ACOUSTICS AND NOISE CONTROL IN CANADA

THE CANADIAN ACOUSTICAL ASSOCIATION

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

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CONTRIBUTIONS

Articles in English or French are welcome. They should be addressed to a regional correspondent or to a member of the editorial board.

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Vous êtes invités à faire parvenir des articles en anglais ou en français. Prière de les adresser à un correspondant régional ou à un membre de la rédaction.

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(suite au recto de la couverture inférieure)

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EDITORIAL COMMENT

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As this is the first newsletter which is being distributed since I was elected Editor I would like to take the opportunity to comment about past and future publications.

The first privilege I have is to thank the retiring Editor, Tony Embleton, for the fine work which he has done for the CAA and in particular for the work he did in preparing the previous newsletters. The newsletter was something we all looked forward to receiving. I believe it filled a real need especially for an informal association such as ours. I'm glad to say that Tony has agreed to help in the future so that his talents will not be completely lost to us.

In order to assist with the preparation of future newsletters, Dr. Daryl May from the Ontario Ministry of Transport and Communication has agreed to assume the post of Assistant Editor. I look forward to working with Daryl in the coming months. I would also like to acknowledge and thank Don McKay for agreeing to continue looking after the printing and mailing of the newsletter.

I believe that the newsletter should continue in much the same form as it has in the past. It should therefore appear in about the middle of each quarter of the year. This means that this issue should have been out by the middle of November. The newsletter will be assembled during the first part of each quarter so that notices of meetings, seminars etc. should be submitted well in advance if the readers are to be notified of its occurrence before the day or days arrive. It is planned to have a regular section in the newsletter called the Notice Board for items of this sort.

The largest amount of material to be published in the next year will likely be from the CAA meeting in Toronto on October 8 - 10. I would ask that all authors submit their papers to me as soon as possible. Each author's submission should be prepared so that little retyping if any is necessary before inclusion in the newsletter. This means that a summarized version of each paper is required. It should be between one and five pages in length when typed single-spaced on standard sized paper (i.e. like those found in the newsletter). We ask that there be double spacing between paragraphs and more space between the heading and text - with title capitalized. As few figures as possible are requested and they must be suitable for xerox reproduction. This means that colors and photographs will not be reproduced very well.

I would like to close with the hope that the newsletter will continue to fill the needs of the CAA membership. If there are any last minute items or if there are any questions concerning the newsletter please do not hesitate to write me or call me at (403) 432-3446.

SCATTERING OF SOUND USED TO STUDY THE ATMOSPHERIC BOUNDARY LAYER

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Introduction

We are using the scattering of sound for the remote sensing of thermal turbulence in the atmosphere. Over the past several years an acoustic radar has been developed and operated at the University of Toronto to study the planetary boundary layer. We were one of the first groups to operate successfully in a noisy urban environment. A brief outline of the concept and technique of acoustic echo sounding will be given along with a discussion of some of our observations.

In the past, the study of the planetary boundary layer (50 m — 1 km) of the atmosphere has been limited by the lack of access with direct access being limited to occasional baloon ascents or airplane traverses and in a few cases, to instrumented towers extending beyond 100 m. Recent advances in remote sensing techniques now allow us to remotely monitor parameters of the boundary layer on a continuous real time basis. Acoustic radar, FM-CW radar and lidar (laser radar) are the three techniques being most actively investigated and applied.

Theory

Inhomogeneities in the acoustic refractive index produced by atmospheric turbulence will scatter sound with turbulent fluctuations of both temperature and wind speed contributing to the scattering. The location and intensity of turbulent regions can be determined by transmitting pulses of sound into the atmosphere and monitoring the scattered signal. Repetitive operation generates a cross section of the distribution of turbulence in the portion of the atmosphere advected through the beam of the transmitting system. An understanding of the scattering characteristics of atmospheric turbulence allows the turbulent scattering to be used as a tracer for the study of larger scale structures in the boundary layer.

For the ideal case of homogeneous, isotropic turbulence of sufficient extent to fill the pulse volume, the scattering cross section has been shown to have a linear dependence on the spectral densities of thermal turbulence and turbulent kinetic energy (Monin, 1962). The angular dependence is such that backscattering is due only to thermal turbulence. For backscattering, the scale of turbulence interrogated is equal to 1/2 the acoustic wavelength.

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The operating frequency for an acoustic radar is a compromise primarily between the high noise levels at the low frequencies and the stronger attenuation by the atmosphere at higher frequencies. The University of Toronto acoustic radar normally operates at 2000 Hz and can give reasonable results over the range from 1300 Hz — 3700 Hz.

Quantitative work with acoustic echo sounding is hindered by the uncertainties in the received signal associated with the attenuation of the transmitted and scattered sound. The strong absorption due to the presence of water vapour cannot be accounted for without having knowledge of the real time distribution of moisture in the interrogated volume. For a range of 500 m when operating at 2000 Hz laboratory measurements (Harris, 1966) indicate that for temperatures from -10°C to +30°C and relative humidity from 10% — 90%, the round trip attenuation due to molecular absorption would range from 8 to 50 dB.

Experiment

The University of Toronto acoustic radar is located on the 15th floor balcony of the Physics building on the main campus in the center of the city of Toronto. The system operates in the monostatic mode using the same transducer and antenna for both transmitting and receiving. Monostatic operation means we are looking at backscattered sound and hence detecting scattering only from thermal turbulence. The antenna is a modified microwave antenna with a high power moving coil loud speaker driver as the transducer. The antenna is enclosed in a wooden shield lined with acoustic foam. The transducer is driven by an ordinary audio amplifier. The normal operation involves sending 100 ms pulses at 70 — 90 w electrical power level every 4 s. At that power the sound pressure level 1 m above the antenna aperature is 136 dB while beside the shield it is approximately 70 dB and on the ground it is barely detectable by a trained listener.

The receive section has a gain of 162.5 dB and a very narrow pass band. A variable gain amplifier corrects for the spherical divergence of the scattered sound. The data is recorded on a modified facsimile recorder where each echo train is represented as intensity modulations along a single line. Recording at 90 lines an inch with a 4 s period compresses 1 hour of data into 10 inches of the chart.

Results

Despite the urban background noise, operation of the acoustic radar has been very successful. The unit has been operating on a 24 h basis essentially continuously since March 1973. During this time we have observed structures associated with a wide range of phenomena including:

a) atmospheric gravity waves
b) synoptic scale cold fronts and warm fronts
c) mesoscale cold outflows associated with thunderstorm activity

d) lake breeze circulations
e) layering associated with stable stratification
f) convective fields
g) formation and breakup of nocturnal inversions
h) many periodic structures, Kelvin Helmholtz instabilities and other dynamic instabilities.

The acoustic radar vividly displays the columns of buoyant, thermally turbulent air associated with convective activity. These thermal plumes are observed to occur intermittently with little scattering occurring between them as thermally quiescent air subsides to replace the warm unstable air carried up in the plumes.

The existence of stable layers in the lower troposphere is revealed by the acoustic radar as continuous bands of echoes showing only gradual variation in altitude. Such stable layers are observed in association with nocturnal inversions, synoptic scale subsidence and onshore flow. The decay of the stable layer associated with nocturnal inversions is revealed by the acoustic radar as early morning solar heating generates convective activity. The stable layer is observed to be buffetted and distorted as the thermal plumes impinge upon it. Ultimately the stable layer is lifted and dispersed as the influence of the surface heating extends into the planetary boundary layer.

The acoustic radar has proven to be very effective in monitoring the sequence of events associated with the onset and decay of lake breeze circulations (analogous to the sea breeze). Typically the development of the lake breeze is preceeded by an active period of convection marked by thermal plumes. The passage of the lake breeze front is revealed by the abrupt cessation of convective activity and the development of an intense surface scattering region associated with the internal boundary layer within the inflowing lake-modified air. The continuation of the lake breeze is marked by a regime of stable air in the lower troposphere while the retreat of the lake breeze front often is observed to be followed by the return of convective activity. The acoustic radar is a valuable tool in the study of the dynamic characteristics of lake breeze circulation.

The acoustic radar has also allowed us to monitor and study the passage of both synoptic and mesoscale cold fronts and warm fronts. It also reveals much about the dynamic instabilities prevalent in the boundary layer, particularly with regards to the Kelvin Helmholtz instability.

In addition to the detection of atmospheric structure as revealed by the distribution of thermal turbulence, the acoustic radar has detected scattering from discrete objects. In particular, in the migration seasons, flocks of birds passing through the antenna beam result in a profusion of strong point echoes and during the winter falling snow consisting of large flakes produces a distinct signature on the record.

Our work with the acoustic radar has shown that it can be operated successfully within an urban environment. The technique allows the characteristics and dynamics of many of the features of the planetary boundary layer to be monitored and studied. The acoustic radar offers great promise as an aid to the development of an understanding of the planetary boundary layer.

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Harris, C.M. Absorption of Sound in Air versus Temperature and Humidity. J. Acoust. Soc. Am., 40 (1), 148 - 159, 1966.

Monin, A.S. Characteristics of the Scattering of Sound in a Turbulent Atmosphere. Soviet Physics - Acoustics, 7, 370 - 373, 1962.

NOISE LEVEL/ATTITUDINAL SURVEYS OF LONDON & WOODSTOCK, ONTARIO

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Physical and attitudinal surveys of community noise levels in the cities of London and Woodstock, Ontario, Canada were conducted. The noise monitoring, data retrieval, and data processing systems are described. A summary and discussion of the survey results are presented as a basis for the establishment of community noise regulations.

Introduction

The work described in this article was sponsored by the Ministry of the Environment of the Province of Ontario, Canada, together with the City of London, as part of an overall study to provide background information on existing noise levels and community subjective response to these levels. This information was required to assist the Ministry in formulating community noise regulations for the province as a whole, to assist municipalities in interpreting and implementing these provincial regulations on a local level and to provide guidelines for noise abatement and control procedures for future long-term urban planning. Other investigators concurrently conducted similar studies in Toronto[1] (sponsored by the City of Toronto) and Hamilton, and, subsequently, the Ministry conducted further studies in Sault Ste. Marie, North Bay and Kingston.

Approach Used

In addition to the overall sound level, there are a variety of physical characteristics which contribute to the unpleasantness of noise. Examples of these are its intermittency, its tonal content, the spectrum of dominant frequencies in the noise, its impulsiveness, the degree to which the noise intrudes into an otherwise quiet background. Many complicated rating scales have been devised in recent years to account for these factors.[2] These include PNdB (Perceived Noise Level), NNI (Noise and Number Index), SIL (Speech Interference Level), NC (Noise Criteria Number), NPL (Noise Pollution Level), CNR-community (Composite Noise Rating for Communities), TNI (Traffic Noise Index) and several others. Each of these indices has usually been designed for a specific purpose. While each has a basic utility, workers in the field of community noise measurements have become increasingly skeptical about the excessive complexity of some of the ratings and, indeed, the need for such precision. Many noted acousticians[3-9] have concluded that simple A-weighted sound levels, together with a simple statistical analysis (such as through probability distribution curves), give an acceptable assessment of the subjective sensation of loudness and are as meaningful a basis for establishing correlation between subjective response and physical noise measurements as are the more complicated ratings. On the other hand, such factors as intrusiveness of noise into an ambient situation (which describes the degree to which peak levels stand out above the ambient background) can be readily obtained by simple variations of the L_{10} and L_{90} measurements.[*,10,11] It was decided that for this survey the physical quantities sought should be the L_2, L_{10}, L_{50}, and L_{90} levels, TNI and NPL. An attempt would be made to establish what correlation, if any, existed between (1) a modified A-weighted sound level (such as L_{50}) and (2) a conventional rating scale (Noise Pollution Level NPL) and subjective responses in certain community land-use areas. The data acquisition and processing system was designed accordingly.

Research into the science of community noise surveys, through a review of the pertinent literature,[12,13] suggested that high accuracy in both the gathering of data and the assessment of this data could be obtained through the use of automatic, continuous duty, sound detection monitors rotated throughout well-defined grid patterns over pre-selected and representative zoning or land-use areas of the community, with which the block districts for the attitudinal interviews should coincide.

Based upon general knowledge of the two cities[†] and upon census lists - to ensure appropriate sample population representation of typical cross-sections of the two communities - six areas within London were selected and three within Woodstock. In London these corresponded to (a) residential (single family), (b) residential (single family, adjacent to quarry), (c) residential (multiple units), (d) residential-commercial, (e) residential-industrial and (f) residential-institutional, and within Woodstock to classifications (c), (d) and (e) preceding. Monitoring points approximately ¼ mile apart were selected and each was monitored on a 24-hour basis on at least a typical weekday, Saturday and Sunday, under "good weather" conditions (that is, when snow and ice conditions did not exist). In addition, "winter" (snow and ice conditions) monitoring was conducted at selected stations within the London areas. The numbers of monitoring stations involved and the tapes successfully recorded are summarized in Table 1.

Concurrently with the physical noise monitoring, an opinion survey, utilizing an appropriate interview and questionnaire technique, was conducted in the selected block districts.

The data from these two surveys were processed with

Table 1 - Number of stations monitored in London and Woodstock and associated number of successful recordings obtained

	Number of Stations	Successful Tapes
London, Good Weather	57	165
London, Winter Conditions	18	46
Woodstock	18	54

Distribution of Monitoring Stations in London and Woodstock Land-Use Areas

London	
Residential-single family	6
Residential-single family (quarry)	6
Residential-institutional	9
Residential-commercial	12
Residential-industrial	12
Residential-multiple units	12
Woodstock	
Residential-multiple units	6
Residential-commercial	6
Residential-industrial	6

*L_{10} is the level which is equalled or exceeded 10% of the time. Similarly, L_{90} is the level which is equalled or exceeded 90% of the time.

†Population of London is 235,000; Woodstock is 30,000.

the aid of digital computers and will be discussed in a subsequent section. The time period in which the project was undertaken was from May 1972 to September 1973.

The Automatic Monitor

A prototype monitor was designed and field tested and, subsequently, six field monitors were built. Each monitor consisted of a self-contained, light galvanized steel, weatherproofed box of approximately 13 x 10 x 10 inch dimensions, which included a high quality 2-channel stereo tape recorder, an external microphone and windscreen on a rotatable boom arm, a matching impedance transformer between the microphone and the tape recorder, a solid state electronic timer, and rechargeable battery power supply (see Figure 1). A 2-channel stereo tape recorder was chosen in order to obtain a dynamic range of 70 dB, which was accomplished by paralleling the microphone input to the recorder and attenuating and offsetting the input level to one of the tracks, overlapping the two channel levels by approximately 10 decibels. The measurement range chosen for this survey was from 35 to 105 decibels and the overall frequency response of the system was 40 - 16,000 Hz, the latter dependent upon the input signal level.

The timer was designed to switch the microphone and the tape recorder on and off at regular intervals totalling some 2 minute record time each hour. The prototype monitor was set to sample noises over 10-second periods every 5 minutes, in accordance with ref. 13, and would do this for 24 hours before requiring servicing (that is, recorder tape and battery change). However, at the request of one of the sponsors, the sampling interval and frequency of sampling of the field monitors was adjusted to 40-plus seconds of measurement every 20 minutes in order to conform to the method being followed in the survey of the City of Toronto.

An acoustic calibrator was used to provide calibration signals at the beginning and end of each 24-hour recording, both for a functional check and to aid in the computational processing of the recordings.

A van was equipped with the necessary instrumentation and calibration equipment for servicing the monitors, including a ladder for raising and lowering the monitors to and from their locations (usually 15 to 18 feet up a utilities pole).

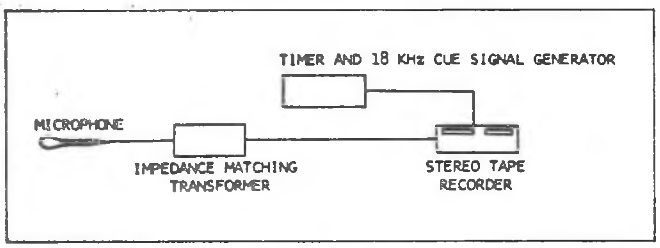

Figure 1 - Schematic diagram of noise monitor

Physical Measurements
Data Retrieval and Processing

The data retrieval and processing involved playback of the recorded tapes through a level detector gating circuit (which discriminated between the sound level on the upper or lower channel of the tapes), converting the information on the tapes to A-weighted rms sound levels, converting this information through a logarithmic potentiometer on a level recorder into decibel notation, and transferring the resulting information through an analog voltage read-out on the level recorder to cartridge tapes of a 7-channel FM tape recorder, as illustrated in Figure 2. The cartridge tapes were interfaced with the PDP 11 computer at the University Computing Centre for digitizing at half-second intervals.

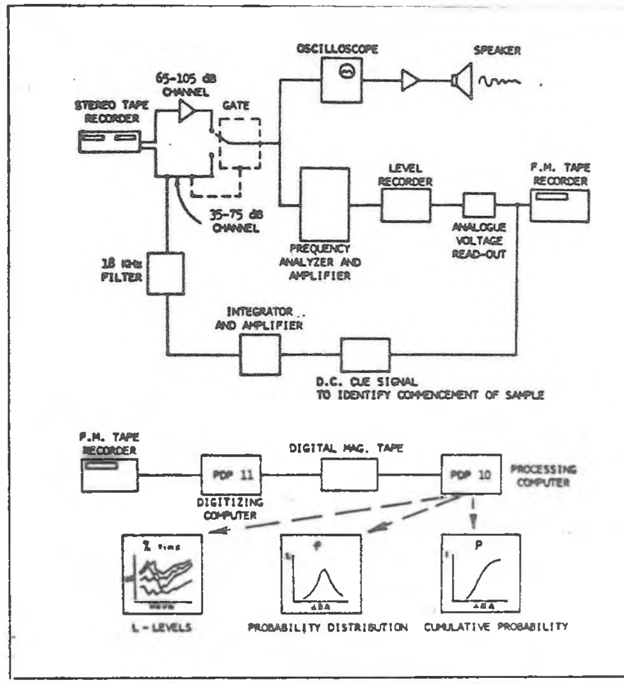

Figure 2 - Schematic diagram of data retrieval systems

All field tapes were audio-monitored during processing partly in order that a high level dc cue signal could be manually inserted on the FM tape at the commencement of each 40-second sample, the digitized value of which enabled the commencement of each sample of meaningful data to be identified during the computer processing. Upon the detection of each cue signal, the subsequent 40 seconds of information was sampled at half-second intervals, and transients due to recorder run up and run down were thereby eliminated. The audio-monitoring of the tapes also allowed the processor to detect and eliminate unwanted data (i.e. rain on the microphone and boom arm, excessive wind noise, etc.).

After digitizing, the data were processed using a PDP 10 computer and relevant information about the noise at each grid location was obtained directly in graphical form. This graphical output took the form of a plot of the L_2, L_{10}, L_{50} and L_{90} values by the hour over a 24-hour period (see Figure 3) and a plot of the percentage time particular noise levels were equalled or exceeded during the three time periods, 7:00 a.m. to 7:00 p.m., 7:00 p.m. to 11:00 p.m. and 11:00 p.m. to 7:00 a.m. (see Figure 4). The partially processed information generated to plot these graphs was stored on magnetic tape for possible further processing, should this prove desirable.

Results from Physical Measurements

Clearly, no attempt can be made in this article to present the vast quantity of data accumulated during the survey. Instead, mention will be made of the results to be found in the report to the Ministry[14] and only the summary of the results will be given here.

From the cumulative probability curves of the type shown in Figure 4, the value of L_{peak}, $L_{2.5}$, L_{10}, L_{50} and L_{90} were obtained and the corresponding indices TNI and NPL* determined for each of the three time periods. These L levels and indices were tabulated on the basis of monitoring location, day of the week and season. In order to arrive at a comparison in *mean* noise level between the various land-use areas in London and Woodstock, values of L_{50} and NPL were averaged and tabulated for each area for each of the three time periods for Saturday, Sunday and weekday (and by season for London). An example of these results,

*The values of NPL were calculated using the formula[9]

$$NPL = L_{50} + (L_{10} - L_{90}) + (L_{10} - L_{90})^2/60$$

$$\text{Traffic Noise Index (TNI)} = 4(L_{10} - L_{90}) + L_{90} - 30.$$

which are believed to be representative of the noise levels occurring in medium sized and small sized cities within Ontario, is presented in Table 2 and gives averages of L_{50} and NPL for London land-use areas in good weather for various times of day and days of week.

Accuracy of the Sampling Procedure Used in Monitoring

In order to check the validity and accuracy of the sampling procedure chosen for the physical measurements (that is, recording 40-second samples every 20 minutes), 24-hour continuous recordings were made in two locations in London (one residential-commercial, the other residential) and were analyzed both on a continuous basis and on a sampled basis.

When sampling at the rate of 40 seconds every 20 minutes, the actual samples obtained depend upon the time of commencement of the initial sample and the exact time interval between each sample. It was therefore decided that three different sets of samples should be extracted from each continuous recording, each set commencing at a different time, the results from which should be compared with those obtained on a continuous basis.

A study of the plots obtained showed that the graphs based upon the hourly information (that is the "L_2, L_{10}, ..." graphs) were somewhat affected by the sampling procedure, particularly in the case of the L_2 and L_{10} values. This is to be expected since those statistics are based merely upon three samples (three samples/hour), together with the fact that, when sampling, short duration loud noises are easily missed but, if detected, their apparent duration is considerably amplified. In the case of the cumulative probability graphs, which are based upon longer time periods, and hence upon greater numbers of samples, close agreement was found to exist between the "sampled" and the "continuous" results, especially in the case of the time period 7:00 a.m. to 7:00 p.m.; this period corresponded to one of the assessed periods in the attitudinal survey and respective correlation study.

Table 2 - Averages of L_{50} and NPL for various land-use areas, times of day, days of week and seasons in dBA

London - Good Weather

Period	Saturday L_{50}	Saturday NPL	Sunday L_{50}	Sunday NPL	Weekday L_{50}	Weekday NPL
Residential (Quarry)						
7:00 - 19:00	55.0	69.0	52.5	69.0	56.1	73.0
19:00 - 23:00	52.2	67.7	48.5	67.0	51.3	66.6
23:00 - 7:00	47.5	63.5	45.8	65.2	45.3	66.1
Residential - Single						
7:00 - 19:00	53.1	69.4	54.5	71.3	53.0	71.0
19:00 - 23:00	49.1	62.3	52.5	69.7	49.7	67.0
23:00 - 7:00	45.4	56.7	46.5	59.3	45.0	61.9
Residential - Institutional						
7:00 - 19:00	53.7	72.2	53.7	74.9	56.7	75.5
19:00 - 23:00	51.5	69.7	51.3	69.6	52.9	72.1
23:00 - 7:00	48.1	57.8	47.2	59.9	45.5	58.7
Residential - Commercial						
7:00 - 19:00	60.1	76.4	58.5	77.3	63.2	77.7
19:00 - 23:00	55.7	71.6	57.3	75.0	59.1	72.1
23:00 - 7:00	50.7	69.8	51.0	70.2	53.2	75.1
Residential - Mixed						
7:00 - 19:00	57.3	74.0	54.0	73.6	56.9	73.7
19:00 - 23:00	54.0	71.6	51.7	71.0	52.8	68.7
23:00 - 7:00	49.7	63.4	45.4	64.4	49.1	64.5
Residential - Industrial						
7:00 - 19:00	56.4	72.6	54.1	71.6	57.5	73.6
19:00 - 23:00	54.5	69.3	53.0	68.3	53.6	68.8
23:00 - 7:00	50.5	67.5	47.7	63.5	50.8	67.7

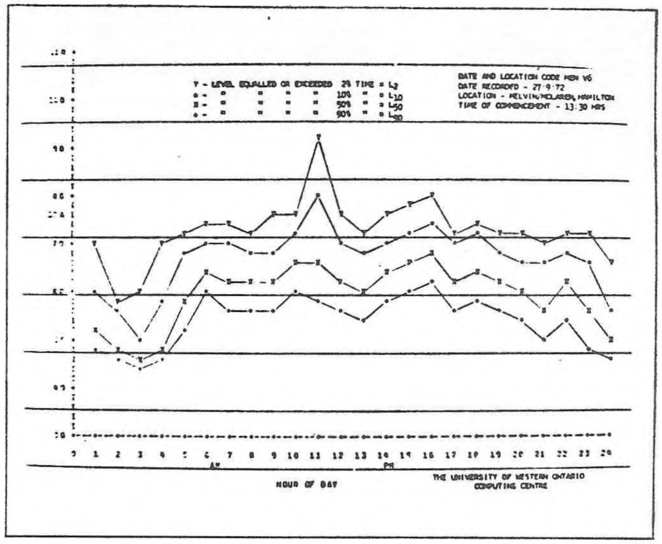

Figure 3 - Typical plot of levels exceeded 2, 10, 50 and 90 percent of the time, by the hour

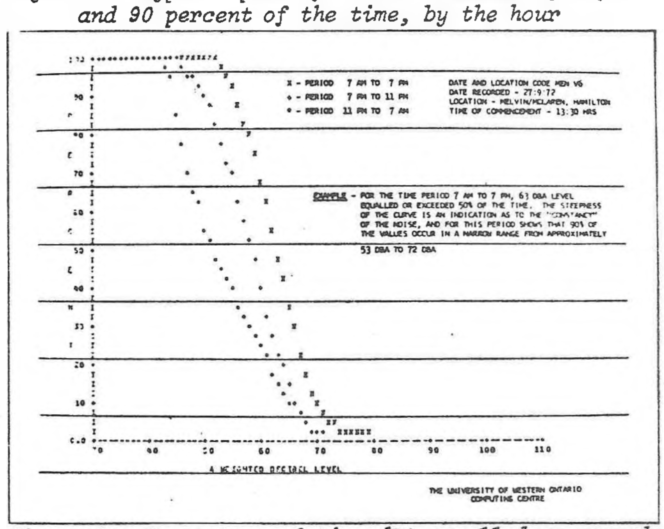

Figure 4 - Percentage of time dBA equalled or exceeded during three time periods

A comparison between the L_{peak}, $L_{2.5}$, L_{10}, L_{50} and L_{90} values extracted from these latter graphs and the appropriate TNI and NPL values showed that the variation between the "sample" and the "continuous" values for L_{10}, L_{50} and L_{90} was greater than 2 dBA in only one instance and was frequently less than 2 dBA.

Table 3 - Maximum difference in dBA between the "continuous" and "sample" L_{50}, TNI and NPL values for the three time periods

Location	Time Period	ΔL_{50}	ΔTNI	ΔNPL
Residential-Commercial	7:00 - 19:00	1	4	2
	19:00 - 23:00	2	7	3
	23:00 - 7:00	2	8	4
Residential (Single Family)	7:00 - 19:00	1	4	2
	19:00 - 23:00	1	1	1
	23:00 - 7:00	1	12	6

Table 3 shows the maximum variation between the L_{50}, TNI and NPL values for the "sample" and "continuous" analyses for the three time periods for the two locations. For both locations, it may be seen that the TNI value is more affected by the sampling procedure than either the L_{50} or NPL. This is again to be expected, since it has a heavy dependence upon the L_{10} - L_{90} value (it being weighted by a factor of 4) which is likely to be affected by the sampling procedure. For similar reasons, though to a lesser extent, the NPL value is more affected by the sampling procedure than the L_{50}.

In summary, it would appear that the sampling procedure used is likely to provide considerable under or over estimation of peak or near peak values, especially on an hourly basis, but, over the longer time periods of 7:00 a.m. to 7:00 p.m. etc., the L_{10}, L_{50} and L_{90} values are reasonably representative of the true values. The value $L_{10} - L_{90}$, however, may tend to err rather more due to the possibility of compounding errors; thus the TNI values, which involve this value weighted four times, may be somewhat in error.

Results From Attitudinal Survey

The object of the study of the attitudes of the residents of London and Woodstock to the noise in their neighbourhood was to see whether these people reacted to noises in accordance with the degree of noise measured by the objective measuring instruments in the neighbourhood or whether the attitudes of people were independent of the objective noise level measures.

In addition, it was of interest to know which noises were most bothersome in the neighbourhoods, at what times during the day and year, what citizens had done about bothersome noises and what they were prepared to do about them.

Sample. The object of the sampling design was to find a probability sample of people to interview within a reasonable range of the point at which noise levels were being monitored. A multi-stage probability sampling of blocks was carried out in the six areas in which noise measurements were being taken. Within each of the blocks drawn in the sample, interviewers located respondents on a pre-designed format which was congruent with the maintenance of probability sampling. In total, eight hundred householders were interviewed.

An analysis of the data collected indicated that the sample population was widely representative of the people living in the areas in terms of age, income and education.

Questionnaire: Design, Reliability and Validity. Questions were designed in order to achieve the maximum amount of information in as short a time as possible, that is, to get the full range of people's responses to noise in their neighbourhood while not taxing their patience with the interviewers. An analysis of the questions and the responses indicated that there was a high degree of reliability in response.

Each of the questionnaires was pre-tested and refined over a period of some months. The interviewers were trained in the goals and methods of sampling and asking questions and were carefully supervised throughout the project.

Highlights of Social Survey. The following summarize the major general findings of the social survey.* Specific reference to a correlation between attitudinal responses and physical measurements will be dealt with in a later section.

Perceptions of Noise Levels

Responses to a question asking respondents to estimate the degree to which they were bothered by noise in their neighbourhood showed that 36% were not bothered by noise at all, or reciprocally, 64% of respondents were bothered by noise to some extent. Only 3% of the people interviewed said they were extremely bothered by noise and, on a scale of one to seven where one was "not bothered at all" and seven "extremely bothered", 73% of the respondents were bothered to a degree of only 4 or less. Thus one can report that less than a quarter of citizens were really bothered by the noise in their neighbourhood.

A whole series of questions were then asked about noise and its effects and, at the end of the interview, the questionnaire returned to the first questions and asked the respondents to estimate the degree to which noise bothers them on a scale of 1 (low) to 7 (high). This was to test the extent to which the process of being interviewed had caused them to change their perceptions of noise in their neighbourhood. The change in response was marginal. In fact, if anything, people responded to the end of the scale which indicated not being bothered by noise, but the differences were not statistically significant.

Most Bothersome Noise Sources

While there were some people who were bothered by a wide range of noises, on the whole the chief sources of disturbance were domestic (radio, television, record players, pets and garden machinery) and, outside the domestic setting, passing cars, motor cycles, diesel trucks and squealing tires.

The following percentages refer to that proportion of respondents who were bothered to any extent by the noise source mentioned. The reciprocal of the number is the percentage who were not bothered by that noise source at all.

motorcycles	55%	children	31%
passing cars	50%	record players	25%
transport trucks	43%	radio	25%
squealing tires	42%	television	23%
revving engines	42%	passing trains	20%
domestic pets	36%		

Action Taken

When respondents were asked what action they had taken to control these noises in their lives, it was found that 85% had taken no action whatsoever. Of the remaining 15% some had called the police, some had told the person causing the noise that it was disturbing them and a few had moved to a quieter neighbourhood - or planned to.

Effects of Noise Upon Health

Respondents were asked if they felt that the noise in the neighbourhood was harmful to their health. Seventy percent felt that it was not at all harmful. Of the other 30% only 1% felt that the noise was very harmful to their health with a range of other responses indicating that the others felt it to be only somewhat harmful to their health.

Alternatively, the question was asked to what extent loud noises over a length of time contributed to a number of disorders including hearing loss, irritability, headaches, nervousness and insomnia; quite a number of citizens felt that it did indeed contribute to these conditions. The percentage of respondents who felt that noise contributed at all to these conditions is given below:

hearing loss	75%	headaches	65%
nervousness	76%	insomnia	65%
irritability	81%		

Perceptions of Legal Protection

There are municipal by-laws regarding noise in the cities studied (though they are interpretive and somewhat unenforceable). Thirty-four percent of respondents thought there were by-laws while 22% thought there were not. Another 44% did not know. When asked the degree to which they felt the laws protected them against disturbance by noise, the majority of respondents straddled the fence and said the laws protected them neither well nor badly.

Noise Pollution Compared to Air Pollution

Very little difference was perceived by these residents of London and Woodstock between the problem of noise and air pollutions in their neighbourhoods.

*Prepared by E.B. Harvey, Ontario Institute for Studies in Education, and L.R. Marsden, Population Research Group, University of Toronto

Thirty-six percent felt that air pollution was not a problem at all and 40% felt that noise pollution was no problem at all; 21% felt that air pollution was a little bit of a problem and 22% felt that noise was a little bit of a problem. At the other end of the scale, 3% felt air pollution to be an extreme problem and 2% felt that noise was an extreme problem. Neither form of pollution was felt to be a major problem in the neighbourhoods studied.

Noise Disturbance and Time of Day

Noise was seen as more of a problem during the day and evening by most people and not much of a problem from midnight to early morning. Only 5% of the respondents worked 24-hour shifts.

With respect to the comparison between weekends and weekdays, there was little difference. Fifty-four percent of respondents found noise something of a nuisance on weekends and 55% found it somewhat bothersome on weekdays. Only 8% more respondents said noise was extremely more bothersome on the weekends.

Seasonally, summer was found to be the noisiest season, followed by fall and spring and then winter.

Paying for Noise Abatement

Asked if they were willing to pay for noise abatement procedures in their neighbourhood, 79% of the citizens were not willing to pay anything at all; 21% were willing to pay between $1 and $100.

Correlation between Physical Measurements and Subjective Responses. As mentioned at the outset of this article, it was intended to examine the degree of correlation between (1) a modified A-weighted sound level (such as L_{50}) and (2) a conventional rating scale (Noise Pollution Level NPL) and subjective responses in community land-use areas. To date, this examination has been restricted to the results for the good weather survey of the City of London, but it is intended that the analysis should be extended subsequently to Woodstock, and London and Woodstock combined.

The results of the above correlation study are summarized in Table 4 which presents correlation coefficients for selected NPL values and L_{50} values with the percentage of respondents scoring "noise bother" $\geq$ 2 or $\geq$ 5 on a 7-point scale. It may be interpreted that the percentage of respondents scoring noise bother $\geq$ 2 is the percentage which is *at all* bothered by noise, whereas the percentage scoring $\geq$ 5 is that percentage which is *highly* bothered by noise. The results shown in column 1 of Table 4 suggest that there is good correlation between the L_{50} and NPL values, determined over 24 hours and averaged for Saturday, Sunday and a weekday, and the percentage of respondents *at all* bothered by noise; there is also a good correlation between the daytime L_{50} values, either weekday or averaged for Saturday, Sunday and a weekday, and the respondents *at all* bothered. The results of column 2 indicate that there is less correlation between the percentage respondents *highly* bothered by noise and all L_{50} or NPL values. However, examination of the correlation between the percentage of respondents *highly* bothered by the *ten most significant* noises with the NPL and L_{50} values, as given in column 3, shows that good correlation exists for the daytime NPL values, while there is little correlation in the case of the remainder.

Figures 5, 6 and 7 graphically illustrate the relationship between the subjective response and the various NPL and L_{50} values for the six cases in which the higher correlations were observed.

The results presented tend to suggest that, for the City of London, both the NPL and L_{50} values give acceptable assessments of the subjective sensation of noise, the former seemingly partially related to *high* degrees of annoyance and the latter to *any* degree of

Table 4 - Correlation coefficients associated with the percentage of respondents bothered by noise and average NPL and L_{50} values for the City of London

Index	Percentage of Respondents Scoring Noise Bother		
	$\geq$ 2 All Noises	$\geq$ 5 All Noises	$\geq$ 5 Ten Most Significant Noises*
NPL, 7:00 to 19:00, Average of Saturday, Sunday and Weekday	0.76†	0.60	0.86
NPL, 7:00 to 19:00 Weekday Only	0.73	0.58	0.82
NPL, 24 hour, Average of Saturday, Sunday and Weekday	0.88	0.73	0.65
L_{50}, 7:00 to 19:00, Average of Saturday, Sunday and Weekday	0.85	0.69	0.57
L_{50}, 7:00 to 19:00 Weekday Only	0.86	0.71	0.64
L_{50}, 24 hour, Average of Saturday, Sunday and Weekday	0.91	0.78	0.55

**The ten most significant noises are those for which the highest correlation was obtained between the response of the interviewees of each land-use area to individual noise sources and their overall response to noise.*

†These values were computed on the basis of six data points in each case, corresponding to averaged response and levels in the six land-use areas. Thus, using a two-tailed test of Student's distribution, the minimum values of the correlation coefficients for probability levels of 1%, 5%, 10% and 20% are found to be 0.92, 0.81, 0.73 and 0.61 respectively.

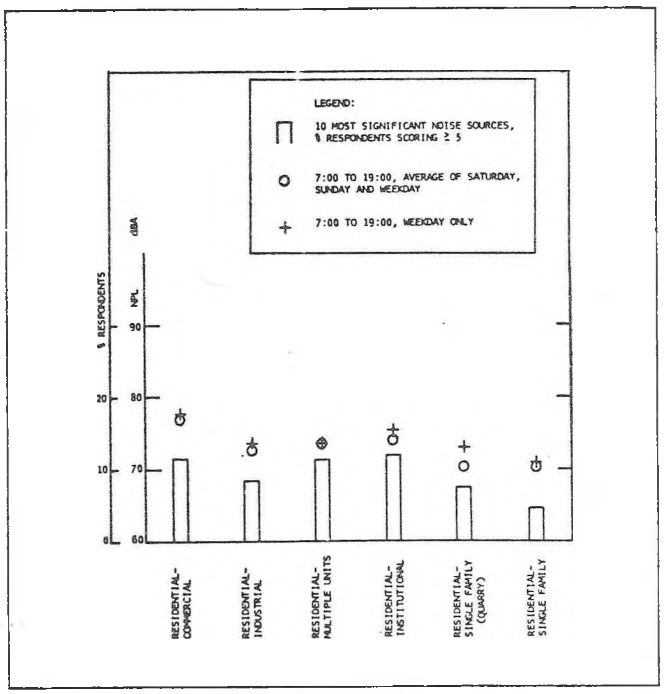

Figure 5 - Noise Pollution Level (NPL) and percentage of respondents scoring "noise bother" $\geq$ 5 on a 7-point scale for London land-use areas, good weather

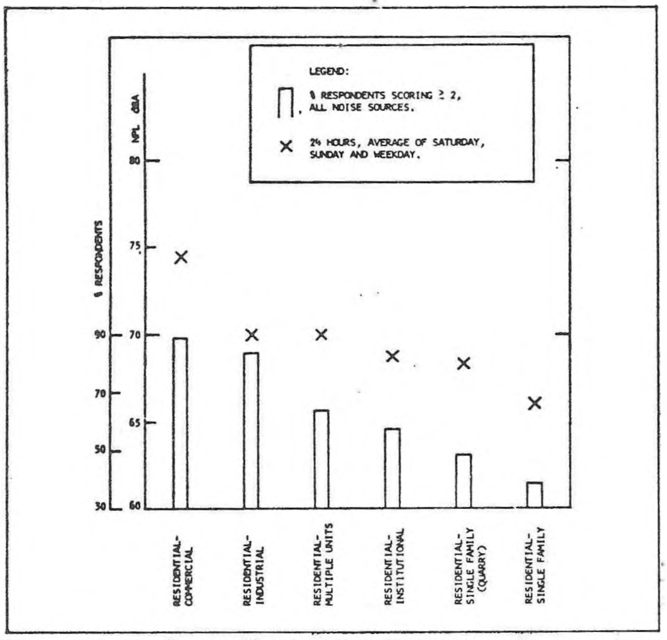

Figure 6 - Noise Pollution Level (NPL) and percentage of respondents scoring "noise bother" ≥ 2 on a 7-point scale for London land-use areas, good weather

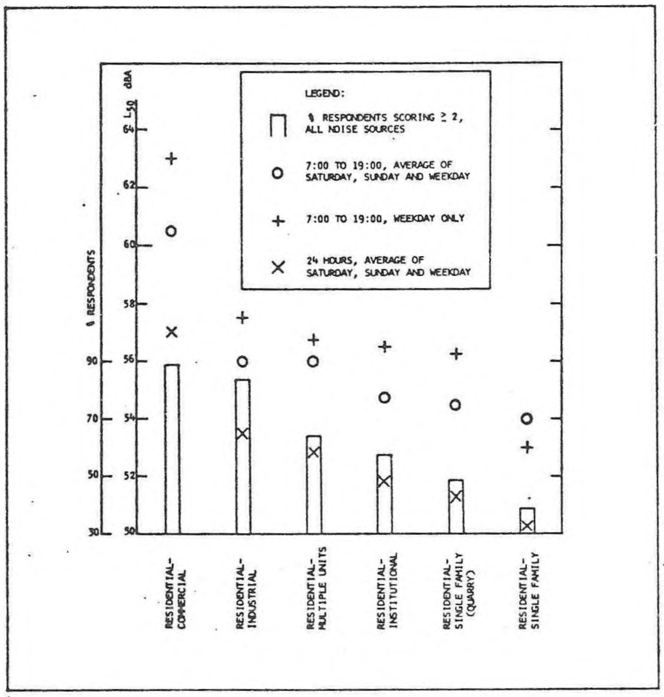

Figure 7 - Noise Level L_{50} and percentage of respondents scoring "noise bother" ≥ 2 on a 7-point scale for London land-use, good weather

annoyance.

It should be recognized that the correlation results presented are each based upon only six data points, although each of the six points was derived from the considerable amount of physical measurement and attitudinal survey data gathered from one of the six land-use areas of the city. It should also be observed that the correlation study conducted to date is of a preliminary nature and that it is intended that further studies should be conducted in this area.

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Acknowledgement

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NOTICE BOARD

A new journal "Acoustic Imaging and Holography" has been established and will publish its first issue shortly. It is proposed that this journal be restricted to research which concentrates on obtaining visual images of objects irradiated by sound or to research which deals with visual images of sound fields.

The Editor-In-Chief and the man to whom manuscripts should be submitted is

E. Eugene Watson
Wolverine Tube Division
Universal Oil Products Company
P.O. Box 2202
Decatur, Alabama. 35601

Additional information about this journal can be obtained from one of the Associate Editors who is our own Dr. H.W. Jones at the University of Calgary.

MINUTES OF BUSINESS MEETING OF CAA

9 October 1975

Held in the Auditorium of Ontario Hydro Head Office, Toronto.

R.J. Donato, Physics Division, National Research Council,
Ottawa, Ontario, K1A 0S1.

Thirty-eight people attended the business meeting which began at 6:00 p.m. The minutes of the 1974 meeting, published in the October 1974 Newsletter, were passed.

NEWSLETTER: EDITOR'S REPORT

T. Embleton reported that the circulation of the Newsletter had now reached 520, up from a little over 300 a year ago. D. McKay at the Federal Ministry of the Environment was responsible for the circulation list being kept up-to-date as well as the mailing of the Newsletter. It was recognized with our sincere thanks that this service was still provided free. G. Faulkner had worked with the editor over the past year and as the editor wished to resign this year he suggested that G. Faulkner be his replacement.

The Chairman, H. Jones, asked if the retiring editor had any comments to make about the editorial board, and the present editor suggested that his successor might like to make some decisions when elected. A second member would probably be needed to help with the organization and the question of regional correspondents needs to be looked at again. The chairman moved the acceptance of the editor's report coupled with a vote of thanks for his several years' work. The motion was seconded by E. Bolstad and carried.

TREASURER'S REPORT

E. Bolstad reported that following the settlement of accounts of the 1974 meeting the cash on hand was now $36.25, and the monies were deposited with the Bank of Montreal, Gold Bar Branch, Edmonton. The Treasurer felt it only a matter of time before the Association would be forced to adopt a more formalized structure if it were to accomplish its avowed purposes. Without such a structure neither criteria for membership nor a fee structure would be possible. Even with our present structure some expenditure is needed. For instance stationery could cost between $50 and $100 a year, and communicative costs might run to $150. The auxiliary services supplied at the annual meetings (programmes, mailing, etc.) could vary between $200 and $300. If we face the situation when the costs of the Newsletter is not carried by the federal government, $500 to $700 a year might be needed. The treasurer felt the mailing list was not as complete or as accurate as it could be and a further fee of $250 to $300 a year might be needed for this.

Sources of funds could be registration fees at the annual meetings, sustaining donations and membership fees, although these would have to be voluntary donations until formal membership status was established.

Publication costs could be obtained from an NRC publication grant, and if the free service given by the Ministry of the Environment ceased, by advertising and a commercial or card service.

B. Dunn proposed acceptance of the Treasurer's report, L. Kende seconded and the motion was carried.

SECRETARY'S REPORT

We are now included on the International Commission on Acoustics list of National and International Acoustical Societies. There are 36 members on the list ranging alphabetically from Australia to Yugoslavia. We are also a corresponding Society of NOISE NEWS published bimonthly by INCE (Institute of Noise Control Engineering) and as members may receive Noise News at $9 instead of $18 p.a.

G. Faulkner moved and C. Sherry seconded acceptance of the secretary's report - carried.

CHAPTERS

At an executive meeting held in Ottawa in April 1975 changes in the organization were discussed. One idea which seemed to be universally accepted was the formation of regional chapters of the Association. Accordingly E. Shaw was requested to investigate this proposal. In his report, presented at this meeting, he felt the CAA was well established as a forum but that a large number of people do not come very often to the annual meetings, and graduate students probably never. These people need others to talk to and it is suggested that they meet as chapters two or three times a year. Natural geographical areas would be Halifax, Montreal, Ottawa, Toronto-Hamilton-London, Edmonton-Calgary, and Vancouver-Victoria. In response to an exploratory letter sent on 25 September 1975, three written replies had been received and two verbal comments. One respondent had suggested that 15 people might be needed for a meeting drawn from a pool of 60 in this area and that perhaps the only area sufficiently large would be Toronto-Hamilton-London; and unless there were real support it was better not to start. E. Shaw proposed no formal resolution but felt that should members feel the idea to be valid they might like to experiment with it. The structure need not be the same in all regions and could be kept informal.

D. Whicker questioned whether a reduction might result in members attending annual meetings if chapters were formed, although we might now be big enough to afford this. C.W. Bradley predicted the opposite and drew a parallel to this idea and the early meeting of the CAA (then the CCA). E. Bolstad was afraid of too formal a structure at the local level and stressed we needed informality there while striving for more formality in the CAA itself. The chairman asked if definite action were to be proposed but C.W. Bradley felt that either someone should be named from each region or volunteers sought. G. Thiessen and T. Embleton backed up the Shaw report and were content to see the results at next year's annual meeting. S. Abel warned that unless someone were designated as a regional organizer nothing would happen. K. Smith and E. Bolstad both drew attention to the chapter-like body in Alberta which organized the 1974 meeting. D. Whicker suggested interested people write to the new secretary (Sec.note: see end for comment) to obtain a new mailing list and B. Dunn suggested a mailing list of the Newsletter be sent to each member; L. Hegvold suggested corner stone names be given. J. McKay cautioned that chapters should be kept spontaneous and informal. The secretary wondered whether the organization of chapters might follow the path of regional editors and contributors. Two regional editors present, G. Jones and L. Russell, stressed the initial interest shown in the regions followed by the paucity of actual contributors. In any case, the Eastern Region might be too small to support such a system. S. Handemann requested a list of Montreal members. D. McKay, responding to comments on the mailing list, mentioned some troubles he was having with their computer retrieval system. The capability was not yet present for category retrieval, or for the inclusion of telephone numbers. These problems were being worked on as well as that of adding new names to the list. E. Bolstad offered to edit the newsletter list into a form suitable for publication. Finally E. Shaw related how Oslo had been holding weekly seminars in acoustics for some years. All the local acousticians attend and discuss their work, papers in preparation and in fact any papers of interest they might like to bring to the group's attention. No formal organization is needed.

H. Jones recommended acceptance of the Shaw report - seconded by S. Abel - carried.

INTERNATIONAL INCE

The chairman gave a brief outline of this organization. It was founded in October 1974 with the aims of sponsoring international conferences, exchange of information and news, promotion of cooperation in noise control research and the application of engineering techniques for noise control, and the development of interdisciplinary contacts. Membership is open to non-profit societies having noise control interest. A Newsletter is published and finances are levied to each member society (300 Swiss francs ≃ $110 p.a.). The CAA received an invitation to join in June 1974 and only two written responses were received from the executive - one for and one against. It was decided to defer a decision until the present meeting.

E. Shaw pointed out that the Acoustical Society of America had declined a similar invitation on the ground that INCE was not a Scientific Society. ICAO also declined as it is contrary to the rules of the Commission. At the moment we have a corresponding editor to American INCE. J. Foreman felt membership of Int. INCE would give an example of the visibility we are trying to establish. The comparison with the ASA was not really valid as our Association had no terms of reference. He forecasted future change in our organization (formalization without institutionalization) in order for us to fulfill our obligation to Canadian acousticians. Int. INCE, while it may not directly help us, would make our identity known. He foresaw us standing more on our own feet in the future, depending less on the generosity of government, and with membership criteria, fees, and the publication of papers in a Proceedings. Our impact would increase with more formality, all the more necessary as much contractual acoustical work is going out of the country. Representations to government are ignored. He drew a parallel with the growth of the Canadian Society of Mechanical Engineers from humble origins to a flourishing concern. C. Sherry questioned whether we should decide now or find out more about Int. INCE before the next meeting. He proposed this last as a motion, seconded by E. Bolstad. G. Faulkner thought we would be better able to comment after we had discussed our own statute. T. Embleton pointed out that Int. INCE as a confederation of Noise Control bodies had only US INCE at the present; by joining we might be forced to become a body like US INCE. H. Jones wondered how we should fit in and was it a question of being an Acoustical Association or a Professional Institute of Noise Engineers? C. Sherry felt we might lose some of our strength or chance for growth by restricting our field. J. McKay suggested a decision could well be delayed for years. E. Shaw felt the question largely academic as Int. INCE were asking US to share the management and financial support when we don't even manage our own. The motion was carried.

LEGAL STATUS

The chairman reported that J. Foreman and D. Allen have supplied some information on our legal position as they were requested at our 1974 meeting. The choice reduced to either becoming a formally constituted Society claiming to represent the interests of acoustics in Canada, or of remaining as we are. J. Manuel mentioned that with the formality would go auditing which could conceivably create a large hole each year in any funds we might have. D. Whicker and H. Jones thought there could be other legal implications and that we could be sued collectively. E. Bolstad stated that there was a difference between being a society and being incorporated; incorporation was usually carried out as any one having a written constitution may be sued. In fact, if fees were ever charged and income tax deductions claimed incorporation became essential. B. Dunn suggested perhaps we might prepare a rough draft of a constitution. D. Whicker proposed and W. Barss seconded a motion that the incoming executive form or appoint a committee to prepare a draft constitution with the object of formalizing our association to be either presented at the next annual meeting or circulated beforehand. L. Kende agreed with the first part of the motion but not the second. B. Dunn thought we should need a constitution one day and that considerable time would be spent in discussing it. S. Handelmann wondered whether we were putting the cart before the horse. J. McKay, who said he would vote for the motion reluctantly, stressed that all we were doing was giving ourselves a year's preparation. The motion was carried.

The chairman asked the meeting whether they agreed to a listing of the CAA in the various directories (Canadian Almanac, Corpus Directory and Almanac) with our Newsletter listed in the Canadian Serials Directory. Agreement was given.

FOREIGN CONSULTANTS IN CANADA

D. Whicker brought up the problem of foreign acoustical consultants being employed by both private and governmental bodies in Canada. He pointed out that the Canadian client usually does not obtain the necessary follow-up arising from these contracts. The Canadian consultant rarely has an opportunity for obtaining similar contracts in the U.S. where restrictions are placed on his employment. He suggested that the CAA should make recommendations to the federal government in order that Canadian expertise in these fields should be recognized and assisted, and that immigration officials set up reciprocal (not restrictive) regulations. D. McKay pointed out the federal government has a policy for federal agencies to give priority to Canadians and L. Hegvold knew of examples of this. J. McKay pointed out that sometimes the Canadian agent hires the US firms. E. Bolstad recalled that every government says they will favour hiring Canadian talent but he feels a positive approach should be made to government. He proposed that the CAA present recommendations to the several governments in Canada that they examine the acoustical expertise present in Canada rather than selecting consultants outside the country. L. Hegvold seconded. J. McKay in supporting the motion blames the problem on managers. The secretary questioned how many governments the proposer had in mind and E. Bolstad replied federal, provincial and eight municipalities in Ontario alone. L. Kende saw the merit in the motion and favoured a stronger type of motion. He felt that international corporations would bring in their own consultants anyway. J. Baine did not feel that writing to governments would be sufficient. He suggested allying ourselves with another body of more substance to make representations. Two bodies who had made similar representations in the past were the APEO (Association of Professional Engineers of Ontario) and ACEC (Association of Consulting Engineers of Canada). T. Embleton questioned the scale of the problem and H. Jones thought that between 20 - 50% of the contracts were going to foreign consultants. D. Whicker knew of 3 or 4 consulting jobs in B.C. alone that had gone to outsiders. E. Bolstad drew attention to the fact that it was always the significant assignments that leave the country. The general opinion was that the problem was not confined to acoustics but was general. D. Whicker added the amendment, seconded by L. Kende, that the executive contact the relevant federal ministers recommending the provision of reciprocal regulations to the employment of consultants. A second amendment proposed by J. McKay, seconded by D. McKay, was that a copy be sent to ACEC and APEO. Both amendments and the original motion were carried.

DIRECTORY OF MEMBERS OF CAA

M. Fayers proposed that the executive prepare and publish an up-to-date membership list of the CAA. D. Whicker seconded and the motion was passed.

ELECTION OF OFFICERS

The following officers were proposed and elected:-

Chairman	H. Jones
Treasurer	E. Bolstad
Editor of Newsletter	G. Faulkner

The secretary announced his intention to resign. A. Edwards was proposed and elected (see below).

CHANGE OF TITLE

The title of chairman be changed to president. Proposed by J. Manuel and seconded by K. Smith - carried.

NEXT YEARS MEETING

Our original plans to hold next years meeting in Halifax-Dartmouth had run into a slight snag as explained by L Russell. It was hoped to clarify the situation within the next two weeks. D. Whicker proposed a vote of thanks to this years convenors - J. Manuel and A. Edwards. This was coupled with a vote of thanks to the retiring members of the executive proposed by H. Jones. S. Abel moved the motion and D. May seconded: carried. The meeting was adjourned.

RETURN OF THE SECRETARY

Something of a comedy of errors arose out of the election of a new secretary. As you will recall A. Edwards had been elected to this post at the meeting. One of the executive had asked him whether he would be willing to serve and he had not given the impression of being entirely adverse to the idea. Unfortunately, when the voting was carried out he had left the meeting. On the following day he regretfully declined because of his many other committments. In view of this your past secretary becomes your present secretary and as he was tempted to say in the discussion of chapters, "things next year won't be any verse".