses are held every fifth year. Four Congresses have been held so far.

1968	Washington
1973	Dubrovnik
1978	Freiburg
1983	Turin

II.3 'International Institute of Noise Control Engineering' (I-INCE)

The enormous expansion during the last 25 years of the surface and air traffic, the industrial revolution with mechanization of industry and the introduction of more and more office machines and electric domestic appliances involve that the noise exposure has increased drastically after World War II. Noise is an insidious poison. The repeated exposure to noise day after day through many years may be a threat to our health. It is, therefore, of the greatest importance that we provide an environment free from noise that jeopardizes the public health and welfare.

The increasing public concern for the environment in the sixties resulted in widespread activities relating to noise. The results of these activities are that we have a good understanding of the noise problems. The knowledge collected through extensive research and development makes it possible to solve many noise problems satisfactorily. The task we have is primarily to disseminate our knowledge, though further research, of course, shall be carried out. It was realized that an organization which could undertake the international leadership in applying noise control technology should be established. The International Institute of Noise Control Engineering was established in 1974. I-INCE is a non-profit organization.



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Purpose

The purpose of I-INCE comprises:

a) the organization of international conferences
b) the international exchange of information and news items
c) the promotion of international co-operation in research on noise control and the application of engineering techniques for the control of noise
d) the development of interdisciplinary contacts between noise control engineering and other related fields of work.

Membership

I-INCE has three classes of membership:

- Member Societies (Acoustical Societies and Acoustical Commissions)
- Associate Members (non-profit education institutions and research organizations)
- Sustaining Members (organizations, corporations, or persons contributing a fixed annual fee).

INTERNATIONAL/INCE has twenty-three member societies in twenty-one countries spread over five continents and five sustaining members. INTERNATIONAL/INCE is certainly a true international organization. INTERNATIONAL/INCE is expecting applications for membership from a number of other societies.

INTER-NOISE Conferences

In fulfilling its purpose the Institute initiates and sponsors INTER-NOISE Conferences in countries of member societies. The conferences provide a medium for the exchange and dissemination of information on the engineering aspects of noise control. This information is of interest to the public, industry, and governmental bodies. The INTER-NOISE Conferences are the only international forum for such activities. INTER-NOISE Conferences have until now been held in the U.S.A. in even-numbered years and outside the U.S.A. in odd-numbered years. Twelve INTER-NOISE Conferences have been held so far:

1972	Washington, U.S.A.	1979	Warsaw, Poland
1973	Copenhagen, Denmark	1980	Miami, U.S.A.
1974	Washington, U.S.A.	1981	Amsterdam, The Netherlands
1975	Sendai, Japan	1982	San Francisco, U.S.A.
1976	Washington, U.S.A.	1983	Edinburgh, Scotland
1977	Zürich, Switzerland	1984	Honolulu, U.S.A.
1978	San Francisco, U.S.A.	1985	Munich, Fed. Rep. of Germany

The number of participants have been between 400 and 800. The number of papers have been between 100 and 350. Participants came from 20-35 countries. Typical categories of contributions are papers on:

- Noise Sources
- Noise Control Elements
- Vibrations (Generation, Transmission, Isolation, and Reduction)
- Environmental Noise
- Effects of Noise
- Noise Measurement and Analysis
- Standards
- Legislation

The next INTER-NOISE Conference, INTER-NOISE 86, will be held in Boston, U.S.A., 21-23 July 1986.

II.4 Technical Committee ISO/TC43: 'ACOUSTICS'

ISO/TC43 is a Technical Committee established by 'The International Organization for Standardization'.

Purpose

The International Organization for Standardization - ISO - is a non-profit organization whose aim is 'to promote the development of standards in the world with a view to facilitating international exchange of goods and services and to developing mutual co-operation in the sphere of intellectual, scientific, technological, and economic activity'.

Members

A member body of ISO is the national body 'most representative of standardization in its country'. The number of member bodies is 74. ISO was established in 1946.

Technical Committee ISO/TC43: 'Acoustics'

ISO's activities within the field of acoustics are undertaken by the Technical Committee TC43, 'Acoustics', and its two Subcommittees, TC43/SC1 'Noise' and TC43/SC2 'Building Acoustics'. The scope of TC43 reads: 'Standardization in the field of acoustics, including methods of measuring acoustical phenomena, their generation, transmission and reception, and all aspects for their effects on man and his environment'.

The scope of TC43/SC1 reads: 'Standardization in the field of noise in all aspects, including methods of measurement of noise produced by diverse sources in diverse environments and the assessment of the effects of sound on man'.

The scope of TC43/SC2 reads: 'Standardization in the field of building acoustics, including architectural acoustics, acoustical properties of building materials and constructions, and sound propagation in buildings'.

The number of documents prepared by TC43 and the two subcommittees was, by the end of 1983:

International Standards (ISO)	49
Draft International Standards (DIS)	32
Draft Proposals (DP)	20

TC43 was established in 1953 and holds its meetings with intervals of some 18 months.

Technical Committee ISO/TC108: 'Mechanical Vibrations and Shock'

The scope of TC108 is:

Standardization in the field of mechanical vibration and shock, including:

- terminology
- excitation by sources, such as machines, and vibration and shock testing devices
- elimination, reduction and control, especially by balancing, isolation and damping
- evaluation of acceptable limits for man, and in machines, vehicles and structures
- methods and means of measurement and calibration
- methods of testing

Liaison with ISO/TC43-Acoustics and IEC/TC29-Electroacoustics, on a mutually agreed basis.

The number of documents prepared by TC108 and its four subcommittees was by the end of 1983:

International Standards (ISO)	22
Draft International Standards (DIS)	19
Draft Proposals (DP)	16

TC108 was established in 1963 and holds its meetings with intervals of some 24 months.

II.5 Technical Committee IEC/TC29: 'Electroacoustics'

IEC/TC29 is a committee established by 'The International Electrotechnical Commission' (IEC). The scope of TC29 is: 'to prepare international standards in the field of electroacoustics and vibrations within the frequency range of infra, audio and ultrasound'. IEC was established in 1906. A member body of IEC is the national body most representative of all electrical interests in the country concerned. The number of members are 42. IEC documents are designated Recommendations and not Standards as it is the case with the documents developed by ISO. IEC/TC29 and ISO/TC43 have a close co-operation and hold usually consecutive meetings. The activities of IEC/TC29 Subcommittee C are especially of great interest to ISO/TC43.

III. CONCLUSION

The number of countries participating in this co-operation is growing rapidly. Many countries are, however, not yet represented at all or are only represented by a very modest number of scientists or engineers. It is hoped that many more scientists and engineers will take advantage of the valuable international exchange of information which takes place in the province of Acoustics. It is, furthermore, hoped that representatives of countries not yet participating in the international co-operation in Acoustics will be present in the future.

12th INTERNATIONAL CONGRESS ON ACOUSTICS

Circular 3: Registration

By the time these words appear in print our final bulletin, Circular 3, should be in the mail inviting our colleagues around the world to register for the Congress in Toronto (July 24–31) and the Associated Symposia in Halifax (July 16–18), Montreal (July 21–22) and Vancouver (August 4–6). This circular contains concise but comprehensive information on each of these meetings including outlines of the programs, hotel arrangements and registration forms. There is also a listing of meetings coordinated with 12ICA and there is supplementary information to help participants plan their itineraries.

During the last week of January and the early days of February, an avalanche of manuscripts landed in Toronto ushering in a period of intense activity for the 12ICA Secretariat and the Technical Program Committee. On February 12, as planned, the Program Committee met with the Subject Coordinators in Ottawa and, by the end of the day, the framework for the 12ICA Technical Program was firmly in place. When the fine tuning had been completed, some 620 papers from 36 countries had been fitted into a tightly knit Program comprising seven plenary sessions with guest speakers who will address the full Congress, 15 structured sessions on well-defined themes, and 64 sessions of contributed papers covering all branches of acoustics. Approximately 35% of the papers are from Europe, 20% from Japan and China and 35% from North America. These papers will appear in some 1300 pages of Proceedings which will soon be sent to the printer in preparation for the opening of the Congress on July 24. On arrival in Toronto, participants will also receive a copy of the Congress Program (abstracts and timetable), a copy of the Exhibition Program and information about technical tours.

Interwoven with the Congress Technical Program there will be several special events and opportunities for 12ICA participants and their families to meet socially: The Opening Ceremony in Roy Thomson Hall on July 24, a Welcome Reception at City Hall later that day, a popular concert and acoustical demonstration in Roy Thomson Hall on July 25, an evening at the Ontario Science Centre with buffet supper on July 28, a banquet at the Royal York Hotel on July 29 preceded by a reception hosted by the CAA, a demonstration concert on July 30 featuring the eight instruments of the violin octet developed by the Catgut Acoustical Association, and a Farewell Reception on July 31, as well as a wide range of social tours, some of which are unique.

While 12ICA is devoted to the entire field of acoustics in all of its diversity, the Associated Symposia are focussed on specific areas of acoustics in which there is strong local activity: "Underwater Acoustics" in Halifax, "Speech Recognition" in Montreal and "Acoustics and Theatre Planning for the Performing Arts" in Vancouver. Most of the manuscripts for these meetings have now been received and it is clear that all three have strong international support.

12ICA has special significance for the Canadian Acoustical Association since it takes the place of the CAA annual symposium. For this year alone, we shall be able to present our work in Canada before a truly international audience. This unique opportunity will certainly be appreciated by the many graduate students who have entered papers for the 12ICA Student Prize and, indeed, by all of the Canadian authors who will present some ninety papers at 12ICA and many more at the three Symposia. Above all, 12ICA provides us with an exceptional opportunity to broaden our horizons as we meet with colleagues from other countries bringing fresh points of view to bear on problems of common interest.

Circular 3 is being sent to all members of the CAA. Be sure to read your copy as soon as it arrives and send in your registration forms without delay.

Edgar A.G. Shaw, Chairman
12ICA Executive Committee

SPECIAL ACOUSTICAL DEMONSTRATION AND CONCERT IN ROY THOMSON HALL

25 July 1986 at 6:45 pm and 8:00 pm

At 6:45 pm there will be a 12ICA pre-concert lecture by Ted Schultz demonstrating the variable acoustics of Roy Thomson Hall and including a special four minute work for symphony orchestra. At 8:00 pm the Toronto Symphony Orchestra with conductor Newton Wayland will present a concert of popular music: "The Best of Broadway."

The 12ICA Local Planning Committee has reserved a block of seats for the Congress at the normal ticket price of $16.50 which includes the acoustical demonstration. This will be a popular event. To be sure of a seat you should complete 12ICA Registration Form A (see Circular 3) and send it to the 12ICA Secretariat without delay. Seats for this event can also be obtained, after 1 June, from the Toronto Symphony Box Office at Roy Thomson Hall (593–4828) or the BASS outlet (872–2233) as long as supplies last. Be sure to mention 12ICA.

JOINT CONFERENCE ON OCCUPATIONAL NOISE

The Toronto Chapter of CAA and the Occupational Hygiene Association of Ontario (OHAO) will hold a joint conference on occupational noise next 1 May in the Skyline Airport Hotel, Toronto.

The guest speaker is Dr. Paul Michael from State College, Pennsylvania, who will talk on early identification of noise-susceptible individuals.

Other speakers and topics are as follows:

- Office Noise
- Criteria and Solutions. A. Behar, Ontario Hydro
- Noise Control, Materials. W. Sydenborgh, Blachford, Canada
- Noise Control, Techniques. J. Cane, Higgot-Cane
- The New CSA Standard on Noise Exposure Measurements. T. Kelsall, Hatch Associates
- Noise as a Designated Substance. S. Gewurtz, MOL
- Criteria for Selection of Noise Measuring Instructions. R. Newman, B&K Canada

A. Behar

TRANSPORTATION RESEARCH BOARD MEETING

The 1986 Summer meeting of the Transportation Research Board Committee on Transportation related Noise and Vibration, Toronto.

Date: July 23, 24 and 25, 1986
Place: Holiday Inn, Yorkdale
Contact: Soren Pedersen
Ministry of Transportation and Communications
Highway Design Office
1201 Wilson Avenue, West Building
Downsview, Ontario M3M 1J8
(416) 248–3541

HALIFAX CONFERENCES

The "15th Symposium on Acoustical Imaging" will be held from 14–16 July 1986 at the Chateau Halifax, Halifax, Nova Scotia.

This meeting will concern itself with:

a) underwater acoustic imaging
b) medical ultra-sound diagnostics
c) non-destructive evaluation of materials
d) acoustic microscopy
e) seismic exploration

For more information write to:

Dr. H.W. Jones
Dept. of Engineering Physics
Technical University of Nova Scotia
P.O. Box 1000
Halifax, Nova Scotia
B3J 2X4

The "Symposium on Underwater Acoustics" will be held from 16–18 July 1986 at the Chateau Halifax, Halifax, Nova Scotia as a satellite symposium to the "12th International Congress on Acoustics."

Special topics will be:

a) underwater acoustic imaging
b) acoustic propagation (including seismic and interface waves)
c) scattering at rough ocean boundaries
d) acoustic signal processing and beamforming
e) inverse methods: using acoustics to probe the ocean environment
f) acoustics on offshore industry: petroleum and fishing

For more information write to:

Dr. Harold Merklinger
c/o Dept. of Engineering Physics
Technical University of Nova Scotia
P.O. Box 1000
Halifax, Nova Scotia
B3J 2X4

A joint session will be held on 16 July on topics of mutual interest.

SURVEY OF CONSULTANTS

We have now received 31 responses to our survey of Canadian acoustical consultants. The results of the survey will be published in our July issue. If you still wish to be included, and have not yet responded, you have only a few days to get your completed survey questionnaire to us. The survey questionnaire and a more detailed explanation were included in our January issue. Don't delay. You might be the only Canadian acoustical consultant not included.

CAA MEMBERSHIP INFORMATION

CAA mailing addresses and member information are kept in a data base on one of our computers here at NRC. There are two things I want to mention. On the label on the envelope that contained your copy of the journal you ought to find a number and the letter 'P'. The number is how the computer keeps track of who is who. The letter 'P' is much more important. It means that according to the records you have paid your dues for this year. If there is no 'P' then either you have not paid or you are not marked as having paid. If there is no 'P' and you have paid your dues, you should contact me at (613) 993-9370 and get the record corrected. If you haven't paid and want to continue to get the journal, send a cheque for the appropriate amount as soon as possible otherwise you will not receive future copies.

This year's invoice contained a list of subject areas that you were asked to indicate interest in. I'm not sure why we did this but ASA does and it is useful at times. Of the 282 members who completed this section of the form, the breakdown by area of interest is given below. Some members indicated interest in more than one area.

1. Architectural	145
2. Electroacoustics	47
3. Ultrasonics	17
4. Musical	65
5. Noise	187
6. P&P	80
7. Shock and Vibration	99
8. Speech	50
9. Underwater Sound	29
10. Other	20

Noise looks like the major interest of the membership with architectural acoustics second. I think the editor is going to expect lots of papers on noise and architectural acoustics for future issues of the journal but I'm sure he'll tell you that there is room for everyone.

The information you gave on the membership renewal form has been used to produce a membership address and phone list similar to that produced by ASA. The list appears elsewhere in this issue. If there are any errors, let me know and they will be corrected in future issues. Some people indicated on the renewal form that they did not wish to be listed. I believe that their wishes have been followed. If there is anyone else who doesn't wish to be included and did not so indicate, please contact me.

Alf Warnock

NEWS FROM ALBERTA

The University of Alberta Mechanical Engineering Acoustics and Noise Unit (MEANU) in conjunction with the Department of Speech has been granted $37,800 for an "Evaluation of Hearing Protection Devices" under CSA standards. The project is to be directed by Dr. Ken Gough and Dr. Gary Faulkner. The grant was obtained through Alberta Workers Health Safety and Compensation under their Occupational Health and Safety Heritage Grant Program.

The 1987 Canadian Congress of Applied Mechanics (CANCAM 87) will be held at the University of Alberta from 31 May to 4 June 1987. This Congress will have special sessions dealing with various aspects of acoustics, vibration and noise control. Anyone interested in participating either as a delegate or an author is asked to contact:

CANCAM 87
Department of Mechanical Engineering
University of Alberta
Edmonton, Alberta
T6G 2G8
Phone: (403) 432-5080

Gary Faulkner

ENGINEERING EDUCATION – CANADIAN PERSPECTIVES

The Fifth Canadian Conference on Engineering Education following its predecessors (Montreal 1978, Toronto 1980, Saskatchewan 1982 and UNB 1984) is sponsored by Canadian engineering societies and organized by faculty from Canadian universities. It brings together educators from all engineering disciplines, administrators of colleges and faculties of engineering, and those in industry and government concerned with the continuing education of engineers.

The Conference has two plenary sessions – one discusses the Health and Future of Engineering Education in Canada and the other addresses Computers in Canadian Engineering Education. There are also sixty technical papers arranged into sessions, some by discipline, specifically Civil, Mechanical and Electrical, and others by topic such as Computer Graphics, Curriculum Content and University/Industrial Relations. There is an overall conference emphasis on the various uses of computers in Canadian engineering education.

The University of Western Ontario
12–13 May 1986

LA FORMATION DE L'INGENIEUR – PERSPECTIVES CANADIENNES

Tout comme les congrès précédents (Montréal 1978, Toronto 1980, Saskatchewan 1982 et UNB 1984) le cinquième congrès canadien de l'éducation en génie sera commandité par différents groupements canadiens en génie et organisé par des membres des universités canadiennes. Ce congrès reunira des professeurs de toutes les spécialités en ingénierie, des administrateurs des facultés et écoles canadiennes de génie ainsi que des membres des industries et des gouvernements intéressés à l'éducation permanente des ingénieurs.

L'état actuel et futur de la formation en génie au Canada et le rôle de l'informatique dans cette formation seront les sujets de débat des deux séances plénières du congrès. Soixante publications seront aussi présentées durant différentes sessions. Certaines sessions seront organisées par domaine de spécialité comme le génie civil, mécanique et électrique et d'autres par sujet comme graphique avec ordinateur, contenu de curriculum et relations université/industrie. Les diverses applications de l'informatique dans la formation en génie seront généralement mises en évidence.

University of Western Ontario
12–13 mai 1986

NEWS FROM ACOUSTICS AUSTRALIA

In 1986 the National Acoustic Laboratories (NAL) will relocate to a new purpose-designed building at Chatswood in Sydney.The building includes an unrivalled complex of acoustical test chambers. These facilities have been designed to allow subjective or objective testing over the full range of frequencies and levels spanned by human hearing, in either diffuse or free-field environments.

It is intended that the facilities will include:

(i) four anechoic chambers, of varied sizes, with cut-off frequencies as low as 50 Hz;

(ii) two coupled reverberation rooms, each of nominal volume 200 cubic metres;

(iii) two rooms designed specifically for tests at high sound intensities;

(iv) three plane wave tubes of differing cross sections covering the frequency range 15 Hz to 560 Hz;

(v) one large, quiet, low-reverberation room;

(vi) ten audiological test rooms.

All rooms have associated control rooms, are air-conditioned, vibration-isolated, and have been planned for maximum versatility in the provision of signal cabling, intercom, data cabling and CCTV.

Consideration is currently being given to means of implementing the government's intention to make the facilities available for use by a wide range of outside organisations, both public and private. Informal expressions of interest regarding the use of these facilities would be of value in determining the likely range of users.

I-INCE NEWS

The minutes of the eleventh general assembly of I-INCE (International Institute of Noise Control Engineering). held on the 20th September in Munich revealed that I-INCE now has 25 member societies. While Inter-Noise meetings have been held in the U.S.A. every other year, in the future Inter-Noise meetings will be held in the U.S.A. every third year from now on. Future planned Inter-Noise meetings include: 1986 Cambridge, U.S.A. 21– 23 July, 1987 Beijing, China, September 1988 somewhere in Europe.

It was reported that Inter-Noise 85 accepted 351 of 400 submitted papers. This was more than at any previous Inter-Noise conference. It is expected that about 250 papers will be presented at Inter-Noise 86. The 1986 meeting in Cambridge, U.S.A. will finish in the early afternoon of 23 July so that participants may travel to Toronto in time for the opening of the 12th ICA. The 1987 meeting will be held in the Science Hall in Beijing, China. The conference is sponsored by the I-INCE and the Acoustical Society of China in cooperation with the Institute of Acoustics, Academia Sinica. the deadline for submission of abstracts is 16 November 1986.

The Board of Directors of the Institute of Noise Control Engineering, U.S.A., has announced a three-day seminar, Advanced Techniques for Noise Control, which will be held in Cambridge, Massachusetts on 17–19 July 1986. Dr. Malcolm J. Crocker, Professor and Head of the Mechanical Engineering Department at Auburn University, will be the leader for the three-day seminar. Among the topics to be covered are modern instrumentation for noise control, modal analysis, sound intensity applications, active techniques for noise control, structural and vibration transmission, and airport noise and monitoring systems. This is the second offering of the Advanced Noise Control Seminar.

NEW RESEARCH CONTRACTS

To Seastar Instruments Limited, Sidney, B.C., $86,490, for "Testing and evaluation of a novel acoustic release." Awarded by the Department of Fisheries and Oceans.

To SH Scientific Computing Services, Vancouver, B.C., $6,040, for "Development and testing of a computer model for simulating the Doppler spectrum of acoustic waves backscattered from the ocean surface." Awarded by the Department of Fisheries and Oceans.

To Manitoba Research Council, Winnipeg, Manitoba, $49,900. for "Identification of defects in cast steel by vibration analysis." Awarded by the Department of Energy, Mines and Resources.

To Barrodale Computing Services Limited. Victoria. B.C., $19,400, for "Development of an ultrasonic B-scan imaging system." Awarded by the Department of National Defence.

To University of Toronto, Toronto, Ontario, $199,300, for "Arms control and disarmament verification. Verification of a nuclear test ban treaty – seismic detection and identification (Dr. G.F. West, Department of Physics)." Awarded by the Department of External Affairs.

To Sparton of Canada Limited, London, Ontario, $69,992, for "Investigation of the long-life surveillance sonobuoy concept." Awarded by the Department of National Defence.

To Sparton of Canada Limited, London, Ontario, $69,817, for "Investigation of the processing requirements for a miniature sonobuoy." Awarded by the Department of National Defence.

To Canadian Astronautics Limited, Ottawa, Ontario, $43,988, for "Investigation of coherent inter sonobuoy processing." Awarded by the Department of National Defence.

To Hermes Electronics Limited, Dartmouth, N.S., $35,108, for "Investigate the conceptual design of a difar VLA sonobuoy." Awarded by the Department of National Defence.

To Hermes Electronics Limited, Dartmouth, N.S., $27,989, for "Costed sketch design for a four-element line array." Awarded by the Department of National Defence.

To Canadian Astronautics Limited, Ottawa, Ontario, $24,383, for "Investigation of multi-static explosive echo ranging." Awarded by the Department of National Defence.

To Hermes Electronics Limited, Dartmouth, N.S., $20,706, for "Development of a costed design of a second sonobuoy order VLS with difar." Awarded by the Department of National Defence.

To Applied Microelectronics Limited, Halifax, N.S., $10,000, for "Investigation of optical recording systems for advanced sonars." Awarded by the Department of National Defence.

NEW BOOKS

Physics and the Sound of Music. 2nd ed.
John S. Ridgen, John Wiley & Sons
New York (1985)

Mathematical Aspects of Seismology (Vol. 17 of Handbook of Geophysical Exploration), 2nd enlarged ed.
London (1984)

Parametric Random Vibration
R.A. Ibrahim, John Wiley & Sons
(1985)

Number Theory in Science and Communication (With Applications in Cryptography, Physics, Biology, Digital Information, and Computing)
M.R. Schroeder, Springer-Verlag
Berlin, Heidelberg, New York, Tokyo (1984)

Acoustique industrielle et environment.
1. Acoustique physique et perceptive
Pierre Liénard and Paul Francois, Editions Eyrolles
Paris, France (1983)

Biological Effects of Ultrasound: Mechanisms and Clinical Implications
Report No. 74 of the National Council on Radiation Protection and
Measurements (NCRP)
Bethesda, MD, U.S.A. (December 1983)

Function, Construction and Quality of the Guitar
E.V. Jansson, Ed.
Stockholm (1983)

Psychophysical, Physiological and Behavioural Studies in Hearing
G. van den Brink and F.A. Bilsen, Eds., Delft University Press
Noordwijkerhout, The Netherlands (1980)

CALENDAR 1986

7–10 April
Spring Conference of the Institute of Acoustics
Salford, U.K.

8–11 April
International Conference on Acoustics, Speech and Signal Processing (ICASSP 86), (IEEE–ASJ)
Tokyo, Japan

May
3rd International Spring School of Acousto-optics and Applications.
Organized by the University of Gdansk.
Wiezyca, Poland

12–16 May
Acoustical Society of America
Cleveland, OH, U.S.A.

13–15 May
AICB (Association internationale contre le bruit), Urban Planning and Traffic Noise

15–18 May
3rd International Conference: Stereo Audio Technology for Television
Rosemont, IL, U.S.A.

3-6 June
5th Hungarian Seminar and Exhibition on Noise Control
Szeged, Hungary

14–18 July
ICA Satellite, Acoustical Imaging and Underwater Acoustics
Halifax, Nova Scotia

21–22 July
ICA Satellite, Speech Recognition
Montreal, Canada

21–23 July
International Symposium on Nondestructive Chracterization of Materials
Montreal, Canada

21–23 July
INTER-NOISE 86
Boston, MA, U.S.A.

21–25 July
Acoustic Emission From Reinforced Plastics
Montreal, Canada

24–31 July
12th International Congress on Acoustics
Toronto, Canada

2–4 August
ICA Satellite, Acoustics and Theatre Planning
Vancouver, Canada

6–8 August
IMACS Symposium on Computational Acoustics
Yale University, New Haven, CT, U.S.A.

24–28 August
International Congress of Audiology
Prague, Czechoslovakia

2–6 September
FASE, European Acoustics Symposium
Sopron, Hungary

21–26 September
10th Congress on Building Research
Washington, DC, U.S.A.

30 September – 3 October
6th International Congress on Nondestructive Testing

7–9 October
International Symposium on Shipboard Acoustics
The Hague, The Netherlands

21–24 October
8th International Acoustic Emission Symposium
Tokyo, Japan

8–12 December
Acoustical Society of America
Anaheim, CA, U.S.A.

CAA MEMBERSHIP LIST

Abel, S.M., Mt. Sinai Hospital, Suite 843, 600 University Avenue, Toronto, Ont., M5G 1X5, (416) 586 8278

Acouscience Inc., 83 Trenton, Town of Mount Royal, Qué., H3P 1Z1

Air Movement & Mechanical Services, 43 Speers Road, Winnipeg, Man., R2J 1M2

Air Navig Planning & Operat. Res., Transport Canada, 4900 Yonge Street, Willowdale, Ont., M2N 6A5

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Alcan Smelters & Chem Ltd, Technical Library - 23a, PO Box 1800, Kitimat, BC, V8C 2H2

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APPSST du Québec, 1061 St. Alexandre, Bur 100, Montréal, Qué., H2Z 1P5

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Benoit, René, G.A.U.S. - CQSSITP, Génie Mécanique, Université de Sherbrooke, Sherbrooke, Qué., J1K 2R1, (819) 821 7144

Benwell, Deirdre, Non-Ionizing Radiation Section, Room 233, EHC, Tunney's Pasture, Ottawa, Ont., K1A 0L2, (613) 990 8892

Berard, Michel, A.B.C. Sonorisation Inc., 6038, Rue Papineau, Montréal, Qué., H2G 2W8, (514) 274 4445

Besenschek, V.P., Timberjack, Division of Eaton Yale, PO Box 160, Woodstock ont, Ont., N4S 7X1, (519) 537 6271

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Boutilier, J.W., RR#1, Ancaster, Ont., L9G 3K9

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China Nat Pub Imp Corp, Periodical Dept, PO Box 50, Peking, Peoples Republic, China

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Collier, Arthur J., c/o DREA, PO Box 1012, Dartmouth, NS, B2Y 3Z7, (902) 436 3100
Collins, M.A., 164-A University Avenue, St. John's, NFL,
Commission de la Santé et de la Securité du Travail du Québec, Centre de Documentation, 1199 de Bleury, 4 Etage, Montréal, Qué., H3C 4E2, (514) 873 3160
Connections Communications Ltd, 4316 Village Centre Ct, Mississauga, Ont., L4Z 1S2, (416) 848 2122
Const Eng Research Laboratory, CERL Library, P O Box 4005, Champaign, Ill, 61820, USA
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Please accept my apologies for errors or omissions. If you tell me about them, I will fix them.

Alf Warnock

NEW BOOKS

FLOW-INDUCED VIBRATION DESIGN GUIDELINES
P. Y. Chen, Editor
The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, 1981
v + 143 pp., paper

The eight papers in this monograph are presented for the specialist who is concerned with the state-of-the-art in flow-induced vibration (FIV). Advances in nuclear power reactor technology have concentrated on three important areas related to FIV: (1) the prevention of potential detrimental vibration and instability causing large amplitude vibrations, (2) the prediction of small amplitude vibrations leading to fatigue and wear, and (3) the understanding of complex phenomena concerning fluid-solid interactions. Information in the literature is not well-organized in such a fashion as to help designers. An ASME working group has recognized the need to provide FIV design guidelines which consolidate state-of-the-art information so that the designer can identify the applicable method for his design considerations. This volume contains eight papers and is the first of a series of monographs. Covered are guidelines for tube arrays and scale model testing, and a general discussion on fluid-solid interactions. FIV is at a state of development where detailed design procedures cannot be finalized in a standard code which is applicable to all types of components and flow conditions of interest. What has been done is to identify flow vibration mechanisms, to describe quantitatively their effects on components and to provide guidance to the designers.

NEW PERSPECTIVES ON NOISE-INDUCED HEARING LOSS
R. P. Hamernik, D. Henderson and R. Salvi, Eds.
Raven Press, 1140 Avenue of the Americas, New York, NY 10036, 1982
xvi + 534 pp., cloth, $74.50

This volume is intended as a reference for engineers, physicians, psychologists, anatomists, physiologists, audiologists, and government officials who are concerned with the effects of noise on hearing. It includes the papers which were delivered at the second Cazenovia Symposium whose objective was to integrate the contributions from key disciplines around the critical issues related to noise-induced hearing loss. The proceedings of the first conference were published as "Effects of Noise on Hearing" (Raven Press, 1976). Highlights of this volume include the following: correlation of the detailed anatomical changes in the cochlea with precise physiological recordings from the VIII nerve in an effort to unravel some of the mechanisms of noise-induced permanent threshold shifts (PTS); possible mechanisms of temporary threshold shifts (TTS); the role of contractile protein in the stereocilia and the discovery that the cochlea is sending sound waves back into the external environment; anatomical changes in the central auditory pathway following severe noise exposure; investigations in normal and noise-exposed experimental animals and humans to develop a comprehensive perspective on the effects of noise by analyzing them at the biochemical, anatomical, physiological, and behavioral level. Finally, the ability to precisely specify noise exposures outside of the laboratory with the rapid advances in microelectronics. The individual contributions are classified in five major sections: anatomy and biochemistry of noise-induced hearing loss; physiology of noise-induced hearing loss; experimental studies of permanent and temporary threshold shift; auditory performance changes with noise-induced permanent threshold shift, and noise standards – economics and demographic considerations.

In all, there are thirty papers from 53 contributors.

FUNDAMENTALS OF ACOUSTICS, Third Edition
L. E. Kinsler, A. R. Frey, A. B. Coppens, and J. V. Sanders
John Wiley and Sons, One Wiley Drive, Somerset, NJ 08873, 1982
xvi + 480 pp., cloth, $34.95

This book is primarily intended as a text book for advanced undergraduate and graduate students in engineering. The first eight of the fifteen chapters of the book provide an analysis of the various types of vibration of solid bodies, and of the propagation of sound waves through fluid media. The remaining chapters are concerned with a number of applications which includes: pipes, cavities, and wave guides; resonators, ducts, and filters; noise, signal detection, hearing, and speech; environmental acoustics; architectural acoustics; transduction and underwater acoustics. Earlier editions of the book were written by Kinsler and Frey. The third edition has been prepared by Coppens and Sanders. It differs from the second edition in that many chapters have been supplemented by the addition of somewhat more sophisticated material reflecting the modern concerns of acoustics. The chapter on ultrasonic and sonar transducers has been omitted. The material on absorption, hearing, architectural acoustics, and underwater sound has been considerably rewritten. New material includes discussions of antiresonance, concert hall acoustics, detection theory, canonical equations, and normal mode propagation in the ocean. A new chapter has been added on environmental acoustics.

THE PHYSICS OF SOUND
Richard E. Berg and David G. Stork
Prentice-Hall, Inc., Englewood Cliffs, NJ 07632, 1982
xiv + 370 pp., cloth, $26.95

Despite its title, "The Physics of Sound" is not a treatise on physics, but a text for an introductory course in musical acoustics for non-scientists. The text is divided into three main sections. The first four chapters present the basic physics essential for an understanding of musical acoustics. The second four chapters illustrate these principles and are written so that they are of general interest to the non-musician and the musician alike. Topics covered include electronic music and synthesizers, and human ear and voice, sound recording and reproduction, and room and auditorium acoustics. The first eight chapters contain the core material for a one-semester course in musical acoustics. The last six chapters of the book present more specialized material in musical acoustics. These chapters are best understood by those with some musical experience. Topics covered include: musical temperament and pitch, woodwind instruments, brass instruments, string instruments, the piano, and percussion instruments. Most chapters conclude with a set of problems; no attempt is made to use a consistent set of units throughout the book as this appears not to be considered important for non-scientists by the authors.

NOISE CONTROL SOLUTIONS FOR THE PRINTING AND PUBLISHING INDUSTRY
Richard K. Miller
The Fairmont Press, P. O. Box 14227, Atlanta, GA 30324, 1984
iv + 114 pp., cloth, $45

NOISE CONTROL SOLUTIONS FOR POWER PLANTS
Richard K. Miller
The Fairmont Press, P. O. Box 14227, Atlanta, GA 30324, 1984
iii + 100 pp., cloth, $45

These two slim volumes continue the series of noise control approaches for various industries which has been initiated by the author.

THE STU TIRE/ROAD NOISE RESEARCH PROGRAM
Various Authors
IFM Akustikbyran AB, Stockholm, SWEDEN

This is a series of reports on research supported by the National Swedish Board for Technical Development (STU). The reports are:

"Tire/Road Noise Generating Mechanisms – an Experimental Study," N. A. Nilsson and Ole Bennerhult, 1979 January.

"Air-Resonant Radiation – a Possible Mechanism for High-Frequency Noise from Cross-Bar Tires," N. A. Nilsson, S. Soderquist, and Ole Bennerhult, 1979 March.

"Prediction of External Tire/Road Noise Using Tire Parameters Derived from Measurements on Non-Rolling Tires," B. Simonson and L. Westin, 1981 April.

"Influence from Coriolis and Centripetal Accelerations on In-Service Tire Vibrations," K. Dovstam and N. A. Nilsson, 1981 October.

ACOUSTIC TRANSDUCERS
Ivor D. Groves, Jr., Ed.
Van Nostrand Reinhold, 7625 Empire Drive, Florence, KY 41042, 1981
xii + 393 pp., cloth, $51.00

This is Volume 14 of the Benchmark Papers in Acoustics Series. It includes thirty-six papers covering the development of acoustic transducers from 1876 to the present. The book is divided into nine sections which cover the following topics: historical development of the telephone, moving conductor in a magnetic field, piezoelectric microphones, condenser and electret microphones, horns and enclosures, moving-coil loudspeakers, electrostatic loudspeakers, and underwater transducers. Most of the papers in this volume cover airborne sound, although many are also applicable to underwater acoustics. Some of the papers which are included are of a historic nature and are rarely referenced, but they show the insight of early investigators and inventors. There is a total of thirty-six papers which are reproduced in this book. Each section of the book includes extensive comments by the editor on the papers included in that section. Each section is also accompanied by a detailed bibliography of other important writings.

ACOUSTICAL MEASUREMENTS – METHODS AND INSTRUMENTATION
Harry B. Miller, Ed.
Van Nostrand Reinhold, 7625 Empire Drive, Florence, KY 41042, 1982
xv + 409 pp., cloth, $53.00

This is Volume 16 in the Benchmark Papers in Acoustics Series. The forty-seven papers in this volume cover the development of methods and instrumentation for acoustical measurements from 1857 to the present. The book is divided into six parts. The first part contains papers on non-electroacoustic oscilloscopes, wave analyzers and microphones. The second part covers electroacoustic microphones and closed cavity calibrations. The third part covers the direct visual observation of sound waves. The fourth part is devoted to papers on free-field calibration methods and the development of the reciprocity method. The fifth part deals with sound absorption coefficient measurement and acoustic impedance measurements. The last part covers phase distortion and transient distortion in electroacoustic systems. Each of the six parts into which the volume is divided in prefaced by a commentary explaining the significance of the articles in that part and their relation to others. Each section is also accompanied by a detailed bibliography of other important writings. This collection of source papers is the equivalent of a textbook on applied acoustics presented by the case-history method. The commentaries by the editor attempt to translate the author's approach into an alternative way of looking at the problem.

ENVIRONMENTAL LAW HANDBOOK, Seventh Edition
J. G. Arbuckle, G. W. Frick, R. M. Hall, Jr., M. L. Miller, T. F. P. Sullivan and T. A. Vanderver, Jr.
Government Institutes, Inc., 966 Hungerford Drive, No. 24, Rockville, MD 20850, 1983
xvii + 507 pp., cloth, $48

There are two chapters in this book of interest to those concerned with noise and its control. Chapter 1, entitled "Fundamentals of Environmental Law," is an overview for laymen of the fundamentals underlying and complementing the environmental laws and regulations of this country. In this chapter, Section 7.1.2 is devoted to "Noise Nuisance" which points out that the most common form of environmental nuisance in this country is noise pollution. Chapter 9 is a fifty-page chapter devoted entirely to "noise," which was written by a former deputy of OSHA. Because the traditional common-law remedies proved inadequate to deal with noise, there was during the decade of the 1970s an increasing resort to federal regulations. The Noise Control Act of 1972 gave overall regulation-setting authority to the Environmental Protection Agency insofar as regulating noise sources was concerned. While OSHA and FAA regulations continue in effect today, most of the EPA regulations have been rescinded by the Reagan administration. The history of the legal developments of the decade of the 1970s is discussed in detail.

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