1813

# ACOUSTICS AND NOISE CONTROL IN CANADA

THE CANADIAN COMMITTEE ON ACOUSTICS

• • • • • • • • • • • • •

# L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

LE COMITÉ CANADIEN DE L'ACOUSTIQUE

JANVIER 1974
VOL.2, N°1

JANUARY, 1974
VOL.2 No.1

ACOUSTICS AND NOISE CONTROL IN CANADA

L'ACOUSTIQUE ET LA LUTTE ANTIBRUIT AU CANADA

## CONTRIBUTIONS

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

## SUBSCRIPTIONS

Acoustics and Noise Control in Canada is distributed free. To have your name put on the mailing list, please contact Donald H. McKay, Environmental Protection Service, Department of the Environment, Ottawa, Ontario K1A 0H3.

This newsletter is published by the Canadian Committee on Acoustics. Coordinating, printing and other administrative services are provided by the Canadian Broadcasting Corporation, the Department of the Environment and the National Research Council. The contents of the newsletter and any opinions expressed are the responsibility of the authors and do not necessarily represent the views of the Canadian Committee on Acoustics or the Canadian Government, its departments or agencies.

(continued on inside back cover)

o o o o o o

## CONTRIBUTION

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.

## SOUSCRIPTION

L'acoustique et la lutte antibruit au Canada est distribué gratuitement. Veuillez communiquer avec M. Donald H. McKay, Service de la protection de l'environnement, Ministère de l'Environnement, Ottawa (Ontario), K1A 0H3, pour faire inscrire votre nom sur la liste d'envoi.

Ce bulletin d'information est publié par le Comité canadien de l'acoustique. La société Radio-Canada, le Ministère de l'Environnement et le Conseil national des recherches s'occupent de la coordination, de l'impression et d'autres services administratifs. Le contenu du bulletin ainsi que les avis exprimés ne représentent pas nécessairement l'opinion du Comité canadien de l'acoustique ou du gouvernement du Canada et des ministères et organismes fédéraux; ce sont les auteurs qui en assument la responsabilité.

(suite au recto de la couverture inférieure)

## CONTENTS/TABLE DES MATIERES



* * * * * *

## REPORT ON THE BALLOT FOR CHANGING THE NAME OF THE ORGANIZATION - CANADIAN COMMITTEE ON ACOUSTICS


R.J. Donato,
Building Physics Section, Division of Building Research,
National Research Council, Ottawa, Ontario. K1A 0R6
Secretary, Canadian Committee on Acoustics


A total of 75 ballots were returned, 50 from members and the remainder from readers of the Newsletter not on our mailing list of members. To refresh your memories the options were:

1. Canadian Acoustical Association
2. Acoustical Society of Canada
3. Canadian Committee on Acoustics
4. Any other name

Readers of the Newsletter were asked to rank order their choices.

On a count of first choices we find 33, of whom 24 were members, picked Option #1, and 29 including 15 members chose Option #2. Adopting a proportional representation scheme and sharing the second votes of those who made either #3 or some other name their first choice between #1 and #2, the scores are 39 (29) for #1 and 33 (19) for #2. (The bracketed figures refer to members, and the unbracketed the total vote.)

The conclusion is that Option #1 wins and that we are now the Canadian Acoustical Association/Association Canadienne de l'Acoustique.

* * * * * *

# AIRPORT NOISE: PERSPECTIVES FROM A REGULATORY AGENCY **

L.T. Filotas
Civil Aviation Planning & Research
Ministry of Transport
Ottawa, Ontario K1A 0N5

With deaf'ning clamour in the slippery clouds
That with the hurly death itself awakes?

W. Shakespere
King Henry IV, Part II, III.

## INTRODUCTION

Most readers will be familiar with charts listing 'typical' noise levels associated with common activities. After attributing the lowest level to some innocuous source - perhaps 'rustling of leaves' - this kind of list will climb through a succession of items such as 'normal conversation', 'home appliances' and 'automobile horns'. And the chief villain topping the list? Almost certainly the jet airplane. As chief regulator of this putative chief villain, the Civil Aeronautics Branch of the Ministry of Transport is the government agency most directly concerned with aircraft noise control and bears the brunt of the public's often vociferous complaints.

Despite stiff competition disputing the jet's community noise championship - notably from road traffic - there seems little doubt that airplanes generate the loudest levels involuntarily experienced by many people. At any rate, many of our larger airport's neighbours are disturbed deeply enough to devote considerable time to lobby against this unfortunate adjunct of the jet age. Accordingly, and quite properly, noise control is becoming increasingly predominant in airport planning and operations. This article examines - informally, from a working level perspective in a federal regulatory agency - some aspects of airport noise: in particular, it reviews the MOT's current practices and future hopes.

## SCOPE OF THE PROBLEM

It is true that light aircraft sometimes cause considerable nuisance in the vicinity of smaller aerodromes. It is also true that noise from seaplanes or helicopters is not always restricted to the neighborhood of any airport. However, aircraft noise poses a major social problem, by and large, only near the major airports. (In Canada these are all owned

---

** The opinions expressed in this article are solely the author's - not official views of the Ministry of Transport.

and operated by the MOT.) Mainly, but not exclusively, affected are those residential communities repeatedly overflown during take-off and landing operations. Engine run-ups for maintenance and other ground noise sources can also contribute but are more readily controlled by standard measures.

The Anglo-French supersonic transport, Concorde, is expected to enter regular commercial service in 1975. During supersonic cruise its shockwave system will seranade the population below with the notorious sonic boom. Several federal government agencies are currently sponsoring sonic-boom research, particularly as relevant to distinctly Canadian problems (effects on native wild-life and boom propagation over ice and snow are examples). However, in the absence of generally accepted limits a recent MOT Air Navigation Order has made it clear that commercial supersonic flights will not be permitted to boom Canadians. Thus, Concorde, should it ever operate in Canada, will be required to fly subsonically and will influence the airport noise environment similarly to other large jets.

Authorities charged with control of community noise face a host of complex multi-faceted problems: the basic issues, involving technology's impact on society and the quality of life, are deeply profound and far-ranging. Indeed, questions concerning imposition of noise on unwilling listeners may be framed in terms of fundamental human rights. Hence, it is not surprising that, in common with other environmental problems, airport noise control cannot be readily slotted into historically drawn bureaucratic boundaries.

In the federal government alone, besides the MOT, the Departments of Environment, Health and Welfare, Wildlife, Regional Economic Expansion, Industry Trade and Commerce as well as the Central Mortgage and Housing Corporation and the Canadian Transportation Commission all share concern for some aspect of airport noise. Even within a single agency conflicting requirements (between, for example, noise control and safety margins) can lead to highly charged confrontations among civil servants primarily dedicated to championing different sets of public interests.

In the absence of formal criteria balancing social costs of airport noise against benefits of air travel, regulatory authorities have traditionally assumed, more or less as an article of faith, that the public's utilization of air travel, air mail and air cargo amply demonstrates its requirement and endorsement of such services. In 1973 approximately thirteen million Canadians, through their purchase of tickets on scheduled carriers, helped provide the statistics to shore up such beliefs. The widespread opprobrium heaped upon Malton Airport's now notorious Terminal II also serves witness to the public's interest in and emotional involvement with aviation facilities. Thus, the regulatory approach has been aimed (and, for some time to come, will probably continue to be aimed) at providing general conditions allowing air service to expand while fighting a rearguard action to minimize the ensuring noise nuisance.

Formal analysis of technologies in order to weight social consequences of alternate strategies - technology assessment - is yet in its infancy. No doubt the current 'energy crisis' will bring into sharper focus our urgent need for such analysis and help develop ways to assess quantitatively the noise control options. In the meanwhile we struggle along with ad-hoc criteria on an agency-by-agency basis.

The Civil Aeronautics Branch has recently taken some hopeful first steps toward establishing the administrative machinery for the formulation and enforcement of coherent airport noise policies. A newly formed committee with representatives from all concerned divisions - Flight Standards and Regulations, Aviation Safety, Airworthiness Requirements and so on - is charged with re-examining, rationalizing and expanding all noise related activities.

NOISE CERTIFICATION

Over the past decade the Aviation Industry has, on a world-wide basis, undertaken a remarkably intense noise reduction program, recognizing that compatibility with airport neighbors is essential in its own long-term self-interest. After all, we need only consider the example of the railroads which, a generation ago, committed economic hara-kiri through blatant disregard of public opinion. Anyone with normal hearing may verify the improvement (and the desirability for yet more measures!) by spending some time under an approach path to a major airport and noting the difference in noise levels generated by one of the new wide-body tri-jets (L-1011 or DC-10) and other large aircraft.

These newer jets demonstrate the most straight forward path to control of airport noise: reduction of source strength. Many varied and ingenious technical approaches are extensively documented. I comment here only on the importance of bearing in mind the distinction between sound power and noisiness. Aircraft noisiness can be reduced without a corresponding reduction in sound power: for example by redistribution of acoustic energy to benign ranges of the spectrum or by cunning use of engine/airframe geometry to change directivity. Since the loudest source always dominates an acoustically heterogeneous environment, replacement of the noisiest current airplanes by newer models producing about 10dB less noise will be heartily welcomed.

American agencies have taken the regulatory lead through introduction of noise requirements as a precondition to the granting of airworthiness certificates. In 1969 standards were adopted limiting noise generated by subsonic jets. These were recently extended to cover newly manufactured examples of airplanes whose type certificate was granted prior to 1969 and to smaller "general aviation" aircraft. The Americans are currently formulating rules to force "retrofit" of older airplanes.

Canada's lack of similar standards is no big copout: the major contributors to our airport noise being of American manufacture. (Over 85% of Canada's total commercial fleet is American made. The largest non-American aircraft: Quebecair's three 65 passenger BAC-111's.) Our immediate concern is to ensure that Canadian carriers operate only the latest and quietest airplanes and will not, for example purchase noisy secondhand equipment outlawed by the Americans.

The MOT is exploring a rather different approach to noise certification - more appropriate to a country that is not a major manufacturer of commercial aircraft. Noise standards applied directly to airports would focus countermeasures on the quantity of ultimate interest - community noise. Such an airport noise certification scheme would tailor approach and departure routes to both aircraft type and population distribution. Specified runways may be restricted to certain types or to certain hours of operation. Though now only at the discussion stage, extension and rationalization of our present noise abatement flight procedures could eventually pave the way to a comprehensive set of regulations curtailing growth of or change in the noise dosage delivered to the airport neighbor.

## NOISE ABATEMENT PROCEDURES

The procedures adopted by the cockpit crew and air traffic control can drastically affect the pattern of noise reaching the ground during a take-off or landing. As a very obvious example, a climbing turn immediately after lift-off can shift maximum noise exposure from areas in line with runways to the right or to the left. In Canada a variety of noise abatement procedures are specified for larger airports (Montreal, Ottawa, Toronto, Hamilton, Winnipeg, Edmonton, Vancouver).

These procedures are published in 'Canada Air Pilot' - the Minister of Transport's official instructions, to aircrews using Canadian airports. Unfortunately, the procedures are often circumvented: the legality of certain ones has been challenged and so far there has been no definitive court test. The MOT is currently educating air traffic controllers, pilots and inspectors on the importance of noise abatement and is studying amendment of the regulations to make it clear that compliance is mandatory and to enable effective enforcement.

In so far as practicable current procedures are tailored to local conditions. At Montreal's Dorval Airport, for example, a noise abatement curfew restricts airport use between midnight and 7:00 A.M. Air traffic controllers assign runways so as to avoid concentration of traffic over any one section of the city. Other measures include requiring pilots to turn 20 degrees right immediately after taking off to the north-west. Should wind conditions dictate south westerly take-offs (runways 24L and 24R) thrust must be reduced as soon as practicable to offer a degree of relief to residents in a development abutting the airport fence.

I will presently discuss the noise abatement thrust cut-back in some detail. But first it should be emphasized that, in general, a host of conflicting factors influence the prescription of noise abatement procedures. Use of preferential runways can, for example, be precluded by wind conditions and influenced by fuel conservation requirements. Even as seemingly straight-forward a measure as a late night curfew can be complicated. It may have to be waived if, for instance, strong head winds or en-route mechanical problems delay an incoming flight. In practice the airport manager will accede to requests for after curfew operations under extenuating circumstances (taking into consideration the basic noisiness of the aircraft type). Exceptions may also be made to allow scheduling of extra flights to meet the Christmas season's heavy demand.

THRUST CUT-BACK

By way of illustrating the many conflicting aspects of noise abatement procedures, consider thrust reduction after take-off - a procedure not generally recommended by the MOT. Cutting back a jet engine's thrust reduces the velocity of the air exhausted from the tail pipe: for a pure jet the associated decrease in mean square sound pressure radiated to the farfield can be estimated (from Lighthill's celebrated $U^8$ Law) as being proportional to the fourth power of the ratio of the final to initial thrusts. This implies, for instance, approximately 4dB noise reduction corresponding to a 20% thrust cut-back. For fan jets the noise reduction is even less because the dominant noise, generated by engine blading, is a weaker function of exhaust velocity. In practice the permissible degree of throttling back is such that the aircraft continues climbing fast enough to clear any obstacles - even in the event of an engine failure.

Due to the reduction in climb angle (approximately equal to the change in thrust divided by gross weight) the aircraft's altitude subsequent to cut-back will be less than it would have been under full-power. The opposing effects of reduced source noise and decreased distance separating source and observer just balance at some point along the ground track. For points further out the noise reaching the ground is actually greater than without thrust reduction. By way of illustration, for a Boeing 707-320B a standard cut-back will decrease noise levels only at points between 3 and 4 miles from brake-release and by less than 2 EPNdB: subsequent points receive up to 5 EPNdB more noise than without "noise abatement". Accordingly, this practice often results in marginal relief for a few people at the expense of a larger increase for a much greater number.

To further complicate matters, meteorological conditions strongly influence both sound propagation and aircraft performance. This influence tends to be so complicated as to preclude formulation of readily applied rules of thumb (for, say, the effect of outside temperature on the desirability of thrust cut-back). Economic factors such as time between engine overhauls and - of increasing current concern - fuel consumption as well as the crew's work load are also strongly affected by the take-off/climb-out thrust schedule.

In a happy, if infrequent, confluence of effects changes in source strength and separation act in harmony to alleviate noise when thrust is reduced during landing approach. Thus raising Instrument Landing System beams from 2½ to 3 degrees is good for more than the modest 1½ dB attenuation indicated by the inverse square law. According to a recently implemented MOT policy 3 degree glide slopes are to be standard in all new installations: older 2½ degree Instrument Landing Systems are to be raised to 3 degrees as soon as possible - priority being based on traffic density.

## MONITORING

Even a cursory acquaintance with the principles of control theory indicates the need for direct sensing of the variable to be ultimately controlled. The feedback signal so obtained opens the way to the many advantages of closed-loop control: not the least of these being the possibility of positive control in face of time dependent or imprecisely defined system parameters. Thus, on-site measurement of community noise levels is fundamental to evaluating the efficacy of or the compliance with existing noise abatement procedures and determining the desirability of modifications or additions.

The MOT currently operates mobile noise monitoring vans in the Montreal and Toronto areas to check out complaints and to alert airport management of potential problems. In other areas, inspectors take isolated readings with portable meters. Extensive but short term monitoring programs aimed at determining the extent of airport noise impact have been carried out through MOT sponsored programs at Montreal, Toronto and Vancouver.

These limited programs may ultimately become the antecedents for permanent noise monitoring installations manned by full-time acoustically trained staff. An MOT group is currently studying the possibility of installing a complete monitoring system, including permanently installed microphones with a full complement of recording and computing equipment, at a single large airport. This pilot project would establish procedures, standards, cost and manpower requirements for possible general application.

## LAND USE CONTROL

Notwithstanding the foreseeable countermeasures, some areas close to busy airports are bound to continue being too noisy for residential development. Obstacles to setting certification standards or flight procedures - measures under sole purview of the MOT - can seem modest in light of the morass of conflicting interests confounding compatible land use.

Though responsible for construction of new airports and expansion of existing ones, the federal government may control land not actually owned only through limiting obstruction heights. Municipalities - always under heavy pressure to develop - are responsible (subject to provincial controls) for zoning and for financing many airport related services.

To head off possible introduction of new airports under the 'fly now, pay later' plan, the federal government can, and does, purchase more land than needed for the actual airport. For example, at the St. Scholastique site of the New Montreal International Airport 88,000 acres were expropriated: less than 20% is needed for actual facilities. Both federal and provincial governments are committed to positive action promoting compatible development of the excess.

With regard to existing sites, it's easy to postulate a sure-fire formula for trouble: take a busy airport, surround it by dense urban development. For smaller airports, not so surrounded, the job is to anticipate and head off incompatible land use. Except for outright purchase, MOT countermeasures against unsuitable development are restricted to the provision of advice and moral support to other authorities. The advice is often based on contour maps of equal noise exposure. These are used, for example, by the Central Mortgage and Housing Corporation to deny loans for residential construction in very noisy areas.

## THE "NEF" METHOD

The 'Noise Exposure Forecast' (or NEF) is a method adopted by (among others) the MOT to produce contours of equal noise exposure from airport operations. It is the single item in our noise control arsenal drawing the severest technical criticism. Very briefly: based on forecasts of future traffic the method attempts to sum aircraft generated 'noise energy' (in some reasonable sense analogous to sound energy) incident on a particular location during a given time interval. This U.S. developed method has been challenged both as to fundamental approach and on detailed execution - as well as on a variety of less logically motivated grounds.

Undoubtedly aspects of the method are wide open to criticism. Certainly the NEF contours cannot be the sole end result of acoustic analysis. But, some generally applicable means of injecting aircraft noise considerations into land use planning is undoubtedly essential. It is the general consensus - pretty well throughout the world - that land use guide lines are best based on an index of cumulative exposure: the NEF seems to be the most soundly based of a number of reasonably well correlated indices.

In the absence of a clearly superior method the MOT must continue to rely on the NEF to provide national standards. Comparison of current with historical data being of such transcendental importance to planning, we should not lightly discard an established yardstick! Forecast data and aircraft and operational parameters are naturally subject to continual updating and refinement. In addition we periodically review fundamental principles and reconsider the merits of alternate practices.

## CONCLUDING REMARKS

The reader may have concluded (correctly!) that the administrative aspects of airport noise control pose extremely complex and challenging problems - perhaps even eclipsing technological issues. Hopefully, we are making progress. We now recognize that noise control requires an ongoing effort; that preventative measures are preferable to the curative: that regulation is called for, not public relations.

Almost a hundred years ago Henry David Thoreau wrote, "Thank God, man cannot as yet fly, and lay waste the sky as well as the earth!" A great deal more coordination and concentrated effort will be required to prove Thoreau's fears unjustified. You, the acoustic fraternity, can help out through your constructive interest in regulations; by providing quantitative feedback and suggestions for improvement; by educating the public, both formally in course of jobs and informally through family and neighbours.

Through our combined efforts we may yet continue to enjoy the many benefits of aviation while alleviating its noise. Who knows, the airplane may yet become (to crib a line from Milton) the "Sweet bird than shunn'st the noise of folly".

* * * * * *

## THE UNIVERSITY OF CALGARY ACOUSTICS GROUP

H. Jones
Department of Physics, University of Calgary
Calgary 44, Alberta

Work in acoustics at the University of Calgary is spread widely through the University and is actively pursued in two faculties, Engineering and Arts and Science, with an interest being taken in the subject by two others, Medicine and Environmental Design. The interest and activity in the area appears to be increasing and the number of co-operative projects between the different individuals involved is also increasing. There is sufficient interest in active liaison between the different individuals for the suggestion of the creation of a University of Calgary Acoustics Group to be considered seriously. Recognition of a common bond would be implied by the title and the existence of the Group should further the provision of more joint courses in basic topics in the subject at approximately graduate level.

The present and immediately projected work in acoustics is listed (in abstract form) below:

Dr. A.G. Doige, Head, Mechanical Engineering Department is engaged in research concerned with the dynamic characteristics of acoustic and mechanical systems by transient testing.

This research is aimed at the prediction and control of pressure pulsations in natural gas pumping stations. Excessive pressure variation adjacent to reciprocating compressors often produces dangerous mechanical vibration in the piping system and reduces compressor efficiency. The approach taken is to obtain the acoustic impedance of the line near the compressor from field pressure measurements. Acoustic characteristics of components such as mufflers (attenuators or snubbers) are obtained similarly from field pressure data. Laboratory analysis of the recorded data allows the calculation of the pressure distribution throughout the original system and also for a modified system that has one or more of the major components altered or replaced. The prediction of pressure pulsations that result for any system change offers a means of avoiding excessive pulsations and resonant conditions when expensive alterations are made. The techniques of obtaining the dynamic acoustic properties of the system employ recently developed transient testing methods first used in structural dynamics. The system is excited in the field by a rapidly-swept sinusoidal input of approximately five seconds duration. Subsequent data analysis includes fourier transformation of the pressure signals and calculations by digital computer to obtain the pressure amplitude spectrum at any desired points throughout the system. The new methods employed should render field testing much more practical because the required instrumentation is minimized and data acquisition for each test requires, typically, less than ten seconds.

Dr. B.E. Dunn, Psychology Department, is engaged in auditory research. This work can be broken down into three areas, one primarily applied and two basic in nature.

The applied area deals with the effect of noise on human ecology. Up to this time the research has primarily dealth with the attitudes of individuals to their noise environment. The research has been part of a major noise survey supported by the Province of Alberta. He has also been interested in investigating certain stress responses produced by noise. At this point his research has primarily been in gathering available published data and not in laboratory or field research (but there appears to be considerable need for laboratory research in this area). Not directly related to noise per se in the sense of the noise survey, research done on perception of fidelity could be placed in this general category. This research has dealt with the effects of distortion and noise upon the desirability of music and speech passages as controlled by individual observers.

One of his basic areas is work on complex auditory processes primarily to do with binaural and contralateral masking. He is particularly interested in relating the binaural and contralateral masking effects to possible frequency type, as opposed to place type, mechanisms in the auditory system. He is also interested in the relationship of contralateral masking to the differences in response threshold of the inner and outer hair cells.

The other area of basic research in which he is interested is threshold theory. He is currently studying some basic theoretical models of signal detection. He is using primarily lateralization where a forced choice is required.

Professor D.R. Hill, Mathematics Department, is concerned with automatic speech recognition and synthesis.

The objective is to investigate generalized descriptors for the varying frequency spectrum of speech signals to allow practical recognition and synthesis procedures to be defined. The emphasis is not only on basic studies, to further the theory of recognition and synthesis, but also on the application of the fruits of this research in practical situations. The subgoals are: (1) the development and maintenance of an advanced signal processing facility for data acquisition and real-time equipment operation; (2) the development of measurement and analysis techniques for speech signals; (3) the development of pattern recognition strategies suited to the variable and voluminous data that characterizes speech, including dealing with the classical and related problems of "time normalization" and "segmentation"; (4) to improve our parameterization of speech for speech synthesis, reduce the data-rate required, and complete the set of rules required for good text-to-speech conversion; (5) to lay a sound basis for practical applications of the fruits of research; (6) to maintain an authoritative position in the field. Patents have been obtained, and another filed on aspects of the work. A speech output unit has been built, and Synthetic speech generated from a time-sharing system. Active co-operation with others advances sub-goal 5 (at Calgary with Dr. Hallworth, Ed. Psych. for Computer Aided Instruction; Essex U., Mr. Witten, and Beloit College, Professor Wheeler, both of the latter having actual hardware on loan). Possible industrial development is forecast.

Dr. H.W. Jones, Physics Department, has been engaged in theoretical and experimental studies related to acoustic imaging and holography. These studies have had three aspects, the first concerned with the theory of operation of Sokolov tubes, the second studying the general nature of ultrasonic imaging and the relation between image processing and receiver operation and the third concerned with the physical theory of acousto-optical lens and mirror systems. He has also undertaken work on environmental noise.

The first work has been completed to the point that a theory for image converter tubes of this type is now available and this theory is supported by adequate experimental verification. The limits of Sokolov tubes in their present form has become clear so that it is possible to make an adequate assessment of their potential in relation to the several other types of receivers.

The study of the second topic has shown that there is a limited range of possibilities in the use of particular types of receivers and it appears that it should be possible to specify the optimum use of such receivers in relation to the method of image production. The question of limiting resolving power of the different arrangements has not been satisfactorily explored; this is a critical factor in discussion of practical applications and consequently it is a subject of some interest.

It is hoped to apply some of the imaging work in a co-operative project with Dr. S. Nicholson of the Faculty of Medicine.

The third topic relates to the need to establish a complete theory for the performance of refracting and reflecting components in acousto-optical systems. Ordinary optical theory provides a starting point to this work. However, the extra degrees of freedom which arise from the effects of (i) the mode conversion of sound (from longitudinal to shear waves for example), (ii) the relatively small size of components compared with the wavelengths involved and (iii) the special problems relating to impedance matching, have not been treated adequately. Some co-operative studies relating to single lens have been done with workers in the U.S.

On environmental acoustics he was jointly responsible for the Calgary Noise Survey with Dr. Dunn and hopes to undertake a joint study on scaling with Dr. Vermeulen.

Dr. P.J. Vermeulen, Mechanical Engineering Department, has been engaged in the study of acoustic flame phenomena.

The interaction of acoustic pressure waves with a flame front is being studies by means of a simple single port burner using premixed gaseous fuel and air. A standard type diaphragm driver generates acoustic pressure waves of controlled amplitude which are fed through the burner port and so through the flame front. The resulting hydrodynamical motion of the front has been investigated by means of high speed photography, and significant signal amplification together with harmonic component modification has been shown to be the result of toroidal vortex shedding at the burner exit. The appearance of a one half harmonic of the modulating frequency has also been shown to be the result of vortex phenomena. The flame behaviour has been shown to be dependent on the frequency and sound pressure level of the excitation signal as well as on the equivalence ratio. The most significant effects are in the frequency range from 50 Hz to 500 Hz.

The fundamental work is continuing, and work is in progress applying the insight gained from the study so far to the design of engineering combustors of improved combustion performance, and, it is hoped, to combustors of reduced acoustic output though not necessarily simultaneously. It is particularly hoped that the combustors for small gas turbines may be improved. The research is presently supported by NRC A-7801.

A request for funding for a study of noise in wilderness areas has been made and this is intended to be a joint project between Dr. H.G. Kariel, Geography Department, and Dr. Vermeulen.

Mr. P.L. Li, Chief Building Inspector, City of Calgary, has acted as an honorary consultant to members of the Group in the environmental noise work related to the insulation of buildings. His contribution to a recent extramural course on environmental noise given by the Group is also acknowledged with appreciation.

* * * * * * *

## NOTICE OF ULTRASONICS CONFERENCE (1975)

An international conference on ultrasonics will be held in London, U.K., in March 1975. For further information contact Hugh Jones, Department of Physics, University of Calgary, Calgary 44, Alberta.

* * * * * * *