ACOUSTICS AND NOISE CONTROL IN CANADA

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

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L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

THE CANADIAN ACOUSTICAL ASSOCIATION

OCTOBRE, 1978
VOL. 6, N° 4

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Articles in English or French are welcome, and should be addressed to any editor.
Vous êtes invités à soumettre des articles en anglais ou en francais. Prière de les envoyer à un des rédacteurs.

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EDITORIAL/*MOT D'EDITEUR*

The editorship of "Acoustics & Noise Control in Canada" changes with this issue. Gary Faulkner has done a fine job of keeping us informed, regularly and even-handedly. The tasks of editors without paid staff are often thankless. Gary deserves a vote of thanks from us all.

The printing and distribution arrangements also change with this issue. The Department of the Environment has been of enormous assistance over several years, but now we are on our own. Thanks are due to their staff for their generous help, Adolf Andres recently, and formerly Don McKay.

We have not been able to find an organization to replace the Department of the Environment, and so printing and distribution will in future be financed by advertizing and mailing list sales. The editor involved welcomes suggestions and enquiries towards this end. As well, we are taking the long-overdue step of updating the mailing list, at the same time "profiling" our membership so we can describe ourselves to advertizers. To ensure you continue to be on the books of the Association, please return promptly the membership renewal form enclosed with this issue.

La rédaction de "L'Acoustique et la Lutte antibruit au Canada" change avec cette issue. Monsieur Gary Faulkner a fait un excellent travail, il nous a parvenu régulièrement et effectivement. Les devoirs de rédacteurs, sans personnel payé, sont pour les plupart sans remerciements. Gary mérite des remerciements de nous tous.

En plus, avec cette issue, un changement concernant l'impression et la distribution commence. Le Département de l'Environnement nous a aidé énormément, pour plusières années, mais maintenant nous sommes sans cette aide. On doit des remerciements à leur personnel, Monsieur Adolf Andres récemment, et Monsieur Don McKay auparavant.

Nous n'avons pas trouvé une organization pour remplacer le Département de l'Environnement; par conséquence, l'impression et la distribution seront financées par faire la publicité et la vente de la liste de distribution. Le rédacteur qui s'occupe de ce sujet, attend vos propositions et répondra à des renseignements. Au même temps, nous reprenons la tâche de renouveler la liste de distribution, cela permettra de donner des renseignements précis aux agents de publicité. Afin de continuer votre souscription ou inscription, veuillez retourner sans retard le formulaire inclus dans cette issue.

Minutes of the Canadian Acoustical Association

Meeting Held in the Chateau Halifax,

Halifax, Nova Scotia - 2 November 1978

1. The meeting was called to order by the president at 4:48 p.m.

2. The minutes were read by the secretary and on a motion by J. Manuel seconded by B. Dunn were Accepted as corrected. (In item #13 the name K. Novack was replaced by Witko).

3. W. Bradley announced the appointment of J. Hemmingway as the official Canadian representative to I/INCE for the Canadian Acoustical Association. In addition, he will also be the contact for all correspondence from I/INCE.

4. B. Dunn moved and J. Hemingway seconded the motion that the tabled motion on the selling of the membership list be lifted from the table. The motion carried by a vote of 16 to 2.

5. During the discussion of selling the membership list, the following points were made:
   a) The mailing list is not up to date.
   b) There is no harm in selling the list.
   c) The news letter could contain an insert that you could fill in to indicate you do not want to be on a list to be sold.
   d) The list would be available in the form of labels.
   e) Each person already is likely on several mailing lists and what is one more.

6. The lifted motion read "The membership list of over 1000 names not be available for sale to anyone for commercial purposes." It was defeated with 2 in favour and many against.

7. D. May proposed and J. Manuel seconded that the mailing list be available for sale at the discretion of the executive.

8. B. Dunn moved and J. Manuel seconded that the motion be amended so that those who did not want their names on a mailing list could be removed. It was noted that this requirement is easily handled. Those in favour 16 and those against 6.

9. The main motion as given in item 7 carried.

10. It was noted that we do not intend to charge ourselves for the mailing list, that we will use common sense in its sale and that an item will appear in the News Letter asking people to reconfirm their membership.

11. The treasurers report, see appendix A, was read to the meeting. F. Toole reported that he had reviewed the books and that to the best of his ability they are in order.

12. L. Russell moved and J. Manuel seconded that the treasurers report be accepted as read. Motion carried unanimously.

13. L. Russell moved and G. Faulkner seconded that the annual fees of 1979 should be $0 levied equally on all members. Motion carried unanimously.

14. The secretary reported upon the requests for the acoustical consultants directory, the future acoustic meetings in Poland and Australia and the notice from Barron & Associates advertising positions for experienced acousticians.

15. It was moved by J. Manuel and seconded by W. Barss that a congratulatory letter be sent to T. Siddon congratulating him on his election to the house of commons.

16. J. Foreman noted the CAA was slowly changing its form and wondered if perhaps the time had come to require members to show acoustical competence and to have a publication containing refereed papers.

17. W. Bradley responded by noting that the informal structure of CAA should be retained and that the social interaction of the participants was one of the keys to its strength. The role of CAA should be an educational one across a broad front not a narrow one.

18. It was proposed by J. Manuel and seconded by J. Hemingway that our 1979 meeting be in Windsor with Z. Reif as convenor. Motion carried unanimously.

19. It was proposed by J. Manuel and seconded by M. Homans that Montreal be the site of the 1980 meeting subject to discussions with the National Research Council. Motion carried unanimously.

20. G. Faulkner proposed and D. May seconded that for 1979 the president be C. W. Bradley and that the treasurer be L. T. Russell. Motion carried unanimously.

21. G. Faulkner proposed and M. Merritt seconded that for 1979 the excutive secretary be J. Manuel. Motion carried unanimously.

22. G. Faulkner proposed and K. Nowak seconded that for 1979 the editor be D. May. Motion carried unanimously.

23. F. Foreman moved and B. Dunn seconded a motion of thanks to G. Faulkner for his excellent work as editor for CAA.

24. L. Russell moved that a vote of thanks be given to C. Sherry for his efforts as excutive secretary.

25. It was moved by L. Russell and seconded by F. Toole that the present directors of CAA hold office for the following terms:

W. Bradley	- 1 year
J. Manuel	- 1 year
G. Faulkner	- 2 years
H. Jones	- 2 years
E. Bolstad	- 3 years
C. Sherry	- 3 years
J. Piercy	- 4 years
D. Whicker	- 4 years

Motion carried unanimously.

26. W. Bradley expressed the association's thanks to L. Russell for a well prepared meeting.

27. L. Russell reported that the experiment of an educational day prior to the presentation of two days of papers was a success. He recommended its continuance at future meetings with the thought that selected standards might provide excellent topics. He also reported on the tours and dinner to take place later in the program.

28. The meeting adjourned at 6:08 p.m.

Cameron Sherry
Secretary

The Canadian Acoustical Association
l'Association Canadienne de l'Acoustique

P.O. Box 3651, Station "C"
Ottawa, Ontario
K1Y 4J7

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS FOR PERIOD SEPT. 1, 1977 TO AUG. 31, 1978.

Receipts

Conference registration fees	$2,297.73
Interest	65.97
	$2,363.70

Disbursements

Bank Charges	$ 1.50
Inn of Provinces	1,446.72
Advertising Refund	30.00
N.R.C. Refund	15.00
Annual Meeting Expenses	66.60
Dodwell Film Services	26.40
Printing	124.77
Receiver General of Canada	30.00
P.O. Box Rental	10.00
	$1,755.99

Excess Receipts Over Disbursements	$ 612.71

BALANCE SHEET

Aug. 31, 1978

Assets

Cash on Hand	$ 286.50
Bank of Montreal Term Deposit	1,600.00
	$1,886.50

Liabilities

Surplus Balance Forward Aug. 31, 1977	$1,273.79
Add: Excess Receipts over Disbursements	612.71
	$1,886.50

MEETING & COURSE ANNOUNCEMENTS

Mechanics of Sound Generation in Flows

To be held in Göttingen 28-31 August 1979.
Jointly sponsored by the "International Union of Theoretical and Applied Mechanics" (IUTAM), the "International Commission on Acoustics" (ICA), and the "American Institute of Aeronautics and Astronautics" (AIAA). Professor H. S. Ribner of University of Toronto Institute for Aerospace Studies is a member of the scientific committee. Inquiries should be addressed to: Prof. E. A. Müller, Max-Planck Institut für Strömungsforschung, Böttingerstrasse 4-8, D3400 Göttingen.

Noise-Con 79

To be held April 30 - May 2, 1979 at Purdue University, West Lafayette, Indiana 47907.
Jointly sponsored by INCE/USA and the Ray W. Herrick Laboratories, Purdue University. General Chairman is Professor Malcolm J. Crocker and the Program Chairman is Professor J. W. Sullivan. The theme of the conference is machinery noise control, including industrial machinery, engines, pumps, compressors, home appliances, vehicle components. Professor Sullivan's phone number is (317) 749-6345.

Sound Localization: Theory and Application

The University of Guelph will be the site of a symposium on Sound Localization: Theory and Application on July 3 - 6, 1979. Its purpose is to bring a number of scholars in the area of localization, from the areas of theory, animal research, human research, and application of localization to industrial and clinical settings. The conference format has been designed to promote as much interchange as possible between invited participants and those attending. Further details are available from R. W. Gatehouse, Psychology Department, University of Guelph, Guelph, Ontario, Canada N1G 2W1. Phone (519) 824-4120.

Ultrasonics International 1979

To be held in Graz, May 15 - 18, 1979.
All aspects and applications of ultrasound in science and industry will be covered. Contact Dr. Z. Novak, Ultrasonics International 79, IPC House, 32 High Street, Guildford, Surrey GU1 3EW, England.

Acoustical Society of America

June 11 - 15, 1979 in Cambridge, MA. This is the 50th Anniversary Meeting. Chairman is Dr. Richard H. Bolt, BBN, 50 Moulton St., Cambridge, MA 02139.

November 26 - 30, 1979 in Salt Lake City, UT. Chairman is Dr. William J. Strong, Dept. of Physics and Astronomy, Brigham Young University, Provo, UT 84602.

April 21 - 25, 1980 in Atlanta, GA
November 18 - 21, 1980 in Los Angeles, CA
May 18 - 22, 1981 in Ottawa, Ontario

Canadian Acoustical Association

In Windsor, Ontario in the fall of 1979, on dates to be announced. Convenor is Dr. Z. Reif, University of Windsor. Further details will follow in a future issue.

Short Course in Ultrasound

The Radiation Protection Bureau of the Department of National Health and Welfare will be sponsoring an intensive short course in ultrasound in Ottawa between 17-18 May 1979. The course will be most useful to medical and technical personnel involved in diagnostic, therapeutic, surgical and dental applications of ultrasound; health physicists, health inspectors, physiotherapists and paramedical professionals who want to gain a general knowledge about ultrasound, its applications and effects; and scientists of all disciplines professionally engaged in this field who want to expand and up-date their knowledge.

Lectures will be given by highly recognized scientists and experts in the ultrasound field, including:

> Professor Wesley Nyborg, Professor Floyd Dunn, Dr. Ted Lyons, Dr. Al Goldstein and Dr. Hal Stewart.

Topics presented will include ultrasound characteristics and biological effects, physical mechanisms, medical applications, quality assurance in imaging, instrumentation and calibration, safe use, regulatory controls and standards. A panel discussion will conclude the course.

The advance registration fee is $175.00 (which includes one nights accommodation, meals and course proceedings). After April 1, 1979, the registration fee is $195.00. Applications are limited to 150 persons. This course will be provided initially in English and later in French according to demand.

For further information contact:

M.H. Repacholi
Head
Non-Ionizing Radiation Section
Radiation Protection Bureau
Environmental Health Centre
Room 233
Tunney's Pasture
OTTAWA, Ontario
Canada
KIA OL2

E.J. Richards in Toronto

Professor E.J. Richards of the Institute of Sound & Vibration Research will be giving 3 lectures at the University of Toronto Institute for Aerospace Studies on January 23 and 24. Their titles are "Noise Problems in Industrial Factories", "The Basic Mechanisms of Impact Noise", and "The Radiation Efficiency of Industrial Machinery". Further details from Professor Werner Richarz at the Institute, 4925 Dufferin Street, Downsview, Ontario M3H 5T6.

ECHANGE D'INFORMATIONS TECHNIQUES AVEC LE CNET - FRANCE

Le CNET (Centre National d'Etudes des Télécommunications) de France - Groupement DAS (Distribution, Acoustique et Services Spéciaux) a fait une démarche auprès de l'Association Canndienne de l'Acoustique afin d'établir un échange d'informations techniques. Le centre a reçu notre bulletin "Newsletter" en échange de la publication "Recherche/Acoustique"; ce dernier ouvrage contient des articles de recherches relatifs à des travaux effectués au CNET dans les domaines divers de l'acoustique; par exemple,

- mesures acoustiques
- perception, codage, analyse, reconnaissance et synthèse de la parole.

Récemment nous avons reçu le volume IV, 1977 de "Recherche/ Acoustique", (accompagné d' une bande-cassette intitulée: Analyse/Synthèse de la parole - Dialogue Homme/Machine), toute personne intéressée à consulter cette publication et poursuivre cet échange peut s'adresser à:

Moustafa M. Osman
Acoustics Office, Systems R & D
Ontario Ministry of Transportation & Communications
1201 Wilson Avenue, Downsview, Ontario M3M 1J8
Tel. (416) 248-3771

THE RELATIONSHIP BETWEEN ENERGY CONSIDERATIONS AND NOISE CONTROL IN NEW RESIDENTIAL DEVELOPMENTS

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Senior Environmental Engineer
SNC/GECO Canada Inc.
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Toronto, Ontario
M5C 2A5

ABSTRACT

The Province of Ontario has taken a leading position with regard to the control of both indoor and outdoor noise levels on new residential developments. Some of the noise control methods in use offer definite possibilities for both energy conservation and solar energy collection. Other methods have opposite effects and increase energy consumption. This interdisciplinary paper examines both areas, pointing out where energy conservation can be very easily accomplished simultaneously with noise control, and also examining methods of handling both concerns even when they have opposing influences.

INTRODUCTION

In recent years man has shown increasing respect for the effect his activities may have on the natural environment. The emissions of industrial operations have come under governmental surveillance with the result that standards now exist to restrict air, water and noise pollution. These standards have been in existence for several years and definite inroads are being made in the reduction of pollution levels to acceptable values.

Against this background of environmental awareness a new factor has emerged, the realization that most of the presently popular forms of energy are finite and that the time when they will be exhausted could well be in sight. In some cases it seems that measures to conserve our natural resources (rivers, lakes, woodland, etc.) need only be extended to include energy conservation. In other cases environmental and energy concerns seem to run in opposing directions (nuclear power stations, etc.).

It is the purpose of this paper to investigate the relationship between one environmental concern, noise control, and energy conservation. Here common areas of interest appear and these need to be highlighted. Where noise control and energy conservation are synergistic, possibilities for their mutual application should be emphasized. In areas where noise control and energy conservation are contradictory influences, solutions to the impasse must be sought to the benefit of both.

Two major areas of noise control exist - industrial and environmental. This paper is mainly concerned with the control of environmental noise as it affects new residential developments. In-plant noise is usually dealt with at the source, whereas noise impinging on a new residential development is abated either along the path of the noise or at the receiving point, the residence itself.

The main sources of environmental noise are road traffic, trains and aircraft - all transportation services and all prime users of energy. The ultimate situation "no fuel therefore no transportation noise" will not be examined here as our civilization would be so drastically affected that energy conservation could be considered to have failed if such a situation arose.

THE CONTROL OF OUTDOOR NOISE

If noise reductions cannot be achieved at the source in a reasonable time frame, then timely noise control can be achieved by interposing a sound barrier between the source and the receiver to deflect the path of the noise. In both Canada and the U.S., the concept of sound barriers has been widely used to reduce the effects of noise. A barrier is any object (a building, wall, solid fence or berm, etc.) long enough, heavy enough and high enough to oblige sound waves to travel away from a receiver at ground level. People who regularly travel Highway 401 in Toronto will have noticed light green steel barriers about 10 feet high along many sections of that highway.

Such barriers present the possibility of energy conservation if instead of steel panels, etc., solar collectors are used. Problems would need to be solved, of course. Dust and film collection along the solar collector barriers could degrade their performance. Light reflection into the eyes of motorists may be a problem. Finally, piping would have to be laid from the collector acting as a rear-yard fence to dwellings with an associated loss of efficiency. However, 15 ft. high solar panels along miles and miles of highway represent a formidable source of energy with noise reduction as an added benefit.

In areas of very high noise level a simple barrier may not provide sufficient noise reduction and a whole building row can be used as a noise barrier. For such a barrier building row to the north of east/west running highways or rail tracks solar panels would be used to form the southerly building facade, replacing the 'blank wall' building which has been used in Ontario to protect against highway and train noise. Rooms with a requirement for natural light (living rooms, bedrooms, etc.) would be oriented to the north, away from the highway, and rooms with less requirement for natural light (kitchens, washrooms, entrances, garages) oriented towards the solar panel side of the building. These north facing windows should, of course, be designed with a view to reducing infiltration and heat loss to a minimum, although acoustically no requirements would exist.

The building barrier in the form of either a townhouse row, stacked townhouse row or low rise apartment block row allows strong possibilities of noise control and energy conservation along highways and rail tracks. Larger areas for placement of solar panels exist than for simple noise barriers. However, only one side of the noise source could be utilized for solar collection. A second problem is that not all highways or rail tracks run east/west. To overcome this problem to a certain extent, staggered unit angles up to 45% to the source of noise could be used to allow the panels to have a more southerly aspect.

Two minor additional considerations for building barriers apply. Row townhouses or apartment blocks are more energy efficient designs than detached residences and hence provide a second-order energy saving. Also in the case of long building rows it may be possible to utilize wind-channeling effects to drive electrical energy generating devices such as windmills, turbines and paddle wheels.

It is felt that the combination of solar panels with both barriers and barrier buildings affords strong possibilities of energy conservation through the use of renewable resources. These possibilities should be investigated by engineers and architects alike. The possibly lower marketability of property close to noisy highways and railroads could well be considerably offset by the solar collection possibilities which exist.

CONTROL OF INDOOR NOISE

Building Envelope Considerations

In many respects, factors allowing the influx of sound into a building will also allow an efflux of heat energy. Poor workmanship resulting in badly filled components will result in small gaps which will allow sound to enter and heat to escape. Consequently a basic factor in providing a building which is well-insulated for sound and heat is that of maintaining a high standard of workmanship. Doors, windows, etc., should be fitted tightly into other building components to minimize sound penetration, heat loss and infiltration.

Windows represent the weakest link in the building envelope with regard to both heat loss and sound insulation. Minimization of sound ingress and heat egress is achieved using similar if not identical measures. Use of double and triple glazing is a well known method of improving heat loss through windows. Such methods will also reduce sound ingress, but greater air space is required between panes to achieve the potential noise reduction. Acoustically air spaces of 2" or 4" are not unknown whereas thermal glazing often only has an airspace of 1/2" or less. Thus double glazing designed for thermal insulation may have to be modified when a certain sound transmission is required.

A further commonality between heat loss and sound insulation is the degree of sealing around the glazing. Openable windows allow greater infiltration of cold air in winter (particularly in north-facing windows) and also have a slightly reduced sound transmission loss performance. Acoustically, only windows facing (or at right angles to) a noise source are considered for improved sound insulation. In consideration of energy conservation, however, north-facing windows (which may face away from a noise source) will also have to be investigated and suitably designed and installed to reduce heat loss and infiltration.

It may be thought that additional heat insulating materials in walls would also increase the ability of the building facade to reduce sound. The wall itself will have an increased performance, but improvement in the sound transmission characteristics of the wall will not have a very great effect as the predominant path for sound ingress is provided by the windows. Reduction of heat loss through a building envelope by upgrading the glazing is often an expensive task and addition of insulation to the walls and roof is preferable. However, in noisy situations the extra gain in sound reduction may make the fitting of double glazing more appropriate.

Ventilation and Air Conditioning

In order for special glazing to achieve its full noise reduction potential, the windows must remain fully closed. Even slightly opened windows will have greatly reduced acoustical performance. The occupants of a residence protected with special double glazing are thus faced with a dilemma; either they close the windows and suffer the heat in summer or they open the windows and suffer the noise. Clearly for the special glazing to reach its full potential in reducing noise levels some form of ventilation must be provided. If mechanical ventilation or air conditioning is provided to allow special windows to remain closed during the summer months, then an energy penalty will have to be paid. In this instance energy conservation and noise control are opposing influences and solutions are required which satisfy the demands of each.

The basic problem is to adequately cool the residence with windows on the noisy side closed. Windows on the quiet side can be opened allowing some exchange of air but not a cross-flow of air from one side of the building to the other. Apartments are faced with a similar problem as they usually only have windows facing in one direction. However, apartment dwellers often attempt to solve the problem by purchasing large fans and this invokes an energy penalty.

Site layout and landscaping considerations can, in some cases, reduce the problem, though not solve it completely. If possible, residences should have openable windows facing north, the coolest side of the building. These windows however should not be large so as to avoid too great a heat loss in winter. Unfortunately many highways and railways do not run east/west and also the demand for serviced land necessitates building on both sides of these noise sources. Hence, a northerly aspect for openable windows cannot always be achieved.

South-facing windows can be protected from the summer sun by suitable shading devices or even deciduous shade trees. In both instances the winter sun would penetrate the residence to allow some solar heat gain. East and west facing windows are more difficult to shade. With low sun elevations, even in summer shading is difficult to achieve. Windows facing east however are exposed to morning sun and hence lower outdoor temperatures. West-facing windows pose a more difficult problem as they are exposed to the evening sun and high outdoor temperatures. Thus residences to the west of a north/south oriented noise source with openable windows facing west pose the most difficult problem.

Apartment blocks offer greater possibilities for solutions to the contradiction between energy conservation and noise control. A single-aspect apartment building - a corridor close to one building face with apartments leading off to the other building face only - offers definite possibilities. The corridor side can be enclosed by a solid wall, but this can look rather ugly and also requires lighting even during the day. Installation of sealed windows to reduce lighting and improve the esthetics of the building leads to the possibility of overheated corridors and hence heating of the apartments themselves.

In Europe apartment buildings are often single-aspect but with an external corridor or walkway to allow access to apartments on each floor. This system has advantages in the present context. The entrance walkways would face the noise source necessitating adequate door design, but also allow windows on the noisy side to light the unit. These windows (if facing south) would be shaded from the high summer sun by the walkway above. If north, east or west-facing, they need only be small (such as over the kitchen sink) and thus minimize either heat loss or solar heat gain as appropriate. Placing the kitchen and washroom close to the entrance on the noise side is reasonable as these rooms are less sensitive to noise than living rooms and bedrooms.

Although the architectural features so far discussed to provide definite possibilities to achieve satisfactory solutions to the problems of noise reduction and energy conservation, they often utilize non-traditional methods which may adversely affect the marketability of the units themselves. It is worthwhile therefore to investigate means of ventilating units of traditional design without using electrical energy.

A number of devices exist which allow air flow but restrict noise transmission. Acoustic louvres are one possibility. These, however, are limited in the amount of sound attenuation they provide, although they are easily installed and are readily available. They can be expensive if a large area is required for ventilation. Cross-talk (Z-shaped) silencers afford a second possibility. These can provide as much attenuation as a dwelling wall itself and are reasonably priced. Such silencers should be designed to fit into the building wall itself to avoid ugly protrusions on the outer building facade.

A further possibility exists utilizing thermo-siphoning (as in the Trombe Wall) as a means of both heating and cooling interior spaces of units. In noisy environments these systems when cooling only need to exclude noise on the noisy side while allowing warm air to escape. Here again acoustical louvres or cross-talk silencers may be used. Alternatively, it may be possible to merely line the internal passages of the system with sound absorbent material to obtain the required sound reduction.

CONCLUSIONS

This paper indicates that considerations of noise control and energy conservation run parallel in many cases. Often the two concerns are complementary and mutually advantageous solutions apparent. In other cases they are opposing influences but means can be found of solving the contradictions which arise. As energy conservation becomes of greater importance in residential construction other concerns such as noise control should not be neglected but rather considered in conjunction with it. In this way energy conservation can be added to other longer-standing environmental considerations in an effort to maintain the quality of life so far achieved by mankind.

THE FORD AUDITORIUM

Philip Dickinson

(using freely the teachings of William Allen and Peter Parkin)

Bickerdike/Allen/Bramble, London, Salt Lake City, Toronto

Paper given at the

Canadian Acoustical Association Annual Meeting

Halifax, Nova Scotia, November 1978

The Henry and Edsel Ford Auditorium is the home of the Detroit Symphony Orchestra, which has been a dominant influence in Detroit's cultural development for more than 50 years. The auditorium, situated in Detroit's riverfront Civic Center, is owned and operated by the City of Detroit. It is used not only for individual or group artistic performances but for lectures, television and radio broadcasts, motion picture screenings, a variety of assemblies, and for displaying the very latest of the Ford automotive products.

The auditorium has a seating capacity of about 2900 - 1800 seats on the main floor, 1100 in the balcony. There are no pillars on either the main floor or the balcony, so all seats have an unobstructed view of the stage. The Proscenium Arch is approximately 75 ft wide and 35 ft high. The stage is about 35 ft deep and 120 ft wide, with an orchestra pit capacity of 65 musicians. When not in use, the pit can be elevated to the level of the stage.

When the auditorium first opened, its performance left much to be desired, and caused a great deal of criticism by the news media, the artists and concertgoers. Finally, in about 1971, the management decided to completely redesign the interior. Lewis M. Dimenco was appointed Architect and Vern O. Knudsen the Acoustic Consultant. At Dr. Knudsen's request, William Allen and Peter Parkin were brought in to advise - particularly in the lower frequency range - following their experience with the Royal Festival Hall and other noted auditoria.

The criticisms of the auditorium made by other observers in previous years, and by Vern Knudsen and Bill Allen in April 1972 are generally consistent and can be summarized:

a) Drums and brass easily overpowered and masked the violins. Stray resonance was sometimes experienced,

b) Reeds and woodwinds were not sufficiently evident on the ground floor to make their contribution to musical texture,

c) The balance and quality varied too much from place to place in the auditorium. In some areas the sound was confused,

d) The liveliness and general strength of sound was not commensurate with the quality and large size of the Detroit Symphony Orchestra.

Stage staff told Bill Allen also that players on each of the extreme wings of the orchestra had complained that players on the opposite wing did not keep time well, and they said also that the musicians did not always hear one another as well as they ought for a well integrated performance.

The auditorium as it stood had design defects which could explain all these criticisms. It was suggested that:

a) The platform and stage enclosure were acoustically disadvantageous for the orchestra and for the propagation of sound,

b) The hall was unable to diffuse this sound when it received it, and this prejudiced the quality of the reverberation,

c) It suffered from echoes in some places,

d) Its reverberation as a whole was deficient at low frequencies.

While there was no doubt that the auditorium was acoustically faulty, the opinion was offered that the architectural character of the interior left something to be desired and that it contributed consciously or sub-consciously to the pervasive, acoustical criticism. The finishes and general quality of the design fell well short of the excellence of the orchestra, and it seemed to both Vern Knudsen and Bill Allen that it did not provide the environment needed to give a desirable sense of occasion.

Orchestras comprise a great variety of instruments, all of which have distinctive character. Composers combine them in all sorts of ways, and have images in their minds of the textures they are thereby creating. They assume that when an orchestra makes the intended sounds, the audience will hear them in the imagined manner. This does not necessarily happen however. The distinctive character and the tonal quality of the musical instruments depends upon their harmonies or overtones. These are short sound waves and are easily shadowed by the bodies of players, music stands, etc. It then follows that if an orchestra platform and the audience area are so related that the different musical departments are very differently exposed, those which can be seen well will be heard well, and those which are poorly visible will lose their distinctive character, their quality of one, and some of their strength. This applies particularly to violins, violas, reeds and woodwind, but not to brass or percussion. Sir Henry Wood had the dictum that "all listeners should be able to see all the f holes n the fiddles". We now know this makes good sense acoustically.

One other fact that was evident was that the hall was very sensitive to singers turning their heads, and intelligibility and loudness increased and decreased disconcertingly depending on which direction was faced. The cause of the trouble was the directionality of the human voice and the lack, then, of useful side reflectors and diffusers at the front of the hall to reflect the artists voices when they turn away.

Tests of the reverberation made it clear beyond doubt that better diffusion was necessary. In general, this is best developed from areas on the walls and ceiling near the stage opening. In this case it was the lower frequency sound that most urgently needed diffusion and the size of these sound waves - up to 10 or 20 ft - necessitated large slopes to cause effective diffusion.

Traditionally this diffusion was a by-product of box seats and ornamental features near the proscenium on each side wall. These provided the acoustical roughness needed. In the Ford auditorium the best location was occupied instead by a vertical lighting recess, open and lined with sound absorbents - in this way actually weakening what should be a point of strength for reflection. This absorbent opening is as bad a feature to have in this position as could be imagined.

<u>New Design Considerations</u>

Reverberation is necessary to give strength, liveliness, fullness and richness of tone. It comprises mainly a rapid succession of inter-reflections which lose energy more or less rapidly as they encounter various surfaces. Normally the audience is by far the greatest absorbent. Ideally the decay of individual sounds should take place uniformly and be prolonged for a time of the order 2.2 to 2.5 seconds at mid frequencies (250 to 500 Hz), and rather longer (about 3.0 seconds) at the lower frequencies (60 to 100 Hz).

If inter-reflections are to take a long enough time, obviously a hall must have a satisfactory value for the amount of absorption present. As a rough approximation, one allows 300 cubic ft per seat. The Ford Auditorium has only about 200 cubic ft per seat. Automatically, one's expectation is that reverberation will be too short. By definition, the reverberation time is the time it takes for a decay of 60 dB to occur, but whether a listener feels he is hearing the full reverberation depends a lot upon the shape of the decay curve, for if it departs substantially from a smooth fall, the length as defined technically will not correspond to the listener's impression, which is the only real criterion in the end.

It used to be assumed that the larger the hall, the larger the reverberation time should be, but now it is generally agreed that for any substantial hall a reverberation time of 2 seconds at mid frequencies is about right with a slight prolongation at lower frequencies. Much of this line of thought is due to Leo Beranek in the United States and C. W. Kosten in Holland, who has devised further simplifications which seem to give even more realistic predictions. These simplifications are so drastic that they seem to suggest that all halls could be turned out more alike than they are - supposing that to be desirable. In fact, it means that some of the traditional arithmetic is pointless with this new perspective, and always had less bearing than was supposed.

Reverberation is important, but the fact that it can be computed and measured more easily than any other aspect has given it undue prominence. What is equally important is the sound that reaches the ears initially. That is why, above, emphasis was laid on the value of a direct visual, and hence aural, view of all the sources of sound in a performance. The initial pulse of every individual sound makes our minds decide its direction and character, and its subsequent decay comes as a sort of savouring or appreciation period in which something in the nature of an aural aesthetic of the space is created.

Beranek, after an in-situ study of numerous concert halls over a period of years, came to the conclusion that a quality he called "intimacy" was desirable, and could be attained by ensuring that the initial part of the sound reaching a listener was followed quickly by a sideways reflection. Unhappily the initial application of this idea was to the Philharmonic Hall in New York where a misfortune diverted attention from assessing its value, and, so far, it has had no widespread effect upon acoustical practice.

However, Howard Marshall a New Zealand architect, working at the Institute of Sound and Vibration Research in Southampton, produced a more general theory of the same ilk, which indicates Beranek had a valid point: Marshall was able to postulate that an acoustical impression of a hall depends largely on what happens to reflections in the first one-tenth of a second after the initial sound is heard, i.e., reflections whose paths are not more than 100 ft. longer then the direct path. Marshall's "room response" seems to be an extension of what Beranek conceived as "intimacy".

Briefly, Marshall's argument was this: There is a moment lasting about one-fortieth of a second after hearing a strong pulse of sound, during which one is "blinded acoustically" to what follows - like the momentary effect of a flash of light-and there is no point then in receiving any more information at this time. If the reflection is from the same direction it adds to the "blinding" effect and, if from some other direction, it will not be registered. In this case "the same direction" includes a reflection from above the source of sound because as our ears are horizontally arranged we cannot distinguish easily the direction of sounds vertically related. Instead we need some strong information next from another direction after the necessary interval, which should be reflections from the side walls, and, as Beranek observed, they should have paths about 25 or 30 ft longer than the direct sound. An overhead reflection from the ceiling is then more or less inevitable - in fact desirable - and the last reflection likely to be obtainable in this critical period is from the junction between ceiling and walls. In this way, it seems, the shape of the room is appreciated acoustically, and one's sense of being enveloped by sound is enhanced.

Marshall's idea is still too new in our thoughts for us to have evaluated our listening experience in relation to it. But it seems likely that it goes some way towards explaining why we feel differences in the acoustical character of rooms.

It is generally reckoned that diffusion is a good thing. In particular it is accepted that it is valuable to have at least some areas of a hall's boundaries acoustically rough, which means the use of irregularities large enough to modify the reflection of waves of 10 ft in size or larger.

There is no doubt that the use of great flat planes for walls and ceiling introduces the risk that the reflections, which continue to take place after the initial one-tenth of a second, will cause irregularities in the reverberation that may prove to be unpleasant. On the other hand, large irregularities over the whole ceiling and wall surfaces may not be altogether good either. Bill Allen and Peter Parkin's preference is for moderation in the use of roughness, which should be on walls rather than ceiling, and should not entirely cover the walls. But, as so often is the case in acoustics, there are exceptions such as the Concertgebouw in Amsterdam - a great simple rectangular box in which some lovely sound is heard.

Finally in these design considerations we come to two psychological parameters that are no less important than the acoustical ones. First there must be concern for what happens on, around, and behind the stage - i.e., all the factors that make for a good performance and for a good initial shaping of what the audience will hear a moment later. It has been assumed too easily that nothing a designer does has any influence on the quality of performance, and too little attention has been given to the way the design of the performance end of the house influences what the audience hears - and of course what the performers themselves hear.

It should be self-evident that performers should be put into as good a frame of mind as possible to make their music, but musical people have had only fragmented opportunities to discuss their needs: proper lavatories and showers, comfortable rooms for the principals, a 'green room' with a view to provide space in which to warm up out of 'earshot' of the audience and a cheerful space in which to meet friends afterwards for the emotional run-down - a space incidentally which friends can easily reach. All this should be instinctive to the good designer in the provision of backstage facilities.

Then care must be taken in choosing the path along which the performers come to meet their audience. This is especially critical for the principals who have a particular rapport to establish for a successful performance. It is generally accepted that entry should be from the left as the audience sees the stage. This is not just a convention: It is the natural approach to keyboard instruments. Also it is the side of the first violins - the hardcore of most performances. It does not follow from this that entry must be on the extreme left. There is a strong backing for an entry just to the left of centre. Then that part of the path within view of the audience should be so laid out that the performer is always exposed to his or her best advantage. There is something to be said for an entry slightly above the platform, with a slight descent to the place of performance. Basically the principal performers must be given advantageous entry to etablish the 'rapport' with the audience which they will need from that moment on.

The performers must be placed in a situation that, as Sir Malcolm Sargent put it, "demands excellence". And they should be able to hear themselves together with others that may be performing or accompanying also. Among the surfaces that can surround an orchestra, the overhead canopy or reflector has become almost inevitable. Its purpose, however, is often misunderstood. When it is termed a reflector, it is often because it is believed the sound from the stage needs help in reaching distant seats, and it is angled accordingly. This is a mistaken belief. The sound should only need help if the basic design is not doing its job, and the help such a reflector can give can never fully correct a basic fault. The chief function of this element is usually to be part of the existing system for the orchestra, for which purpose it must be low enough to feed back quite quickly, preferably from no more than 30 ft above the instrument line. It could, of course, be part of the ceiling of the hall, but one must have big volumes to get long reverberation, and this generally results in ceilings much higher than 30 ft over the stage. The canopy therefore is normally to be regarded as a lowered section of the ceiling. But it must be aesthetic enough to draw the attention of the audience towards, and not away from, the performer.

Having mentioned "rapport" it must be remembered that the listeners too have a part in this. They must be in the best receptive mood possible. Rows should not be straight, for they have no focus and diminish concentration - one cannot see other faces and, without visual contact, it is difficult to share emotional experience. As the esteemed Hope Bagenal once put it, "There must not be a conflict of the optic and the acoustic". In a place where people face inward, the sense of sharing an experience can be tremendous.

Also the seats should not be too spacious and relaxing 'like an armchair at home' because this tempts individuals to retreat from the tension of participation. One should be helped to keep alert and to follow the performance.

Finally, to be truly successful, the whole building must give people a 'sense of occasion'. The Royal Festival Hall is the best example we know. There foyers are quiet, luxuriously absorbent places, and from these one passes through a very "deadened" sound lock to enter the hall itself where, in strong contrast, one at once senses a large and lively acoustic space, unexpectedly possessing (we believe) a quality of acoustic tension and excitement.

<u>The New Interior Design of the Ford Auditorium</u>

All the above factors were included in the considerations for a new interior design, but inevitably, economics severely restricted what could be done. The shell of the auditorium and stage had to be retained, of course, as did the floor, and its rake, both on the main floor and in the balcony. New carpeting and seats were installed, but these were a choice of a committee and any acoustic considerations were completely 'forgotten'. After installation it was found that the steel seat pans 'rang' and damping - with heavy building felt - was necessary.

The auditorium has a large pipe organ above the stage with, originally, four large openings into the main space of the hall. Organ louvres have been fitted to close up these openings when the organ is not in use. The ceiling - a very low one of only 35 ft maximum height - otherwise remains unchanged.

Large radius diffusion shapes, proposed by Vern

Knudsen, now form the side walls and the rear wall below the balcony - a position where a curved wall has long been known to be a potent source of acoustical problems because of the way it concentrates reflected sound. Strangely (to us that is) it seems to work very well. The front of the balcony has been curved also and given a slight downward tilt. Whereas the wall diffusers are of heavy plaster, with a surface of two browning coats, and one gloss finishing coat, the balcony facade is of one half inch plywood panelling. The sidewall lighting alcoves are covered except for two parts on the left and one on the right for necessary side lighting. If more side lighting is needed a hidden cupboard in the main box - the Christine Ford Box - can be opened to reveal a number of mountings.

On stage in the concert shell the original BBN-designed two-piece ceiling made up of tetrahedral shapes is all that remains of the original acoustic fabric of the auditorium. The sides and back of the shell are formed of convex diffusion shapes - moveable 2 inch to 2 1/2 inch plaster panels on a steel frame with rollers. Except on the front rail of the balcony, all the convex diffusers are of heavy plaster weighing more than 6 lb per square ft - to minimize vibration.

Finally the canopy (in front of the fire curtain), again of convex shape is new. It is made of fibreglass and at 80 ft by 25 ft is, we believe, the largest structural fibreglass panel ever made. It is held in place by twelve hoists which can raise, lower, tilt or bend it according to desires.

Back stage only a little decorating was possible.

<u>The Present Situation</u>

After these design configurations were put into effect, the character of the hall was changed significantly. No longer does one have to shout to be able to converse between the stage and parts of the body of the auditorium. A conversation in a normal voice is now quite possible. The sound now received by the audience is clear and 'brilliant'. The entrance - which indeed is very tastefully done - and the seating go some way to creating an atmosphere of "excited tension". But the lower notes still need some correction. Initially, it was proposed that assisted resonance - which was, of course, originated by Peter Parkin - be installed to do just this. But cost considerations, so far, have not allowed this, which, we believe, would bring the performance of this auditorium as close to perfection, from an acoustical point of view, as possible.

In its present state, the auditorium has had glowing commentaries. The critics have applauded its acoustical response. The concertgoers too have been unanimous about their appreciation of its performance.

But all is not well. The Detroit Symphony Orchestra has a new Director, Antal Dorati and he, to whom most of all the auditorium must appeal in order to get truly great performances, is not entirely happy with it. It is our understanding that he believes the auditorium is a little too harsh at the lower frequencies for his music, and needs mellowing - which of course would be the effect of our proposed assisted resonance. And as a new director - like all others before him - he would like a brand new home for the Symphony, as is quite understandable. But it is suggested that the problem is not so much mechanical as psychological. Economics did not permit our ideas for backstage to be put into effect, and the existing facilities I consider inadequate for the needs of the performers. Indeed I have likened part of the backstage decor to that of a subway station.

It is here, backstage, that I believe some serious refurbishing is urgently needed. Until this hidden, non-acoustic, parameter is corrected the auditorium wil never be considered one of the greats. Only when the performers are one in accord with the auditorium will it reach the heights we believe its acoustics deserve.

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