

DEPARTMENT OF
NATIONAL DEFENCE

**DEFENCE
RESEARCH BOARD
OF CANADA**



REVIEW 1971

OTTAWA, CANADA

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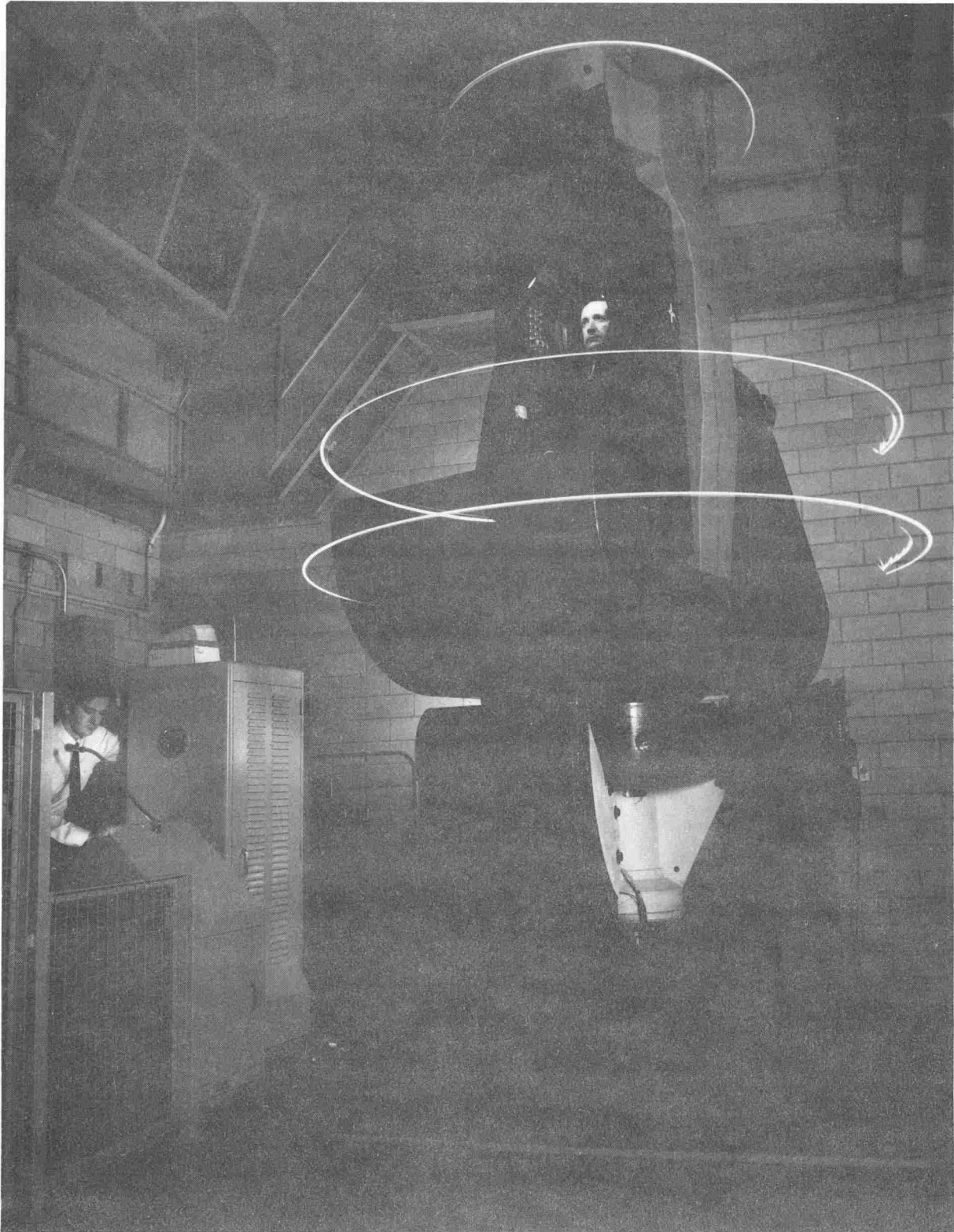
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FOREWORD

This Review deals with activities during 1971 at the Defence Research Board's headquarters in Ottawa and its seven research establishments across Canada. The Review does not attempt to provide a full survey of the Board's operations and scientific projects, but instead concentrates on certain programs selected to provide a conspectus of the kinds of research with which the Board concerns itself. The annual reports of the Board's establishments should be consulted for further information on scientific programs and publications.

The Precision Angular Mover is used to present accurately controlled rotatory stimuli to animal and human subjects. By measuring a subject's reaction to these motions, and thus gaining insight into the operation of the vestibular organs, it is expected that his effectiveness can be improved in the unnatural motions often found in modern machines.



THE DEFENCE RESEARCH BOARD

The Defence Research Board was established in 1947 by an amendment to the National Defence Act. Generally, the Board is concerned with providing scientific advice to the Minister of National Defence, meeting the research requirements of the Canadian Armed Forces, contributing to the collective defence research efforts of our allies, and supporting research of defence interest in Canadian universities and applied research in those Canadian industries that require a defence science and technology input.

The Defence Research Board consists of a chairman and vice-chairman, a number of members appointed by the Governor-in-Council for three-year terms, and as ex-officio members the Deputy Minister of National Defence, the President of the National Research Council of Canada, and three Senior officers of the Canadian Armed Forces. A list of present members of the Board is given on page 43. The Chairman of the Board is its chief executive officer, and the headquarters of the Board is one of the three entities (the others are Canadian Armed Forces Headquarters and the Deputy Minister's Branch) that constitute National Defence Headquarters in Ottawa. The work of the Board is carried on at its Headquarters in Ottawa, at its research establishments in Nova Scotia, Quebec, Ontario, Alberta, and British Columbia, and at its liaison offices in Washington, London, and Paris.

Three meetings of the Board were held in 1971 during which the members received special briefings on problems relating to the operations of the Board, defence problems in the Far North, and the change of emphasis in defence policy announced by the White Paper on Defence.

In May, the Board members accompanied by members of the senior staff made an extended visit to the Far North including such places as Frobisher Bay, Resolute, the Robeson Channel area, and Churchill. At Resolute, a Board Meeting was held during which the members were briefed on defence activities in the Far North by Brigadier General R.M. Withers, Commander Northern Region.

At the October meeting held in Ottawa, the Board members heard Lieutenant General M.R. Dare, Vice-Chief of the Defence Staff, present a brief on the implications of the White Paper on Defence.

The Professional Institute of the Public Service of Canada honored the Defence Research Board by awarding its Gold Medal for contributions in Pure or Applied Science to the laser team of the Defence Research Establishment Valcartier. This award, which represents the highest honor the Institute can bestow, now has been won twice in the last decade by DRB scientists. The research and development efforts that led to the laser breakthrough at the Defence Research Establishment Valcartier were carried out during the past several years.

The Board welcomed eight new members in 1971. Mr. Sylvain Cloutier, Deputy Minister, Department of National Defence and Lieutenant General M.E. Pollard, Chief of Technical Services, joined the Board as ex-officio members; and Mr. Laurent Beaudoin, President and General Manager of Bombardier Limited; Dr. W.C. Gibson, Research Professor, Faculty of Medicine, University of British Columbia; Dr. G.F.O. Langstroth, Dean of Graduate Studies, Dalhousie University; Dr. Larkin Kerwin, Vice-Rector (Academic), Laval University; Dr. Maurice LeClair, Deputy Minister of Health, Department of National Health and Welfare; Dr. John D. Wood, Senior Vice-President, Engineering and Research, ATCO Industries Limited, joined as members by appointment.

Assessment of the long-term scientific responsibilities of the Defence Research Board continues through planning studies. During the past year the areas under review have been: the Behavioral and Biosciences; Nuclear, Biological, and Chemical Defence; Maritime Research; Communications and Surveillance in the North; and the Board's University Grants Program.

Recent reorganizations of the Board's scientific program have been largely oriented toward meeting the changing defence priorities announced in the White Paper entitled "Defence in the 70's". More emphasis is being placed on research related to the roles of the Canadian Armed Forces in maintaining Canadian sovereignty and internal security. Relevant to these are studies of human performance under environmental stress, surveillance and communications in the north, military mobility under arctic conditions and sociological studies of military-civilian relationships, particularly in times of social unrest. Since the Defence Research Board has limited resources, this change of emphasis in its scientific program has necessitated a reduction of effort in other areas, such as the programs on Nuclear, Biological, and Chemical Defence, Weapons Research, and Deep Ocean Anti-submarine Warfare Research.

Wherever possible, the Defence Research Board attempts to make its specialized scientific resources available to civil agencies in Canada. The decision announced in 1970 to create a Defence and Civil Institute of Environmental Medicine, by amalgamation of the former Defence Research Establishment Toronto and the Canadian Forces Institute of Environmental Medicine, has been implemented. This Institute possesses unique resources for physiological and psychological investigation and assessment of human performance under stress, for studies of operator efficiency in man-machine systems, for investigations of the human factors associated with accidents, for clinical examinations of personnel who are required to work in extreme environments, e.g. divers and aircrew, and for the education of these personnel in the physiological and psychological hazards associated with such environments. Provision has been made for personnel from civilian agencies to work at the Institute on programs related to the interests of their agencies.

Some other items of interest during 1971 were:

- (a) The 1,000 square mile DND property at Suffield, Alberta operated by the Board for the past twenty-five years, has become Canadian Forces Base Suffield in order to implement the agreement to train British troops there. The scientific program continues at the Defence Research Establishment Suffield which will retain and control the laboratories and the range areas necessary for its experiments.*
- (b) The post of Scientific Adviser to the Forces Mobile Command was created and staffed during the year, in order to provide the Commander with scientific and technical advice and to enable him to use the resources of the Defence Research Board more effectively.*
- (c) The Defence Research Board and the United States Air Force have started a program of cooperative research on the performance of Over the Horizon Radar.*
- (d) Arctic research has continued, and a small research station was established during 1971 in the high latitudes. The behavior of ice in the northern channels is being studied which, together with other work should show the costs and feasibility of a limited subsurface system to provide warning of unusual maritime activities. The results should be of civil as well as military interest, as will the study of the movement of icebergs.*
- (e) During the year a special incinerator was designed and installed at Defence Research Establishment Suffield to destroy DDT. The intention is that this "DDT Destructor" will be used to destroy military stocks, then those of federal and provincial agencies. As far as is known, it is the only installation of its type.*
- (f) The Board has given advice and aid on technical problems associated with disarmament since the end of World War II and notably since the middle fifties. Steps were taken during the year to increase the capability to help.*

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

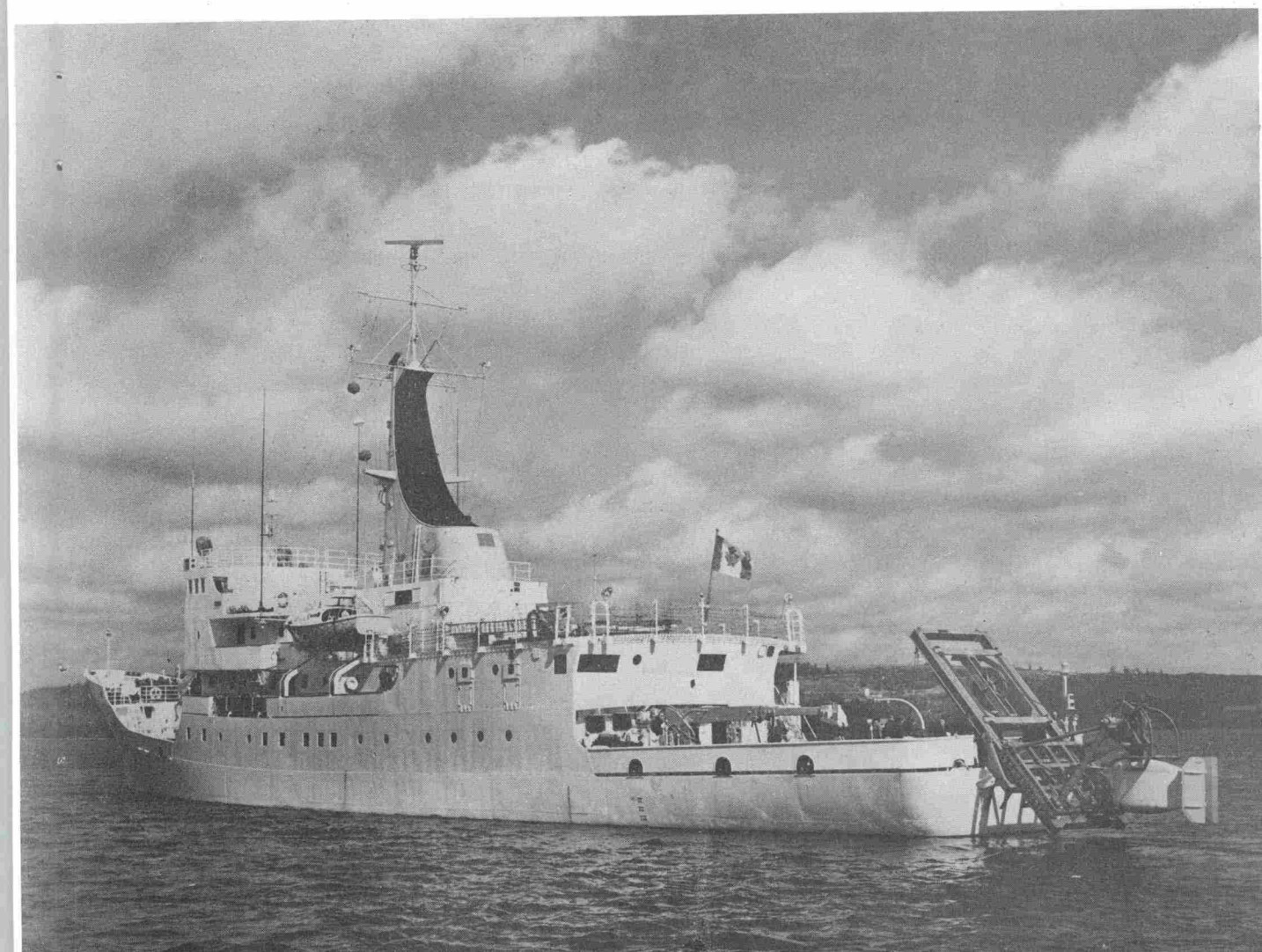
DARTMOUTH, N.S.

DREA's ultraquiet research vessel CFAV *QUEST* launching a variable depth sonar body specially instrumented for signal processing research applied to the automation of active sonars.

In February 1940, the Royal Canadian Navy turned to Canadian science for assistance in combatting the German magnetic mine. This was the beginning of a research program in aid of Canada's maritime forces and it continues still at the Defence Research Establishment Atlantic (DREA), DRB's easternmost laboratory. The program has changed necessarily through the years and, in 1971 as in the past few years, the research dealt largely with underwater acoustics and hydrodynamics. About one-third of the establishment's effort was applied to direct response to requests from the Canadian Armed Forces, both in Maritime Command and elsewhere.

Underwater Acoustics Research

In their role of surveillance and control, as defined in the White Paper on Defence, Canada's sea and air maritime forces are required to detect and identify what is happening under her coastal waters and, in their NATO role, to carry this capability to the open ocean. The most effective means of such detection

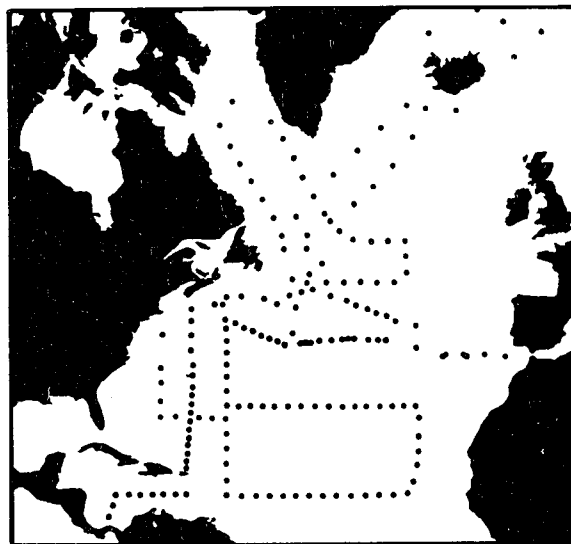


and identification is by underwater sound, through such devices as sonars and sonobuoys. For operational use, as well as in design of this equipment, there is a strong internationally stated requirement for further information on the ocean's effect on submarine detection and on the background noise against which detections have to be made. In 1971 DREA research produced results in several aspects of this requirement.

Low frequency acoustic research in northern waters received additional emphasis in 1971. Experiments were carried out by CFAV *Quest* in Davis Strait and in the Labrador Sea to gather information on propagation loss and on the directional characteristics of both submarine-like signals and the prevailing noise. A pilot project was set up to extend this investigation to Baffin Bay using air dropped sonobuoys to make quantitative measurements of ambient noise and propagation loss. The results of the sonobuoy trials indicate that the quality of the data is good and that such measurements complement the more sophisticated measurements which can be made from equipment deployed from research vessels -- thus providing a facility for making such measurements in areas inaccessible to surface ships.

Investigation of the performance of vertical and horizontal arrays of hydrophones suspended from the sea surface continued during 1971. Results indicate that multi-element arrays can be designed to exploit the differences in the signal and noise directionality revealed in field trials so as to yield significant improvements in detection performance over the single hydrophone detection systems commonly used in sonobuoys.

Volume reverberation, which forms part of the background to submarine detection by sonar, has been shown to come from layers of fish at various depths in the ocean which scatter sound toward the ship or sonobuoy. In February and March 1971, DREA continued the study of deep scattering layer phenomena in several distinctly different oceanographic areas in the mid-Atlantic between latitudes 15° N and 40° N. This should complete the sampling of the distinct water masses in the North Atlantic, except for extreme northern waters. The total set of measurements gives a comprehensive picture of the



Locations of DREA's acoustic measurements of deep scattering layers show the sampling of the North Atlantic completed in 1971. This allows estimates to be made of the contribution of volume reverberation to the sonar background in water masses throughout the area.

areas where high or low reverberation is present and the frequencies at which such reverberation occurs, enabling estimates to be made of the contributions of volume reverberation to sonar background. One of the points of particular interest is that the scatterers observed in the Labrador Sea have been found to show much less variation with frequency and more consistency in scattering strength than have been found in other areas of the Atlantic. This would seem to indicate a more uniform distribution of the scatterers in size and population density than has been observed elsewhere. The frequency aspect will be a factor in the design of Canadian sonars for use in these waters.

For some years DREA has been investigating the effects of the ocean environment on sonar signals passing through it. During the past year, the effort in signal processing at DREA has been primarily toward application of the knowledge to automation in active sonars. An experimental towed sonar, incorporating advanced signal processing and two small computers, has been assembled and taken to sea for the first time to study problems associated with automation. Research has also been continued on submarine echoes, propagation and reverberation to provide information

required to achieve the best performance from such a system. The experimental results appear to promise significant improvements in active sonar performance, both for mobile ship mounted systems and for stationary systems such as sonobuoys.

Hydrofoil Craft

On 2 November 1971, the Minister of National Defence announced his decision to lay-up the hydrofoil ship HMCS *Bras d'Or* for a five year period because a reassessment of Maritime Command's requirements had scaled down her priority. However, he emphasized that research into hydrofoils would be continued by DRB. The immediate objective of DRB's continuing work will be to determine the potential of hydrofoil craft in relation to that of conventional surface ships for a future replacement program.

During the past year a DREA — De Havilland of Canada team has been carrying out studies for follow-on hydrofoil ships to meet possible Canadian Armed Forces and NATO needs. In the area of hydrodynamics, general handling and seakeeping ability, trials of HMCS *Bras d'Or* have validated the principles behind Canadian hydrofoil systems. The trials results have been used in these studies, with variations introduced to meet a general purpose requirement and to improve reliability, increase structural assurance, and decrease costs. Parametric studies have suggested an optimum size and configuration for a general purpose hydrofoil ship, and this design, known as FH 3, should give a balanced capability over a wide range of speeds to a top speed of 50 knots in calm water and 45 knots in sea state 5. One-third scale trials of the foil system for such a craft will be

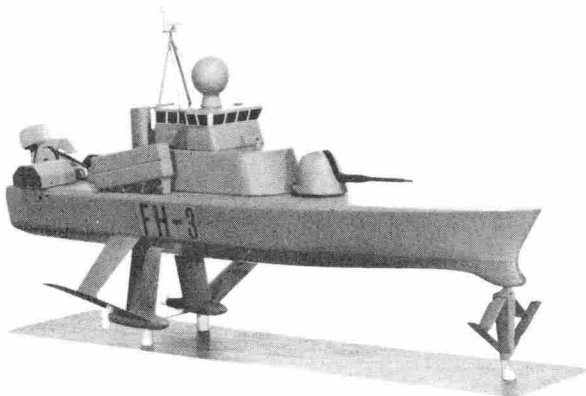
carried out using the research hydrofoil craft *Proteus*, the foils for which are being made on DREA's numerically controlled milling machine.

Direct Assistance to Canadian Armed Forces

DREA gives direct scientific assistance to the Canadian Armed Forces — and the Maritime Command in particular — through its Dockyard Laboratory and its Service Projects Unit. In addition, DREA supplies a Scientific Consultant to the Maritime Commander.

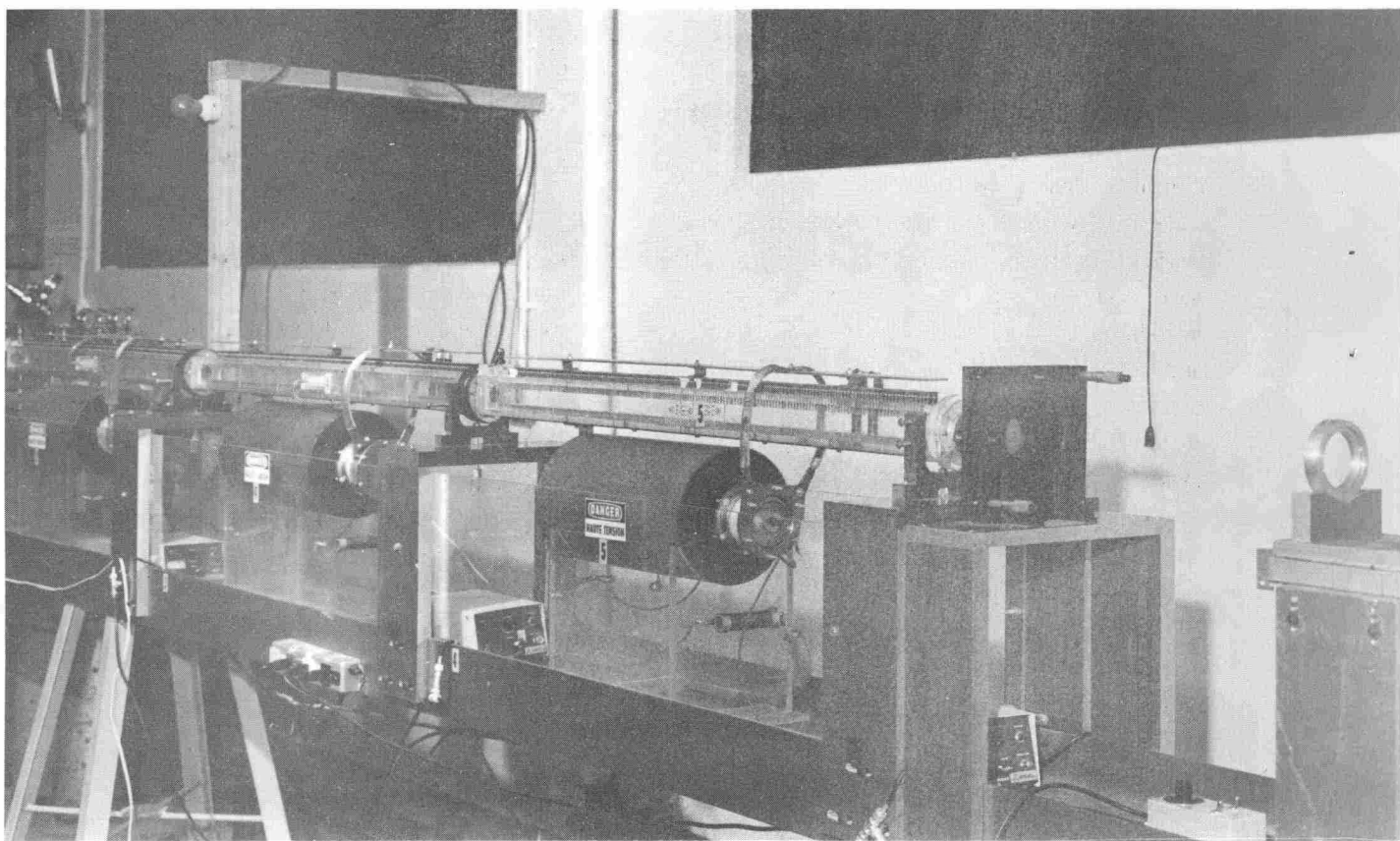
The Dockyard Laboratory provides such service in broad fields of engineering and chemistry with particular emphasis in the areas of fuels and lubricants, metallurgical investigations, and non-destructive testing. For example, a program of spectrometric oil analysis designed to show the state of Sea King helicopter engines is now fully accepted as a necessary procedure for aircraft safety and maintenance. High concentrations of metal have shown up on several occasions which, if not detected, could have led to inflight failure.

The Service Projects Unit applies scientific expertise to specific problems encountered by the Canadian Armed Forces in the operational use of submarine detection devices and in a wide range of associated equipment. Among many problems treated in the past year, the Unit has demonstrated that background noise in sonobuoys when in rough seas can be reduced through an optimized design for the hydrophone suspension system. It has also shown that noise encountered at high speed in variable depth sonar bodies can be dramatically reduced by sharpening the trailing edges of the tail fins.



A typical design for a future general purpose hydrofoil craft for the Canadian Armed Forces.

This laboratory TEA carbon dioxide laser delivers a pulse of about 10J. It uses a resistive electrode structure, the basic feature of the initial DREV invention.



DEFENCE RESEARCH ESTABLISHMENT VALCARTIER

VALCARTIER, P.Q.

The Defence Research Establishment Valcartier (DREV) is the largest bilingual research center of the federal government. While the majority of the staff numbering 700 speak French, most of the French and English speaking groups are bilingual and both languages are in use.

The program includes scientific research of short-term and long-range problems, and preliminary development of new and improved equipment, techniques, and systems for the Department of National Defence, and to a limited extent for other government departments.

The current program stresses work on surveillance and armament problems as well as research on lasers.

TEA Lasers

The announcement of a significant breakthrough in laser technology was made early in 1970 by the Defence Research Establishment Valcartier by the revelation of the successful operation of a Transversely Excited Atmospheric (TEA) carbon dioxide (CO_2) laser. The important feature of this novel laser is the substantial increase in power and energy generation that occurs from a given volume of the gaseous medium with the large concentration of active molecules at atmospheric pressure. The TEA laser has passed through interesting advances within the last two years and is now challenging solid state lasers in the competition for high peak power and energy. Several tens of joules in pulses shorter than a μsec can easily be produced at a wavelength of 10.6 micrometers in systems of reasonably small dimensions and modest cost. This performance is several orders-of-magnitude above the previous state-of-the-art in CO_2 laser technology. From the results of scientific discussions and papers presented at recent conferences in Europe and the United States, it appears that the TEA laser concept has led physicists into reconsidering CO_2 for the study of high intensity laser light interaction with matter.

Successful attempts at achieving powerful emission at wavelengths other than 10.6 micrometers by using other molecular gases have been reported for as many as 150 wavelengths throughout the spectral range

1-15 micrometers. From the military point of view there is a considerable interest in the hydrogen fluoride molecule which has strong emission lines in the range 2.8-3.0 micrometers. Since these emission lines lie in a transmission window of the atmospheric spectrum, this molecule appears to be an interesting candidate for communications and optical radar applications of the TEA laser.

Canadian industry will be able to take full advantage of this DREV invention by being the first to reach the TEA laser market. Commercial TEA lasers are now being engineered for specific applications by the Canadian firms which were granted the rights to the Canadian Government's patents. Lumonics Research Ltd. in Ottawa is marketing a single pulse TEA device with a high peak power capability which should be particularly attractive to spectroscopists and plasma physicists. GEN-TEC (1969) Inc. in Quebec City has concentrated on a rapid rate pulsing laser of medium peak power capability. This laser is designed principally for material processing applications and should have an obvious appeal to customers interested in scribing and micromachining.

Since the public disclosure of the DREV invention, a large number of small TEA laser devices have been constructed in different laboratories all over the world. Also several variations of the original DREV design have been proposed in the literature. The DREV activity in the laser field is presently directed toward the development of larger devices with increased volumetric excitation and better optical characteristics. Efforts are oriented also toward achieving a good control of the radiated pulse by incorporating sophisticated electro-optic and acousto-optic modulators in the laser. Techniques are being explored for potential applications in high resolution optical radars and also because of the possibility of producing several hundreds of megawatts of pulse power in high level amplification systems. Such large pulse intensities may have potential military implications in weaponry systems and material damage.

Optical and Infrared Surveillance

The work at DREV in optical and infrared surveillance emphasizes the development, the analysis, and the evaluation of detection and imaging equipment. Activities which are given in direct support of the Chief of Technical Services Branch of CFHQ form an important part of the work. They include studies of optical and infrared camouflage, evaluation of infrared line-scan systems for airborne surveillance in northern and maritime environments, and the improvement of naval capabilities by means of infrared surveillance technology. In addition to the work which is being done in-house, there is work under contract in industry which shows promise of leading to a significant increase in Canadian production of infrared surveillance equipment.

Considerable effort is being directed towards new methods of displaying surveillance and reconnaissance information to ease the problems of interpreting the information. One method converts the analog signal from a slow-scan infrared camera to digital form. By means of a memory and other auxiliary circuits, the signal is used to display a flicker-free thermal image of a scene. Thermal information in the signal is also available for subsequent processing by computer.

With the help of the eye's effectiveness in discriminating different colors, another method uses a color TV display to present more sensor information than otherwise could be assimilated. A third method which has also shown progress has used relatively inexpensive commercial TV and electronic equipment to coordinate the display in real time of multi-spectral sensor information. The simultaneous presentation of low-light-level TV and infrared images for example, provides a superior surveillance, reconnaissance, or target identification capability than is possible from a single sensor.

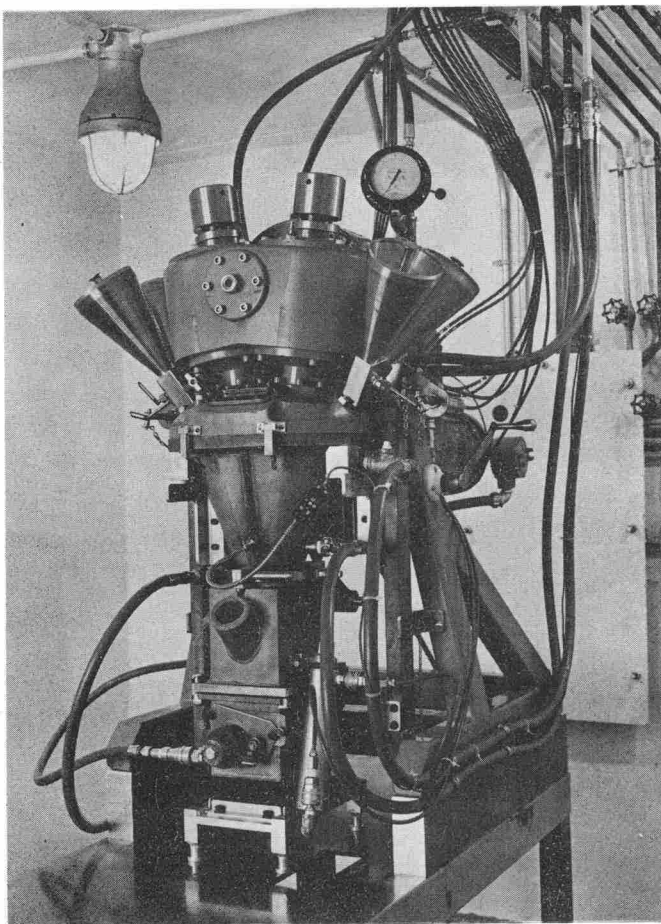
A basic activity of great promise, supported by contracts at the Centre de recherches sur les atomes et les molécules (CRAM) of Laval University is concerned with establishing the fundamental limits of spectroscopic sensing. Increased contractual support

for experiments using a high resolution Michelson interferometer is anticipated, since such experiments are a vital element in defining the limitations of detection in certain optical and infrared surveillance systems.

Calibration measurements in the field and viewing with image intensifiers and television systems are made from a mobile self-sustaining van. Measurements of target signatures and of target background contrasts in the thermal infrared are made with infrared imaging cameras (AGA and BOFORS) and with radiometers. Similar instruments were used to measure the thermal radiation from Canadian Armed Forces' ships near Frobisher; the instruments were mounted in a Sea King helicopter and on the deck of an accompanying ship. A more sophisticated version of the airborne instrumentation is now being packaged to facilitate installation in a helicopter at short notice, and thus be available for urgent surveillance or reconnaissance missions.

Castable Composite Explosives

Today, as for the last half century, trinitrotoluene (TNT) is the workhorse explosive for Canadian Armed Forces applications. This preference is likely to continue for the majority of present uses because: (1) it can be readily cast loaded, having a low melting point of 80°C; (2) other more powerful explosives may be readily incorporated, e.g. RDX or HMX; (3) other ingredients may be readily added for special purposes, e.g. aluminum powder for underwater use; and (4) its cost is relatively low. All explosives containing TNT, however, have disadvantages due to their properties. They are unsuitable for any high temperature environment where they would be subject to remelting, e.g. under aerodynamic heating; when temperature cycled they tend to exude or to crack leading to hazardous munitions; and they shrink considerably while solidifying, with the consequent risk of cavity formation or of other defects, which may result in premature initiation under high accelerations of gun launching or target penetration.



Helicone Vertical Mixer used in the preparation of castable composite explosives. Mixing and casting operations are completely remote controlled.

A relatively new type of explosive, of the cast composite family, consists of explosive crystals and other ingredients dispersed in a liquid polymer which, through an irreversible process is subsequently cured. There is no volume change during curing, so it is easier to ensure that a filling is free from cavities and other defects. Moreover, the cured binder is highly resistant to all temperatures to which it might be subjected. Crack formation does not occur on temperature cycling due to the superior mechanical properties of composite explosives over the operational temperature range.

An extensive program of research and development in this new field began at DREV in 1968. Since then, numerous formulations have been mixed, cast, cured, and detonated. Very promising results which include good physical and mechanical properties, ease of initiation to detonation; adequate range of detonation rates, relative insensitiveness, etc., have been obtained. It is expected that a fairly complete characterization of some of these new formulations will be achieved by the end of 1972. Presently, emphasis is being placed on determining such explosive properties as output, sensitivity to impact and friction, and behavior upon very high sudden compression which is encountered in modern gun firings. A new facility for remote control processing of batches of up to 150 lb of these materials was completed in 1971.

Training Devices for Canadian Armed Forces' Weapons

Defence Research Establishment Valcartier has developed a range of training weapons in which certain characteristics of their parent weapons are reproduced. The training weapons have these advantages: both for training and for exercises, ammunition is used at greatly reduced cost and danger is virtually eliminated.

A class of sub-calibre training devices has been built for the recoilless anti-tank weapons Carl Gustav, M72 and the M40 106mm recoilless rifle. The mount for the sub-calibre device has the external configuration of the ammunition for the main weapon to allow realistic loading procedures as well as firing. The noise and smoke of the main weapon also are simulated to ensure realistic handling practices in



The 20-gauge subcalibre training device with back blast simulator for the 84-mm Infantry antitank rifle.

training, and the projectile carries a tracer and a flash charge to indicate impact at the target. The trajectory and time of flight are well matched in the simulation.

A 0.22 machine gun has been mounted on the Lynx vehicle to represent the 0.50 heavy machine gun for practice firings on the indoor range.

Training ammunition has been developed for the 20-pounder and the 105mm antitank guns. The present training ammunition is a discarding sabot type which has a low cost steel core; however, the round is still expensive, and the danger area after ricochet is extensive. Full-bore ammunition with a thin light-alloy ogive mounted on a steel body is the suggested replacement.

Work has been initiated to modify the MK 106 air launched practice bomb to give a better match with the trajectory of the live Snakeye bomb. (The MK 106 has a high drag coefficient and consequently has a shorter distance to impact point.) The profile

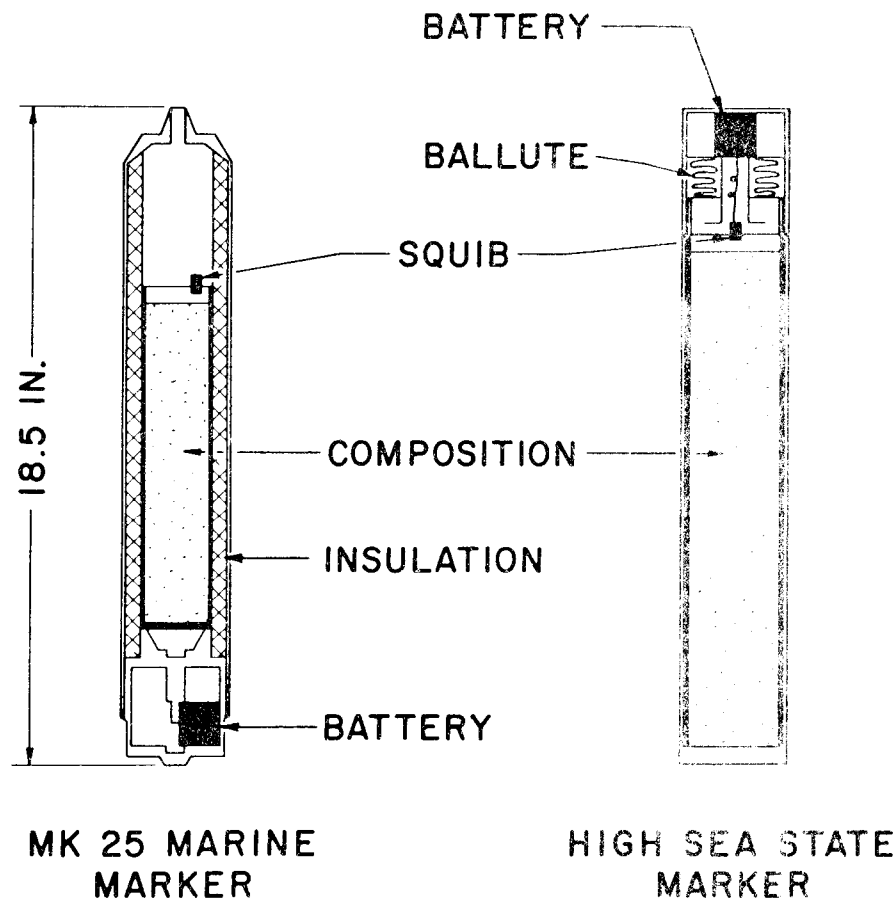
of the new bomb has been formed by adding a hemispherical nose to the MK 106, and the mass has been distributed to provide aerodynamic stability. The nose is made of plastic which deforms on impact and thus minimizes ricochet. Point of impact is marked by a smoke cartridge.

The Claymore mine is designed to protect a defended position against infiltration or attack by firing a fan-shaped beam of projectiles forward when actuated by a trip wire. A simulation was required by the Canadian Armed Forces for use during training exercises to give an audible signal and thus to allow assessment of possible casualties. The practice Claymore mine is externally similar to the real mine, with all the required fittings for emplacement and sighting. A powder charge provides an aural indication of the mine actuation and a smoke cartridge then visually locates the position.

Pyrotechnics

The scope of work in pyrotechnics was expanded this year to include castable compositions which present a number of distinct advantages over comparable pressed compositions. They have longer and more controllable burning times, better reproducibility, smoother burning, and superior mechanical properties. Moreover, a greater variety of configurations can be loaded, safer manufacturing procedures can be used, and lower production costs are achievable.

In response to a request from the Maritime Air Element of the Canadian Armed Forces for a smoke marker that could be seen from the air in sea states 3 to 5, development of an improved MK 25 Marine Marker was initiated. (In high sea conditions the standard MK 25 Marine Marker cannot be seen readily because its white smoke merges with and becomes indistinguishable from the white caps and



As the MK 25 Marine Marker cannot be seen from the air when deployed in Sea States 3 to 5, maritime air operations are limited by weather conditions. To improve high sea state performance, the marker has been redesigned to hold twice as much pyrotechnic composition, thereby greatly enhancing its flame and smoke output.

spray which accompany high sea states.) Although severely hampered because the external dimensions of the MK 25 marker must be maintained to permit retrofit to existing aircraft, prototype models constitute a considerable improvement over the existing marker.

To maintain the several development tasks already underway in support of the Canadian Armed Forces, research effort has been recently increased. The study of fire-hazard free spotting charges, both white and orange, has been pursued in an attempt to improve upon the $TiCl_4$ and $VOCl_3$ systems presently in use. With regard to the thermophysics of pyrotechnics, experiments have been designed and preliminary testing conducted for the precise measurement of temperature and mass histories of burning compositions; the results will be used to build up a model that will describe pyrotechnic combustion. Finally, new facilities and equipment shortly will permit the controlled evaluation of smoke clouds for reflectivity, color, and density.

Explosive Ordnance Disposal

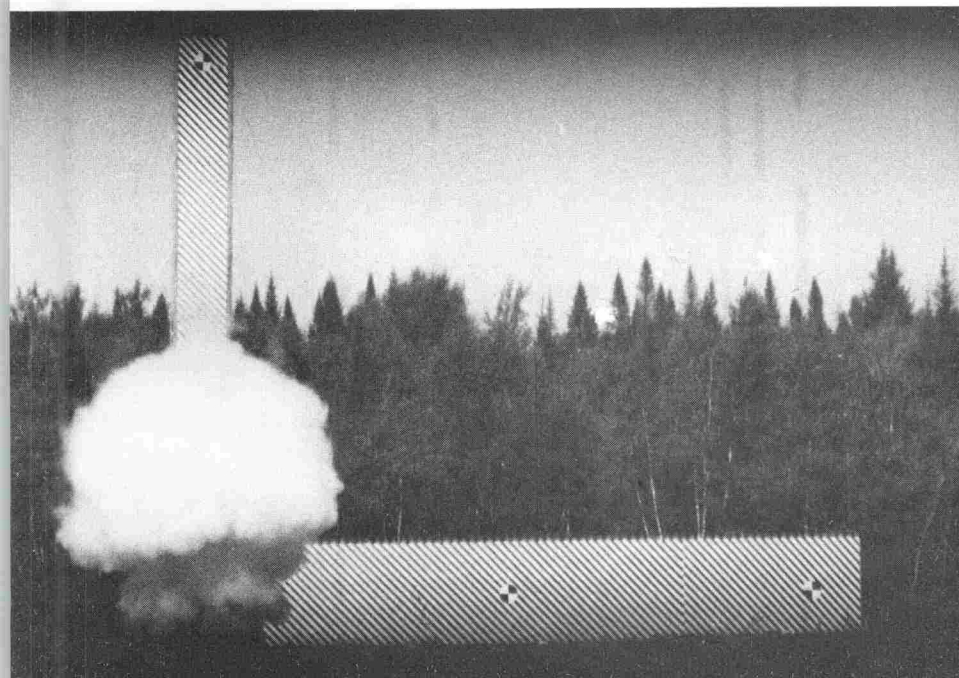
Research in the area of Explosive Ordnance Disposal (EOD) was started at DREV in late 1970.

An original request from the Canadian Armed Forces to evaluate some of their protective equipment has recently evolved into a more complete study of the hazards associated with explosive devices and the development of new improved equipment.

Studies being carried out in response to specific requests from the Canadian Armed Forces include work in the following areas:

- (a) Development of a container for the safe transport of relatively large improvised devices through a city street.
- (b) Development of a portable container to allow the transfer of an improvised device from a building to the primary transport container.
- (c) Development of a shield and other aids to allow an EOD operator to work on an improvised device from a safe distance.

In addition to the above tasks, a small research program has been started to devise techniques for the safe disruption of explosive packages that are protected by anti-handling devices.



An evaluation has been made of the level of blast overpressure around the Canadian Armed Forces' explosive disposal bins. Photo-optical methods are used to determine the propagation of the shock wave.

DEFENCE RESEARCH ANALYSIS ESTABLISHMENT

OTTAWA, ONT.

The field of interest of the Defence Research Analysis Establishment (DRAE) is operational research and systems analysis in the broadest sense, carried out in support of the Canadian Armed Forces and of the Department of National Defence. It does not include direct laboratory research but it may involve designing and participating in trials with the Forces to obtain data necessary for analytical studies. These studies may deal with current military activities at Commands, planning for future operations of the Forces, the management of men and materiel, and the place of the military in the Canadian internal and external environment. They are usually interdisciplinary, requiring inputs from both the physical and social sciences as well as from military expertise. The establishment is staffed by civilian scientists and military officers in the proportion of about 3 to 1. In Ottawa, the establishment has two divisions: the Operational Research Division, which carries out studies of military operations and requirements, and the General Analysis Division, which is particularly concerned with strategy and planning in the broad sense and the management of men and materiel. The establishment also provides scientists for a number of small operational research sections working in military commands outside of Ottawa.

Simulation and War Gaming

Simulation and war games are used extensively in DRAE. They are used for the same purposes, the distinction being that the war game format is necessary where the interaction between opponents involves sequential human decisions. There is, however, no firm dividing line; partial simulation of operations on the computer can frequently be introduced into a war game to speed up the play.

War gaming was invented to study land operations and it continues to be a major tool for that purpose. Games are developed to provide a vehicle for training officers as well as to study the implications of changes in force structure, equipment, and tactics. A considerable effort is required to develop realistic game rules, based on the best available evidence on vehicle sensor and weapon capabilities, technical evaluations, field trials, and tactical experience. Computer assistance helps the control staff in making

assessments during the play of games. A game, in support of a study of the development, tactics, and cost effectiveness of air defence systems for the field forces, was conducted in 1971. On the other hand a simulation of the movement of troops in forward areas was developed for use in future war games.

There is extensive use of simulation to study performance of aircraft in different roles. An example of this is the aerial combat role. For this purpose a computer program was written which employs the aerodynamic description of a specified aircraft and computes its performance throughout the combat flight envelope. The aircraft performance can then be compared with that of an adversary aircraft and those situations favorable to each determined. This would lead to the formulation of tactics which would allow the pilot to capitalize on his advantages and to avoid dangerous situations. Another continuing simulation is CASSTRO, Canadian Air/Sea Simulation of Transport Operations. This is a set of programs for evaluating the capabilities of the Canadian Armed Forces to deploy various types and sizes of forces over long distances using transport aircraft and ships. The simulation has been validated by comparison with several live exercises involving troop deployment. The latest program has extended the simulation to cover the problem of troop deployment from several loading bases simultaneously.

A maritime computer-assisted war game has now been developed to the stage where various maritime force mixes can be evaluated in the performance of specific tasks. It is used extensively to back up studies of future maritime force composition.

Command and Control

The military term, command and control, is approximately equivalent to the mechanism by which operations are managed. The study of command and control does involve information systems but it is concerned primarily with how the information can be put to practical use in controlling activity. On the operational side, the major project has been the development of an improved command and control system for Maritime Command. A number of detailed studies in support of the project have been carried

out over the past six years and it has now advanced to the stage where program packages capable of supporting operations on a real time basis, are available. The system is open-ended and the expertise gained and the common language computer programs which have been developed could form a useful basis for developing sub-systems relating to the Arctic, offshore surveillance for pollution, fishing activities, and search and rescue activities.

During the past year the Computer Assisted Posting System has been put into limited operation in six military trade classifications. This system is a good example of computer-assisted control of manpower allocation, in which the main pattern of allocation is determined to minimum cost criteria by computer, but in which the human element is retained by allowing career managers to override the program in specific cases. Substantial cost savings can be achieved in spite of this concession.

Logistics analysis can conveniently be considered under Command and Control since the ultimate objective is to develop an efficient and integrated management control system. The studies which are being carried out are concerned with utilization of the information which is, or could be, available to reduce costs of the operation by more efficient inventory control and by other means. A specific example is a study to determine the optimum quantity of spares to purchase in support of a system when both spares of complete assemblies and also repairable sub-assemblies are to be included. This is a difficult optimization problem, but a heuristic solution has been developed under a DRB grant which has been shown to be applicable in practical cases with near optimum results. Another example was a study of the relative cost effectiveness of modifying or replacing an existing type of electronic equipment whose operational reliability was considered to be too low.

Planning, Programming, and Budgeting

In preparing the Canadian Armed Forces Program Forecast, the planning, programming, and budgeting procedures require that objectives and sub-objectives of the program and the consequent activity and sub-activity structures, be aligned with the four priorities

for defence policy announced by the Government in April 1969 and since repeated in the White Paper. In addition it is desirable that the levels of performance capability needed in each activity and sub-activity be quantified in output terms. It is recognized that the development of quantified capability levels for the activities, which can then be compared to existing capabilities, are the essential basis for a meaningful forecast of the resources and budget plans needed to achieve the program objectives.

Work on developing such quantified levels of capability was undertaken by DRAE in 1970-71 and over one-half of the more than 100 capabilities recognized in the several activities and sub-activities were quantified in output terms. The corresponding capabilities of the Forces and resources programmed to be available in 1972-73 were estimated and compared with the "required" levels, thereby providing measures of effectiveness (that is, indexes) of the extent to which these Forces could be expected to meet the capability levels defined. The corresponding deficiencies in capabilities were then readily identified.

The results of this work represent a definite step forward in the difficult task of quantifying force capabilities, measuring force effectiveness, and identifying deficiencies in capabilities. These results provide a quantitative basis for forecasting the resources and budget requirements for determining and achieving program objectives. Results to date represent a first step only. Work is proceeding to refine the required capability levels which have already been defined and to extend the defining process to capabilities which have not yet been quantified in output terms.

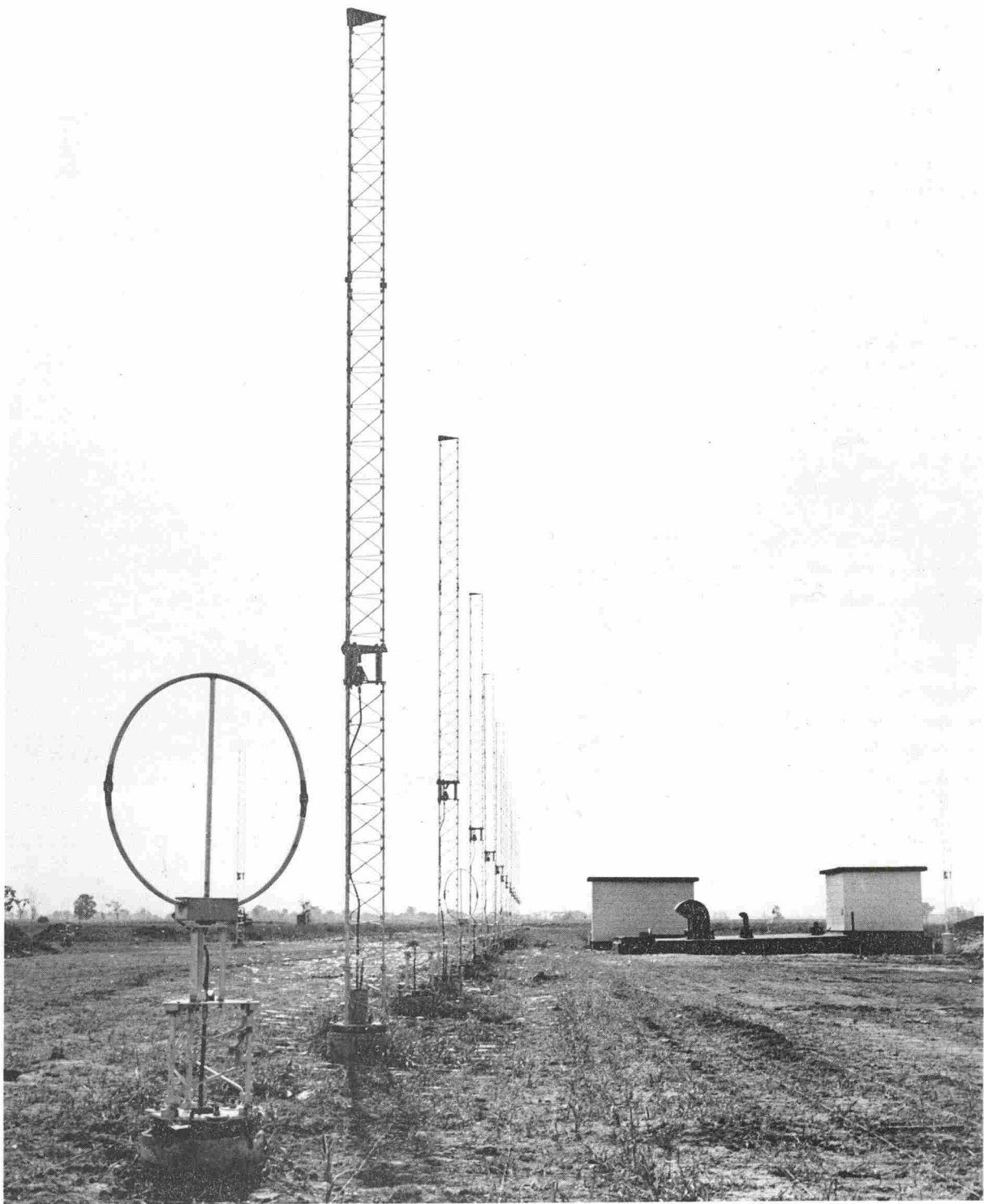
Strategic Studies and Arms Control

One of the continuing activities of DRAE is strategic analysis and the study of Canadian defence interests and of issues affecting Canada. This is an area in which DRAE has acted in an advisory role to the Canadian Armed Forces and to External Affairs and has, where possible, backed its views by quantitative studies. One topic that is becoming an increasingly significant factor in military planning is arms control in all its ramifications. During the past year DRAE staff have played a major part in a number of NATO Arms Control studies, including the exploratory studies on mutual and balanced force reduction in Europe. A program of internal studies is now being formulated, to be directed towards the development of a logical and defensible Canadian position on force reduction.

The Social Environment

One of the activities of the Forces set out in the White Paper on Defence is to provide assistance to the Civil Authorities in a variety of ways. There are many kinds of interaction between the military and the social environments which require study if a harmonious relationship is to be maintained. A modest start has been made on a program of studies of this kind. Two studies are nearing completion. One might be regarded as dealing with the effect of the civil environment on a matter of considerable military concern, the other with the opposite situation, the influence of the military on the civil environment. The first is a study of the roles and structure of the reserves, the second deals with the contribution of the Canadian Armed Forces to national unity.

High frequency direction finding array located near Ottawa.



DEFENCE RESEARCH ESTABLISHMENT OTTAWA

SHIRLEY BAY, ONT.

The primary responsibility of the Defence Research Establishment Ottawa (DREO), which is located in the Ottawa Valley five miles west of city limits, for many years has been to conduct research in the fields of protection against biological, chemical, and nuclear warfare, as well as work in the electrical power sources field. More recently, the scope of the establishment's activities has been reoriented to include work on protection against the environment, research on the arctic environment, and defence electronics. The defence work conducted at the Communications Research Centre (CRC) of the Department of Communications, in defence communications, radar, and related fields, is part of the program of Defence Research Establishment Ottawa.

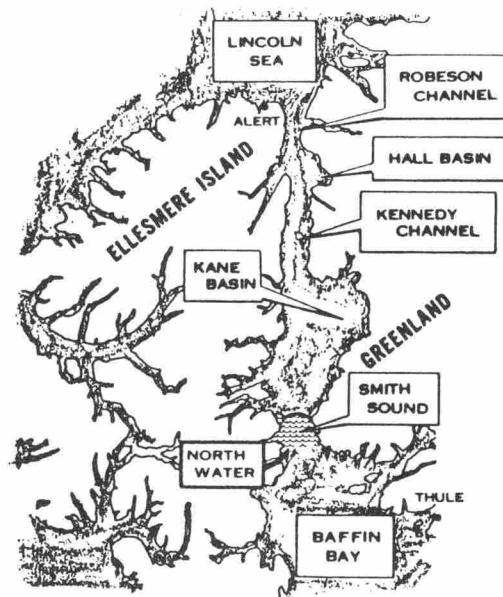
Nuclear and Chemical Defence

Research on nuclear defence includes the evaluation of instruments for measuring the amount of ionizing radiation to which an individual has been exposed, the development of instruments for measuring the intensity of the radiation produced by fallout, and the study of the amount of protection provided by shelter materials. There is also an active research program on drugs to decrease the susceptibility of humans to the effects of radiation. A recent achievement has been the development of an instrument to measure the amount of fallout radiation at a number of points dispersed over a wide area. At a Canadian Armed Forces base, for example, the hazard to men working at exposed locations can be accurately assessed. The equipment will read the amount of radiation at any of two to ten sensors located up to 10,000 ft from the control unit. An alarm will flash a warning lamp and sound a horn when the dose rate at a particular sensor exceeds a preset level. One hundred and one units are being obtained. This has been a cooperative project with engineering design and support being provided by the Land Engineering and Test Establishment of the Canadian Armed Forces.

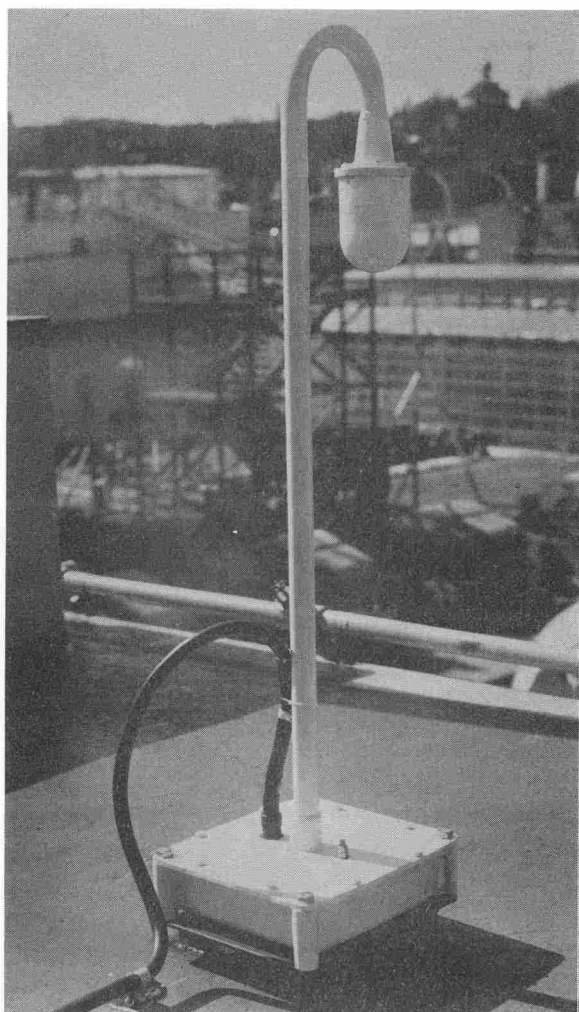
The chemical defence program is involved with the detection of the presence of chemical agents, the removal or destruction of the materials which fall on skin or other surfaces and with protective equipment such as gas masks, and special clothing which will

keep contaminating liquids away from the skin. During 1971, considerable effort went into a large-scale trial of a new chemical protective garment. Over 100 men of an infantry unit wore the clothing, virtually continually, for three weeks in the trial which was designed to determine the amount of degradation of the chemical protection with wear and the extent to which the garment interfered with normal infantry activities. Testing of the garments has not yet been completed but the trial showed that the extent to which the garment interfered with the soldier's activities was negligible.

Nares Strait indicating the North Water. ▷



Radiation sensor mounted on the bridge of HMCS *Fraser* (Canadian Armed Forces photo).



Research in Support of Arctic Operations

This work pertains to the determination of the effects of the environment on communication and information gathering systems used by the Canadian Armed Forces as well as the effects of the environment on the Armed Forces' ability to conduct operations, particularly as it affects the individual and his mobility.

Significant progress has been made on the study of the drift and movement of sea ice in channels of strategic and economic importance. The long term objective is to model the sea - ice - wind - water interactions so that predictions can be made from simpler synoptic measurements. As a preliminary to attempts to measure ice drift by a land-mounted radar in the northern part of Nares Strait (Robeson Channel), a reconnaissance of the ice conditions in Nares Strait was made during the winter of 1970-71. Observations were made from Argus overflights using the aircraft radar supplemented by visual observations when possible. It was found that consolidation of ice in Robeson Channel did not occur until late February. At the same time the North Water, a body of open water of varying size located at the head of Smith Sound, was studied. The observations made were in keeping with fragmentary historical records of earlier explorers on foot. For the continuation of this work an all-weather camp has been established at Lincoln Bay.

The requirement of the Canadian Armed Forces for information on possible anomalies in the arctic under all weather conditions has resulted in DRB studies on the most suitable sensors that can produce interpretable imagery during the dark period and in all kinds of weather. Thus, infrared line scanners (IRLS) and sideways looking airborne radar (SLAR) are being evaluated. The DREO research includes work on the infrared spectral signatures of possible background and target materials at arctic ambient temperatures to determine if there are any features of the spectra that can be exploited in semi-automatic processing systems. A contract has been let to study image processing procedures that might aid the human interpreter to process the large amounts of imagery these sensors produce.

Problems of land mobility of personnel and individual protection are exemplified by the work on the study of the energy budget of a small unit operating in the arctic. This study has resulted in the formulation of a set of parametric equations for the total energy expenditure that can be adapted to a wide variety of scenarios because each of the basic input parameters can be varied separately. To date operations on foot, in the M113 Armored Personnel Carrier, and in a hypothetical unit have been analyzed. Implicit in the development of the parametric equations is the concept of a vehicle shelter unit to solve problems of individual mobility and protection in the arctic. Other aspects of research on individual protection include the beginning of a joint project with the Arctic Petroleum Operators who have similar problems to those of the Department of National Defence.

Battery Research and Development

This activity involves many tasks concerned with the improvement of the performance of various batteries, fuel cells, and other sources of electrical energy for military applications. Work has been conducted with batteries for use in sonobuoys, aircraft beacons, torpedoes, aircraft, and satellites.

Important progress has been made during the year on the development of lead chloride cathodes to replace the expensive silver chloride used in many batteries. A number of batteries for a passive sonobuoy

have been successfully built and tested at DREO and work initiated under contract by industry should lead to commercial production of sonobuoy batteries in 1972. The performance characteristics are similar to those of magnesium/lead chloride batteries but a substantial cost reduction should be possible. Other work in industry includes the application of lead chloride to batteries for beacons and emergency radios as well as for short-life high-drain batteries.

Communications and Radar

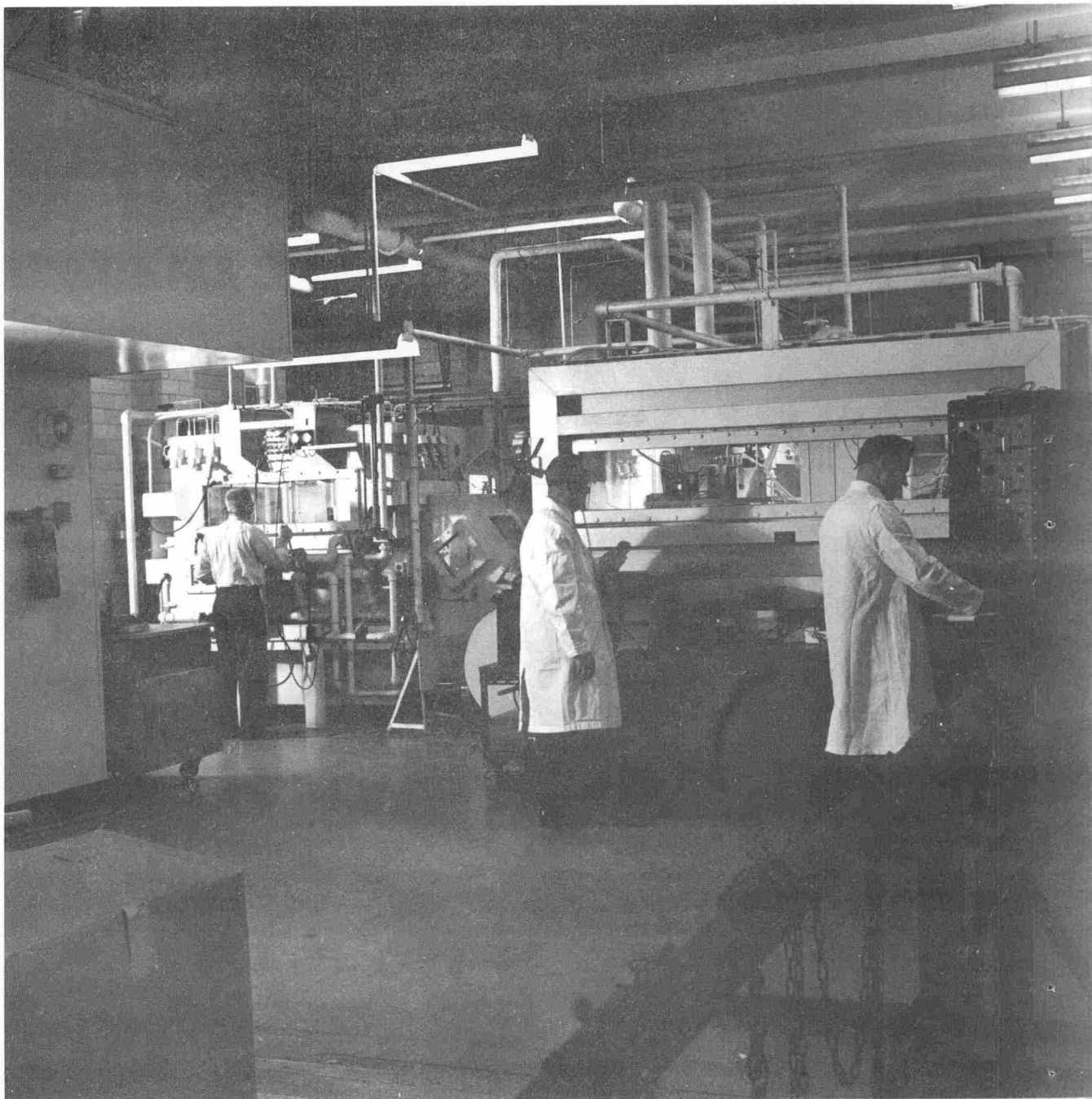
A major program pertaining to military communications and radar is supported by DREO at CRC. Most of the work is in direct support of the Canadian Armed Forces.

During the past several years the feasibility and value of tactical military satellite communications using small mobile terminals has been established. A portable vehicle-mounted terminal has been developed and successfully tested during military exercises. A phased-array antenna which can be automatically aimed at the satellite during communications has been developed and tested in a C-139 Hercules aircraft. Successful tests with shipborne terminals have also been made. In addition, a large number of small short term tasks concerned with communications have been undertaken both for the Canadian Armed Forces and for DRB.

Work in the radar field of the Canadian Armed Forces has involved a considerable number of rather short term projects. Examples are: assistance in the planning and technical evaluation of a SLAR; a feasibility study of developing additional modes for high resolution radars so that they can meet surveillance requirements; measurement of ground clutter profiles at twelve Canadian Armed Forces air traffic control stations; and a feasibility study of the use of phased-array antennas on ships.

In addition, two projects are connected with the effect of the ionosphere on high-frequency radio propagation. One concerns the effect of irregularities in the ionosphere in temperate latitudes on long distance propagation, and the other has involved the planning of a major cooperative project with the United States Air Force to assess the effects of the polar ionosphere on high frequency over-the-horizon backscatter radar systems.

DCIEM technicians are shown operating the high-altitude chambers used by the School of Operational Medicine to acquaint students with physiological problems associated with high altitudes.



DEFENCE and CIVIL INSTITUTE of ENVIRONMENTAL MEDICINE

DOWNSVIEW, ONT.

The Defence and Civil Institute of Environmental Medicine (DCIEM) is a new DRB establishment, formed in April 1971 by amalgamation of the Defence Research Establishment Toronto and the Canadian Forces Institute of Environmental Medicine.

The term "civil" in the name of this Institute reflects the existence of a collaborative arrangement with the Department of National Health and Welfare whereby the resources of the Institute are made available to support civil aviation medical activities as well as military. It is envisaged that similar collaborative agreements can be negotiated with other departments if and when the need arises.

The objectives of the Institute are: (1) to expand knowledge of the characteristics, capabilities, and limitations of man in adverse environments; (2) to study the human factors inherent in engineering systems; and (3) to apply this knowledge (a) to effective design and development of man/machine systems for use in adverse environments, and (b) to the effective education in clinical evaluation of military and civilian personnel.

The Institute is pursuing these objectives through six programs:

*(1) Human Effectiveness in Hyperbaric
Environments*

This program is devoted to extending man's capabilities under the sea so that he can descend safely to greater depths and work there for longer periods.

*(2) Human Response and Adaptation to
Adverse Environments*

The primary objective of this activity is to solve or ameliorate physiological problems encountered by men living and operating in the Canadian north. It includes studies on adaptation to cold, immunity to disease and mountain sickness as well as on how physical fitness can be attained and retained, and its importance to survival in the north.

(3) Human Perception and Performance

Research in this field is aimed at extending our understanding of how the sensory and central nervous systems of man attend to, select, and process information from the external world to enable him to operate effectively in a complex military environment.

(4) Human Engineering of Man/Machine Systems

Developing solutions to problems posed by the integration of man and machine is the aim of this work.

(5) Human Effectiveness in Transportation Systems

The major goal of this program is to maintain maximum effectiveness of operators and passengers in any transportation system. Individual projects are devoted to evaluating clothing, and equipment requirements for various transportation systems as well as solutions to various safety and physiological problems such as motion sickness and disorientation. Work is being carried out to improve the human factor investigation of accidents and to provide improved analysis of accident data.

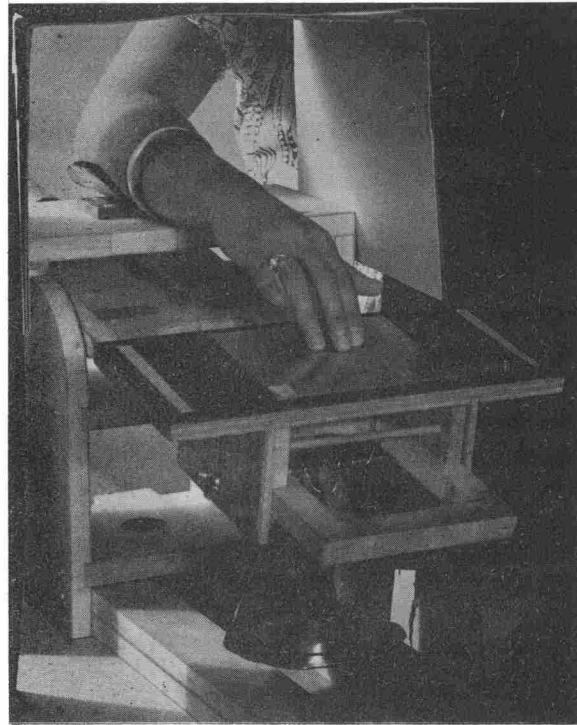
(6) Medical and Clinical Activities at DCIEM

This portion of the Institute's program includes the operation of a School of Operational Medicine and the Central Medical Board. The School offers a variety of courses devoted to teaching professional personnel and technicians the operational handling of medical problems associated with military and civilian activities. The Central Medical Board utilizes Canadian Armed Forces medical officers and civilian medical specialists to examine personnel from various activities who are referred to the board for medical examination.

Man under the Sea

The Institute has continued to evaluate the pneumatic analogue computer which it developed for operational use with the Canadian Armed Forces. Regulations for diving profiles have been produced which are being used by the Forces. An extension of the pneumatic computer development is the development of an electronic computer which will allow the programming of a proposed working dive in order to provide the appropriate logistics and life support.

A computerized data bank pertinent to decompression has been established, comprising a system for storage, analysis and evaluation of information collected during all Canadian diving operations. Such



An experimental arrangement used to learn more about the sensitivity of human touch receptors is illustrated.

a bank will serve as a center for the accumulation of national and international diving information. It will incorporate the physical characteristics and medical histories of all divers in order to permit search for any predisposition towards decompression sickness.

Teams from DCIEM and the University of Western Ontario have cooperated at the Institute in carrying out a human diving program to ascertain changes in the hemostatic system associated with decompression. Two large scale experiments have been carried out and the results indicate that decompression from the hyperbaric exposure tends to predispose a diver to a coagulation disorder known as disseminated intravascular coagulation. It has also been confirmed that there is a 30 to 40% decrease in circulating platelets 3 to 4 days following a no-bends dive. Institute scientists and divers are actively working on human and equipment problems which must be solved in order to permit men to work effectively at great depths in the sea for prolonged periods of time.

Specific tasks during the year included: bringing the submerged navy Tracker aircraft which, in April 1971, crashed into the sea off Sheet Harbour, Nova Scotia, to the surface from a depth of 230 feet; and examining and sealing the ports of the oil-carrier *Irving Whale* which had foundered in 200 ft of water, in order to stop coastal pollution due to oil leakage.

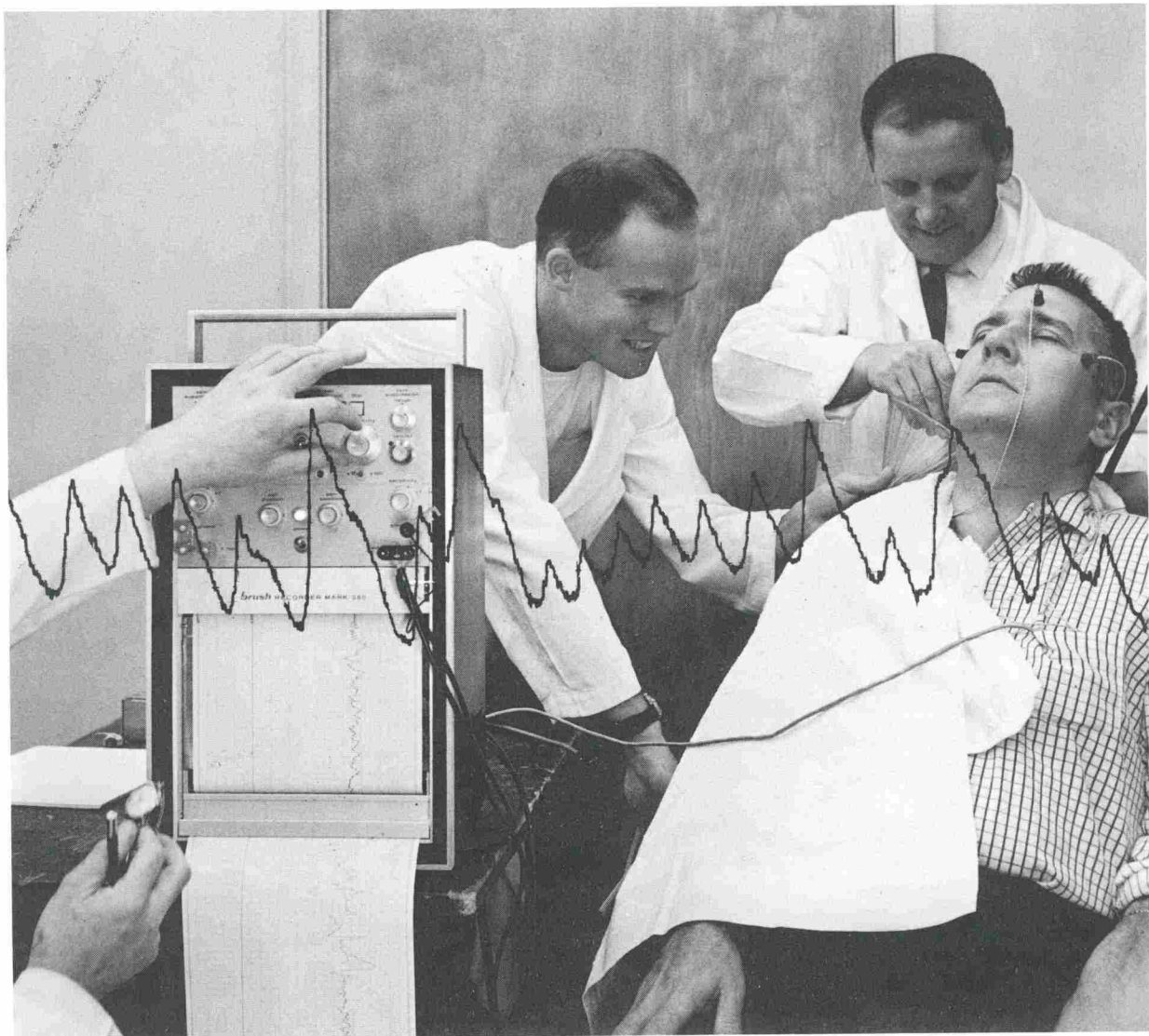
Man in Adverse Environments

During 1971, scientists from the Institute participated in a high altitude expedition on Mount Logan.

Evaluation of specific drugs to combat mountain sickness, studies on adaptation of men for work at altitude, and testing of specific equipment and rations for high altitude work were carried out. Scientists of the Institute have visited and participated in northern exercises to experience various cold weather operational problems and to test equipment developed at DCIEM.

One of the main constraints to operating effectively and without injury under arctic conditions is "on-the-spot" knowledge of cold stress at any given time.

A subject's eye movements are being recorded with eyes shut. Such movements are associated with the operation of the organs of balance (vestibular mechanism).



Work is therefore being carried out on a single-valued cold-stress index which will integrate all the influences and measurable parameters affecting heat exchange in man. The approach is to construct a miniature ("approximately the size of a cigarette package") direct single read-out electronic device which incorporates air temperature, wind speed, solar radiation, amount of clothing, and metabolic factors ("work load") which will "tell" the commander or civilian foreman the length of time the environment may be tolerated by a human in safety.

A heat stress meter developed in the Institute is under evaluation by civilian and military agencies.

As a consequence of studies on impaired consciousness in jet aircrew during operational flight, a program of immediate post-flight examinations has been established and controlled post-flight blood samples of affected pilots are sent by the flight surgeons to the bioscience division for analytical examination.

Human Engineering

DCIEM has recently completed a study of shipping in the St. Lawrence Seaway aimed at finding means of decreasing accidents during passage through Seaway locks. Evaluation of gun sights used on Canadian small arms, in order to provide a small, economical, yet

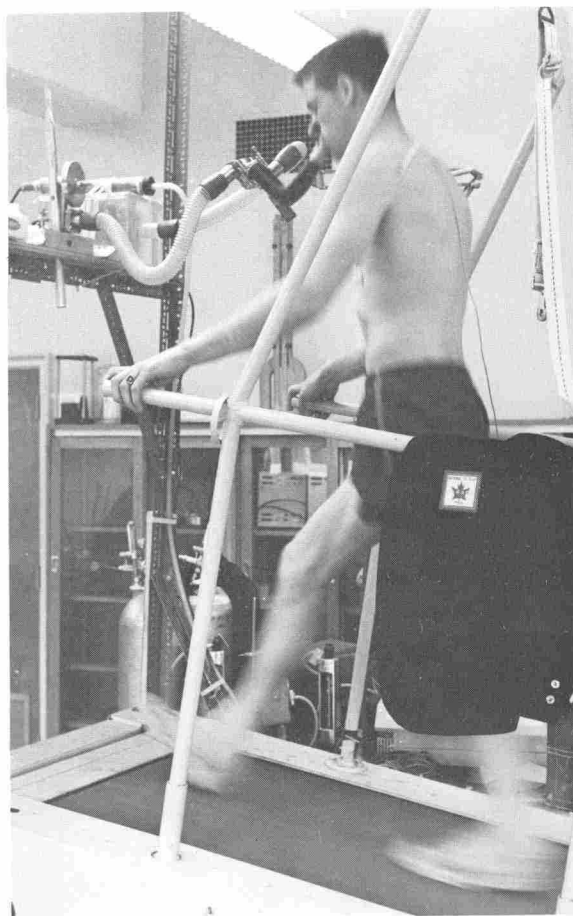
A campsite of the annual Mount Logan expedition in the Yukon is shown. The expedition is funded jointly by the Defence Research Board (DCIEM) and the Arctic Institute. The site is at 17,500 ft. At this laboratory of combined altitude and cold, DCIEM scientists have found methods of minimizing or preventing mountain sickness.



effective sight for use by the Canadian infantry man, has been completed. Work has been carried out to improve human engineering design in the diving tender that is being procured by the naval element of the Canadian Armed Forces as a support vessel for their submersible vehicle. The submersible vehicle is also being examined with the aim of providing a more effective work area for the crew. A full scale model of the Submersible Diving Lockout has been constructed at DCIEM in order to study how it may be made more efficient for utilization at increasing depths in the sea.

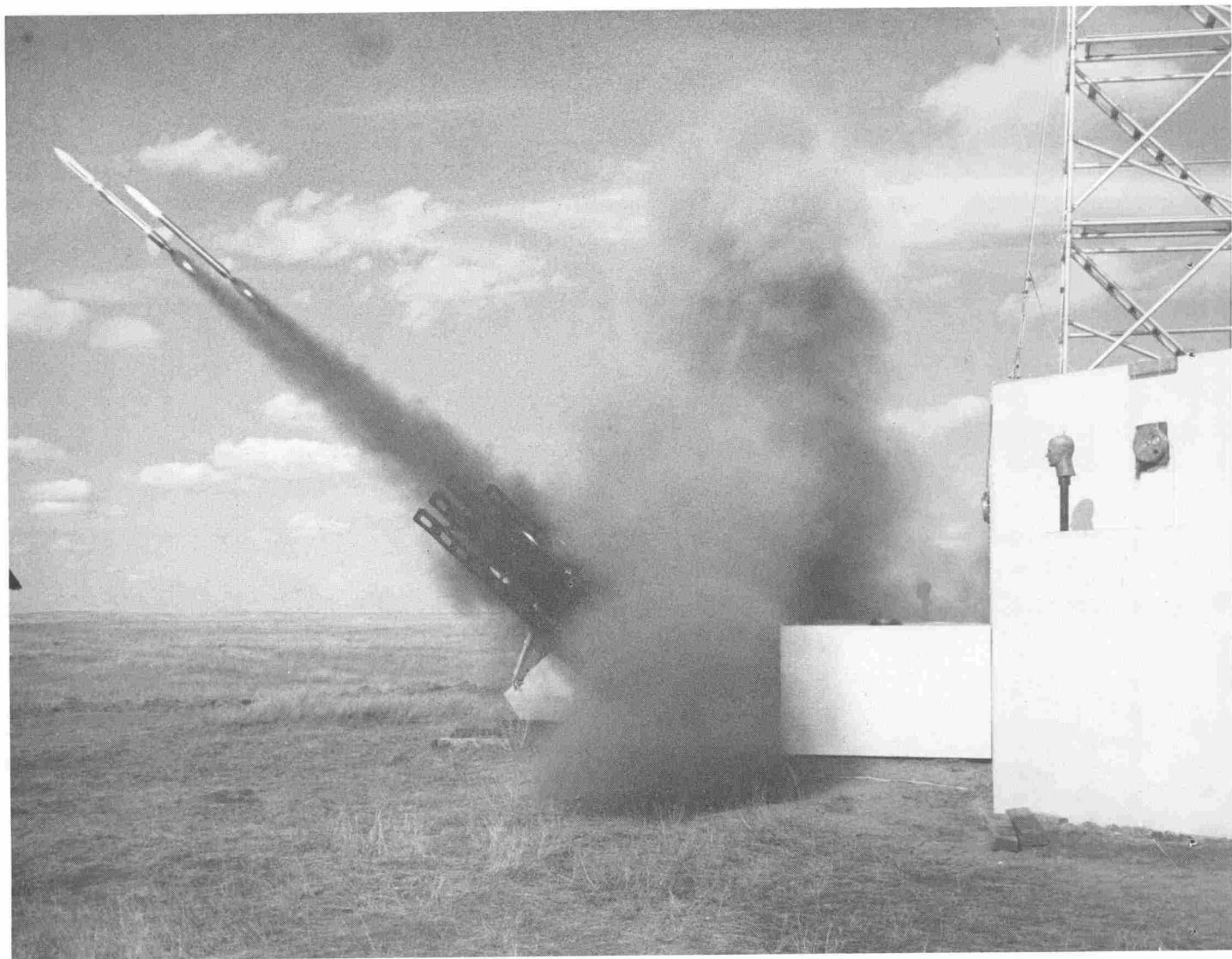
Scientists of the sonics group have been studying the problems of assessing sonar signals while helicopter-borne. It has been ascertained that adjustment of the frequency of the sonar signal will eliminate masking by helicopter noise and provide significant improvement in detection.

An anthropometric study of shortcomings in operator location, reaching distances to critical controls, etc., in Canadian Armed Forces aircraft has been carried out. The information will provide additional substantiation for recommendations regarding more effective human engineering of future Canadian Armed Forces aircraft. Work has also been completed for the Chief of Technical Services, regarding Instrument Flight Rules and the use of computer generated displays in conjunction with keyboard entry in Canadian Armed Forces control towers.



A subject's physical fitness is being measured. It has been found that physical fitness is related to the ability to withstand cold movements.

Simulated superstructure and instrumented dummy heads made in lead are included in the layout of pressure sensors in DRES trials of the 10.3 cm naval flare launcher designed to provide data on preferred locations for crew members and associated equipment aboard Canadian destroyers.



DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

RALSTON, ALTA.

The Defence Research Establishment Suffield (DRES) program was reoriented in 1971 to cover certain requirements following the new Defence Policy outlined in the White Paper. Research has continued in such areas as detection of biological agents, therapy for chemical agents, structural response of Canadian Emergency Measures Organization (CEMO) shelters and naval masts to shock and blast, and atmospheric turbulence. New areas include studies on Arctic diseases, pollution from ships' funnel emissions, and the disposal of ships' wastes. Technical contributions have been made to the Department of External Affairs concerning problems in the verification of adherence to chemical and biological disarmament treaties.

The nature of DRES research activities is indicated by particular examples dealing with chemical and biological protective procedures, impulse noise in military engineering, and disposal of hazardous materials.

Protective Procedures in Biological and Chemical Environments

An infantry company temporarily located at Suffield to carry out a wearing trial of Canadian chemical protective coveralls, sponsored by the Director of Clothing and General Engineering, provided the opportunity for testing further the biological and chemical protective procedures.

In a test in which a platoon occupied ground contaminated with a training chemical simulant, the persistence of the irritant effect on the skin, eyes, and nose, from a component of the simulant, provided direct evidence to the platoon of any breach of procedure. A second component of the training simulant allowed measurement, through urine analysis, of any intake of simulant into the body either by skin, mouth, or inhalation. Men contaminated with the same simulant were used to test procedures designed for handling and transporting casualties to a unit aid station. This simulant was the end product of considerable laboratory research and safety testing carried out at DRES, and it represents a significant advance in chemical defence training.



A portion of the layout used in trials at DRES to obtain data on the secondary aerosol produced when men occupy ground previously exposed to biological attack. In addition to free-air sampling, filters were fitted to mask inlets to provide direct estimates of individual exposures.

In a second test, information was obtained on the amounts of secondary aerosols which would have been inhaled by unmasked men occupying ground at various times after it had been subjected to a simulated biological attack. Information was also obtained on the contaminant produced on the clothing of men directly exposed to the attack who continued to occupy the area, and on the clothing of others brought in as reinforcements.

In a third test, the effectiveness of immediate action drills for defence against attacks of chemical spray were examined.

The tests have indicated the general effectiveness of current defence drills and procedures, and they

have also indicated where improvements can be made. The experience acquired has aided the further development of systems for providing troop training in operations in biological and chemical environments.

Impulse Noise

The levels of impulse noise or overpressure produced when weapons are fired can be sufficient to cause temporary or permanent hearing loss. By determining the pressure wave forms, DRES is, in co-operation with the Defence and Civil Institute of Environmental Medicine, providing bases for developing operating procedures to minimize these losses among firing crews and others who have to be in the immediate vicinity of the weapon. The transient peak pressures are measured by piezoelectric

transducers mounted in vibration free supports, or more realistically in the ear canals of dummy heads made of lead, which are exposed in various orientations and at different heights at crew positions and along radial lines from the weapon. Decibel contours are derived from these data and used to determine the best locations for crew members and the limits of exposure for them. Such data have been recorded for a number of anti-tank weapons, howitzers, recoilless rifles, and mortars, in firings at Canadian Forces Bases at Gagetown and Shilo, and data have been obtained on the Suffield range for a naval flare launcher. For the latter trial, the superstructures of dummy ships were provided to ensure proper augmentation of pressure where reflection could occur. Data for a wide range of orientations of the launcher in relation to the superstructures are being obtained economically, by the exposure of a model in a 6 ft shock tube. Dummy heads with recorders installed in the ears also are being used to evaluate the attenuation provided by hearing protective devices which might be considered for use by the Canadian Armed Forces.

The immediate objective of this work is to provide a basis for the continuing review of regulations governing weapon training.

Thermal Destruction of Hazardous Materials

As a result of restrictions placed by the Canadian Government on the general use of DDT, DRES was requested to investigate methods of disposal of very large stocks of solutions of this material held by the Canadian Armed Forces. Research work at the Fuel Research Centre of the Department of Energy, Mines and Resources, had shown that essentially complete degradation of DDT in kerosene could be achieved in a properly designed "blue-flame" burner, and for this reason it was decided to investigate commercially available incinerators.

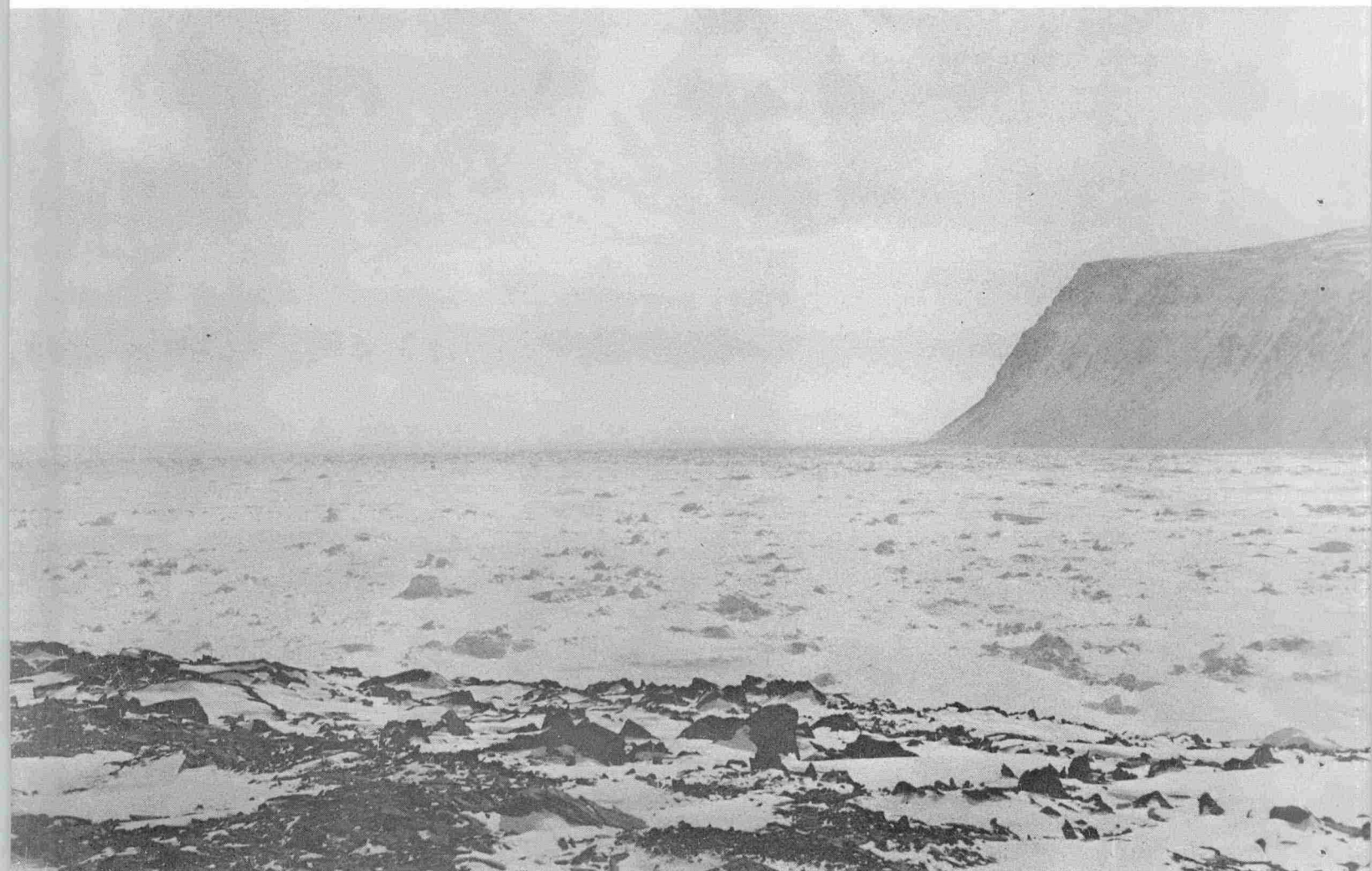
In consultation with industry, a design for a thermal destructor was selected, and it has now been constructed at DRES. The facility, which is flexible in operation, automatically maintains the optimum



Determination, in the 6 foot diameter shock tube at DRES, of the attenuation provided by protective ear muffs in a helmet provided for crews of armoured fighting vehicles.

combustion temperature as determined by computer analysis based on the composition and calorific value of the materials to be destroyed. With 5% DDT in kerosene at a throughput of 100 gal/h, near perfect combustion is achieved as only H_2O , CO_2 , and HCl gases are produced. The latter gas is removed in a scrubbing tower, the water from which is piped into holding ponds for neutralization before recirculation. Analysis of samples taken from the holding ponds and from the stack, at intervals over a period of 30 d operation, by procedures allowing detection of 0.5 ppb of DDT, has shown no DDT in the effluent water and a limiting value of 0.0002% DDT as unburned, in the effluent gases.

Wrangel Bay, Ellesmere Island.



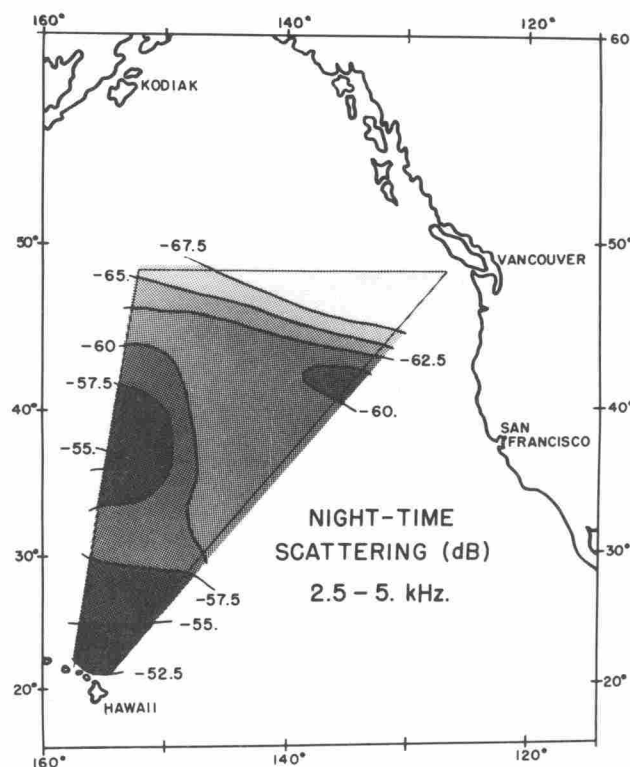
DEFENCE RESEARCH ESTABLISHMENT PACIFIC

ESQUIMALT, B.C.

Improvements in maritime operational procedures and equipment effectiveness and reliability are largely dependent on a thorough understanding of the ocean environment in which they operate. Research conducted at the Defence Research Establishment Pacific (DREP) is concerned primarily with environmental factors that relate to subjects of interest to the maritime units of the Canadian Armed Forces. Systems based on sound ranging and magnetic phenomena are still the major tools used in the field of underwater surveillance and detection, and factors affecting these systems are of prime importance in the research projects.

Acoustics Research

Acoustics research is conducted in the N.E. Pacific and in the waters of the Canadian Arctic. During the past year investigation of the characteristics of ambient acoustic noise and the nature of the back-scatter of sound from the volume of water surrounding a transmitter, has continued in the N.E. Pacific. An example of the results of this work is illustrated in the accompanying chart which shows contours of night time scattering strengths in the 2.5 to 5.5 KHz band for an area between Vancouver Island and



Reverberation level contours in a N.E. Pacific area.

Hawaii. The program is conducted to produce information to demonstrate seasonal, diurnal, and geographic distribution of reverberation levels for the N.E. Pacific.

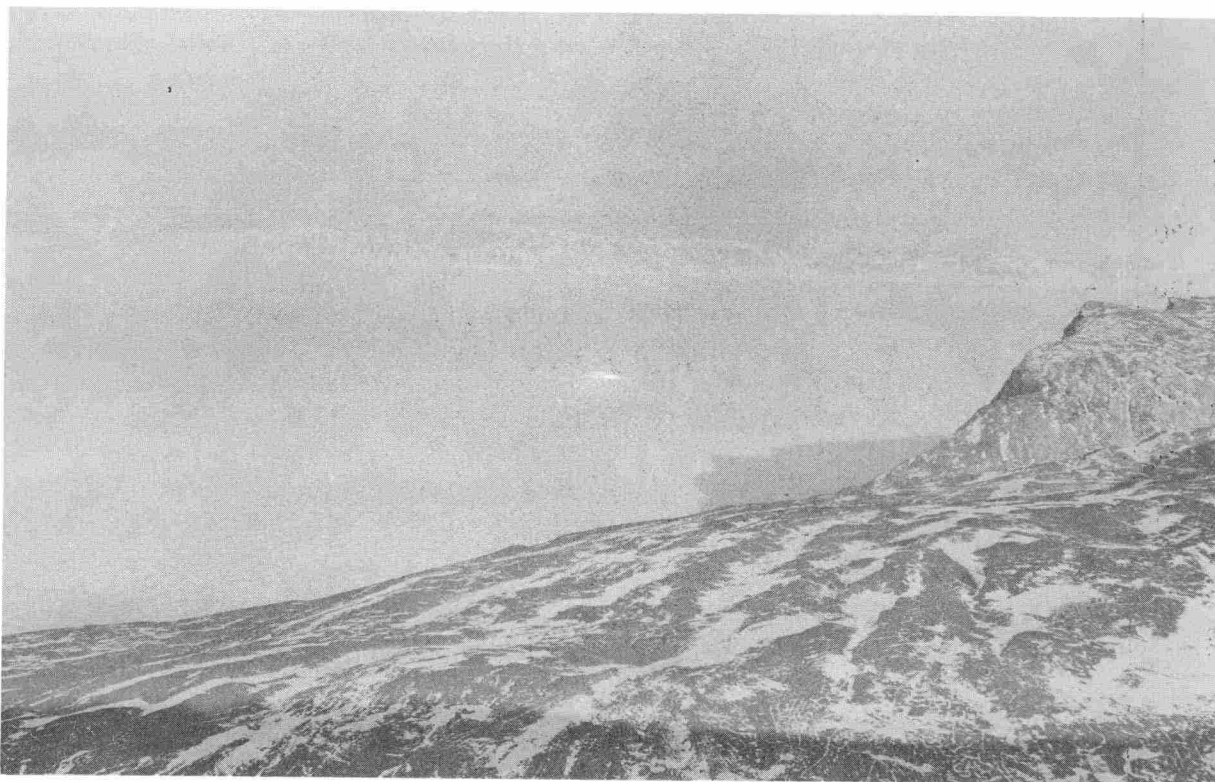
Increased effort has been applied to the investigation of acoustic phenomena in waters of the Arctic Archipelago. In previous years the collection of data on a year-round basis was limited to that which could be recorded in submerged instrument packages that were installed one year and recovered the next. The data collected was of necessity condensed, and was produced using periodic sampling techniques. During this past year systems have been developed and installed that present data, on a real and full time basis, measured by permanently deployed acoustic sensors. Telemetry links between remote sensors and permanent habitations on the Arctic islands provide a facility for collecting data not only during

the times when field operations are possible, but also during periods when the areas of interest are inaccessible. The large amount of information becoming available has created a need for automatic data analysis at the data collecting location. Digital processing techniques are being developed and applied more extensively to meet this requirement.

As part of the continuing study of the acoustic environment in ice covered waters, noise measurements were made in one of the Arctic channels using sensors placed on the snow surface, in the snow cover and at the upper and lower ice surfaces. These measurements are being studied in relation to the type and extent of snow cover, the age, thickness and structure of the ice, and weather factors such as wind and temperature gradients. Wind blown snow has been identified as a noise source and sound absorbing layers of ice have been discovered during the course of the study.

Cable laying in Wrangel Bay, Ellesmere Island.





Robeson Channel looking toward Greenland.

Magnetics Research

The study of naturally-occurring fluctuations of the earth's magnetic field, which can degrade the performance of airborne magnetic detectors, was continued during 1971. Full use was made of the specially designed equipment set up at Ralston, Alberta, for recording accurate amplitude and frequency statistics of geomagnetic micropulsations during the year. Because the equipment is continuously recording, all magnetic storms, whether short-lived or lasting for a day or two, are detected and the effect they would have on airborne magnetometers can be determined. A similar survey was initiated in the arctic, north of the auroral zone, by the installation of equipment in the vicinity of Resolute on Cornwallis Island. Recordings were also made of geological noise utilizing Canadian Armed Forces aircraft patrols along the Northwest Passage.

Materials Engineering

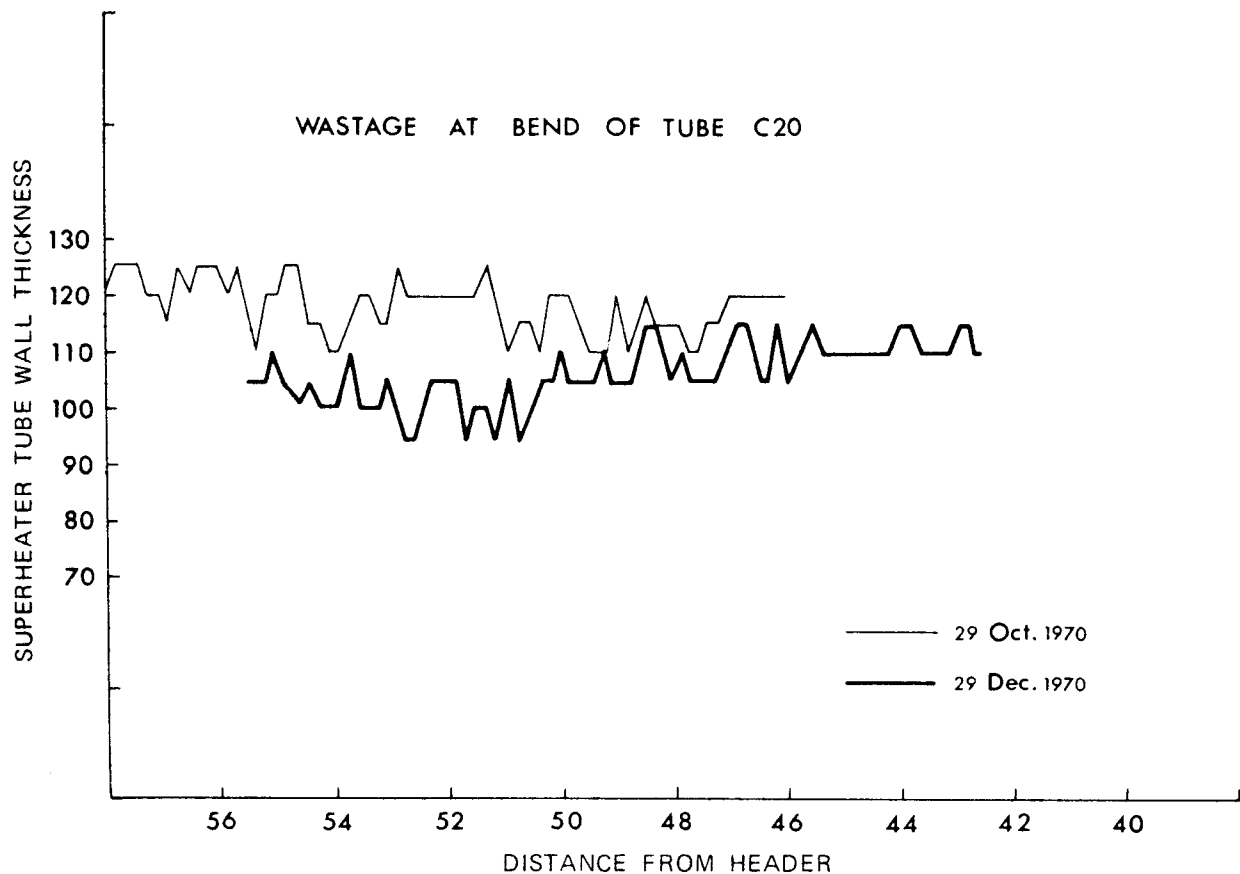
Among the varied capabilities called upon by the Canadian Armed Forces and occasionally by civilian authorities, are those in the armaments line. Concern

for possible TNT contamination in soil resulting from operations at the Armament Depot required a capability of TNT identification in soil samples of ~5 ppm. This was achieved by a DREP method involving solvent extraction, separation, and colorimetric determination. Local authorities were assisted in identification of explosives from bomb fragments, and from intact bombs.

Research into problems associated with the use of maraging steel on the hydrofoil has been continued. Among helpful concepts arising from this work were:

- (1) that cracking under hydrogen embrittlement conditions tends to be confined to the heat affected zone and not primarily to the weld metal (this tends to put less emphasis on critical defects in weld metal),
- (2) the apparent gradual nature of the propagation of cracks.

Recent materials discussions tend to suggest that maraging steel is still one of the more useful candidate materials for the next generation in foil service.



Superheater tube wall thickness vs. distance from header.

The DREP-developed capability to rapidly measure thickness of superheater tubes (relatively inaccessible otherwise) played an important part in a Canadian Armed Forces experiment to determine the effect of reduced steam flow on the remaining tubes when more than the normal number of tubes are plugged or burnt-out. Using an ultrasonic gauge, wall thicknesses were determined before and after a two month period of intense steaming. The results indicated considerable metal loss under such conditions as shown on the accompanying graph.

Problems associated with aircraft provided an interesting challenge in this year. Among these for CF101 were:

- (1) Exploring metallurgical effects of a lightning strike.
- (2) Establishing extent of overheating of skin (by eddy current) associated with an engine fire.

- (3) Determining the role played by a copper-colored anti-seize compound containing lead oxide and molybdenum disulfate on rupture of alloy bolts on the exhaust casing. Molten lead was involved in the intergranular cracking.
- (4) Establishing X-ray and atomic absorption methods for precise monitoring of metallic contaminant levels in hydraulic fluids. Norms were also determined.

Activities in the Spectrometric Oil Analysis Program included drawing up a course of instruction at Canadian Armed Forces request, which has been distributed to NATO navies and committee members involved in Canadian Armed Forces fuels and lubricants activities.

DEFENCE RESEARCH BOARD SYMPOSIUM

The twenty-third annual Symposium was held in Ottawa from 16 to 18 November 1971.

At the opening session in the Theatre of the National Arts Centre, Dr. Michael K. Oliver, Vice-Principal Academic of McGill University, gave the guest address on the subject: "Social Science and Canadian Security." The address was followed by a lively discussion period.

The technical sessions of the Symposium were held in the Chateau Laurier Hotel. On Tuesday afternoon, 16 November, four review papers covering different aspects of the Board's program were presented.

A Seminar on the North was conducted on Wednesday, 17 November. Canadian Armed Forces personnel participated in this session by giving presentations on the roles, objectives, and activities of the Canadian Armed Forces in the North and by presenting several of the technical papers. Two main topics were discussed: airborne reconnaissance and surveillance in the North; and movement and protection of the individual soldier in the North.

The final day of the Symposium was devoted to two concurrent sessions of technical papers given by ten of the Board's scientists.

EXTRAMURAL GRANTS PROGRAM

During 1971 the Defence Research Board supported 483 projects in 40 universities and colleges through grants in aid of research. In addition, support was

provided for university staff members who hold appointments in 12 teaching hospitals. This support of basic research in Canadian universities has three objectives: to acquire new scientific knowledge that may prove applicable to the solution of technical defence problems; to develop and support in the scientific community an interest in defence science, which may contribute to the long-term maintenance of a Canadian defence research capability; and to assist in recruiting young scientists for employment with the Board.

To meet these objectives, the Board invites members of all Canadian university staffs to submit research proposals. These are reviewed in the light of two criteria. The first is scientific quality; this is judged by Advisory Committees of experts in the appropriate scientific fields, drawn from the universities themselves, from industry and business, and from other government departments. The second is concerned with applicability to defence or, in more general terms, with the extent to which the proposed research will contribute to meeting the objectives outlined above; to judge this factor, all applications that have qualified on scientific grounds are reviewed by Defence Research Board scientists in collaboration with representatives of the Armed Forces.

Funds available for extramural grants during 1971 totalled \$3,084,925 of which \$3,000,000 was voted by Parliament for the year's program. The remaining \$84,925 represents unexpended funds carried forward as a credit for use in 1971. The total value of applications received by the Board decreased from \$8,535,904 in 1970 to \$8,113,781 in 1971.

Appendix A shows the distribution of grants in 1971 among universities and other organizations; Appendix B shows distribution by scientific fields.

APPENDIX A

GRANTS IN AID OF EXTRAMURAL RESEARCH – 1971

Distribution by Universities and Organizations

University or Organization	Number of Grants	Program Level \$
Alberta	27	125,250
Arctic Institute of North America	1	7,500
British Columbia	39	255,075
Brock	1	5,000
Calgary	21	115,500
Carleton	11	59,500
Collège Militaire Royal	9	74,100
Dalhousie	11	69,400
Guelph	7	55,150
Lakehead	1	3,000
Laurentian	1	4,000
Laval	24	147,650
Loyola College	1	3,000
Manitoba	20	119,150
McGill	36	341,950
McMaster	23	116,400
Memorial	5	18,900
Moncton	1	4,000
Montréal	17	170,900
New Brunswick	9	52,800
Nova Scotia Technical College	2	9,000
Ottawa	13	67,900
Québec – Trois Rivières	1	3,500
Québec – Varennes	1	4,000
Queen's	15	92,900
Royal Military College	29	237,000
Royal Roads Military College	6	13,300
St. Francis Xavier	1	4,000
Saskatchewan	13	76,700
Saskatchewan (Regina)	2	9,500
Sherbrooke	8	45,500
Simon Fraser	6	34,000
Toronto	49	341,900
Trent	2	10,000
Victoria	5	29,500
Waterloo	31	154,800
Western Ontario	15	87,700
Windsor	5	19,800
York	14	95,700
GRAND TOTAL	483	3,084,925

APPENDIX B

GRANTS IN AID OF EXTRAMURAL RESEARCH – 1971

Distribution by Scientific Fields

FIELD	Number of Grants	Program Level \$
Chemical Research	62	365,750
Power Sources Research	18	98,000
Environmental Protection Research	17	83,500
Clothing and General Equipment	4	24,000
Entomology	13	59,500
Defence Against Biological Agents Research	6	40,700
Human Resources Research	21	159,275
Medical Research	51	378,900
Plasma and Fluid Dynamics Research	32	178,800
Structures and Materials Research	40	244,100
Engineering (Civil and Mechanical) Research	36	203,950
Laser Research	10	87,000
Physics and Electrical Engineering Research	91	640,600
Geophysical Research	53	307,500
Applied Mathematics and Computer Science	31	202,350
Economics, Political Science and Operational Research	12	49,500
Institutional Grants	3	45,000
TOTALS	483	3,084,925

DEFENCE INDUSTRIAL RESEARCH PROGRAM

The Defence Industrial Research Program was established in 1961 to stimulate an increase in the level of scientific and technological competence of Canadian defence industry. Under this program, the Defence Research Board normally pays half the cost of suitable applied research projects by means of a non-refundable contribution. The initiative for submitting proposals lies with industry, the most promising proposals being selected for support on their scientific merits and on their relevance to defence interests.

The financial level of the program has remained unchanged from last year, as the funds available for support in the fiscal year 1971-72 was \$4,500,000. Rising costs, however, mean that the total volume of work supported is on the decline.

During the year it became quite apparent that the level of funding for the DIR program would be inadequate to meet the requests from Canadian industry. The program tends to attract applications primarily in the fields of engineering and physics. In these areas, there exists a high degree of sophistication along with a general need for a high number of technical support staff for each professional employed, as well as a significant shop-work content component in the preparation of research models. Consequently, as industry becomes more involved in research, the costs of individual projects tend to become more expensive, and in addition, more small companies interested in defence technologies are seeking support to establish research facilities.

DIR Statistics for the year 1971*

Total Expenditures by DRB and Industry (1961-1971 inclusive)	\$80 x 10 ⁶
Number of Scientists Employed	300
Number of New Proposals and Proposed Extensions	35
Number of Proposals and Extensions (1961-1971 inclusive)	372
Number of Active Projects	92
Number of Projects Completed	16
Number of Companies Receiving Grants	48
Number of Patents Granted	15
Number of Patent Applications Pending	12
Number of Scientific Papers Published	97
Number of Lectures Given	99

* Note: All DIR statistics are for the year 1971 unless otherwise stated.

Division of Support by Fields of Endeavor (1971)

Aeronautics	8.8%
Power Sources	3.6%
Electronics	58.9%
Materials	9.2%
Aircraft Propulsion	18.0%
Mechanics and Weapons	1.5%

SCIENTIFIC AND TECHNICAL INFORMATION

The Board's responsibility for collecting and disseminating Canadian and foreign scientific and technical information of defence origin is discharged by the Defence Scientific Information Service (DSIS). Their services are available to all who participate in Canadian defence research and development.

Selective dissemination of current information, the most useful way of combatting the information explosion, has been largely automated. The computing work has been brought in-house, with substantial reduction in costs. The coverage has been extended far beyond the documents actually obtained by DSIS, by the searching of magnetic tapes prepared elsewhere, and without the need for costly processing of data. These economies in processing effort permit earlier dispatch of documents to users. Another method of defeating the information explosion that is being assessed is to analyze incoming documents, and to extract only what is new, discarding the rest. This requires extra work by subject specialists, but the additional effort may be well worthwhile, especially for support of research concerned with national sovereignty, the highest priority of defence responsibility.

Advantage has been taken of the economy and convenience of microforms. Cheaper copies of documents are being made more readily available as microfiche. Cassettes of microfilm, indexed and labelled for semi-automatic retrieval, have been introduced containing abstracts of U.S. defense scien-

tific and technical reports published over the last 10 years. This DSIS subject catalog, covering 25 years accessions, is being organized in the same form, with copies of the films to be provided to those defence establishments which wish to do their own searching. Some research and development work has been done on on-line retrieval by computer, but initiation of the main task has to await the selection of a central computer system for the department. Continued development and adoption of new processes, procedures, standards, and quality control methods have helped to streamline production, set quality levels for products and services, and maintain these levels. Participation in planning and reviewing of research and development work, in committees at departmental, national, and international levels, has benefitted the work here, and has enabled DSIS to make some contribution to the work of others.

Selective announcements of current information, a most useful way of combatting the information explosion, has been largely automated. The coverage has been extended beyond the documents obtained by DSIS to those which can be obtained by searching magnetic tapes prepared elsewhere. This is markedly increasing the size of the data-base and doing so without the need for costly re-processing.

PERSONNEL

The following table shows comparative authorized man-years and strength by category for 1970-71 and 1971-72.

	Authorized MY 1970-71	Strength 31 Oct. 1970	Authorized MY 1971-72	Strength 31 Oct. 1971
Executive, Scientific and Professional	506	496	507	515
Technical	720	701	707	712
Administrative and Foreign Service	80	72	84	78
Administrative Support	448	429	420	415
Operational	<u>379</u>	<u>375</u>	<u>369</u>	<u>376</u>
TOTAL	<u>2133</u>	<u>2073</u>	<u>2087</u>	<u>2096</u>
Seconded Personnel	34	28	34	33

During the last quarter of 1971, Collective Agreements were entered into with the Public Service Alliance of Canada for employees in the bargaining units of the Technical, Administrative and Foreign Service, and Administrative Support Categories. Negotiations with the Alliance for new Agreements covering employees in the Operational Category commenced in September. During the same month, negotiations with the Professional Institute of the Public Service of Canada for new Agreements for employees of the Scientific and Professional Category also were initiated.

Most terms in the new Agreement for employees of the Administrative and Foreign Service Category were settled at the bargaining table. As the parties could not reach agreement on rates of pay and on two other items, however, these issues were referred to the arbitration process. This marks the first occasion on which the Board has been a party to arbitration.

Approximately 3,000 enquiries regarding possible employment with DRB have been handled. Thirty-nine Professional, 37 Technical, and 83 Administrative Support and Operational Category personnel were hired. A computer-operated typewriter was used as an aid in processing the more routine letters. The summer employment program provided employment for 207 students across Canada.

ADMINISTRATION AND FINANCE

The year 1971, from an administrator's point of view, has been one for negotiation. The amalgamation of the Defence Research Establishment Toronto and the Canadian Forces Institute of Environmental Medicine to form the Defence and Civil Institute of Environmental Medicine (DCIEM), posed problems

of an administrative nature. The formation of CFB Suffield as a Canadian Forces Base responsible for providing training facilities for British Forces in Canada, and the subsequent necessity for defining the interface between CFB Suffield and the Defence Research Establishment Suffield, has presented problems of an administrative nature as well.

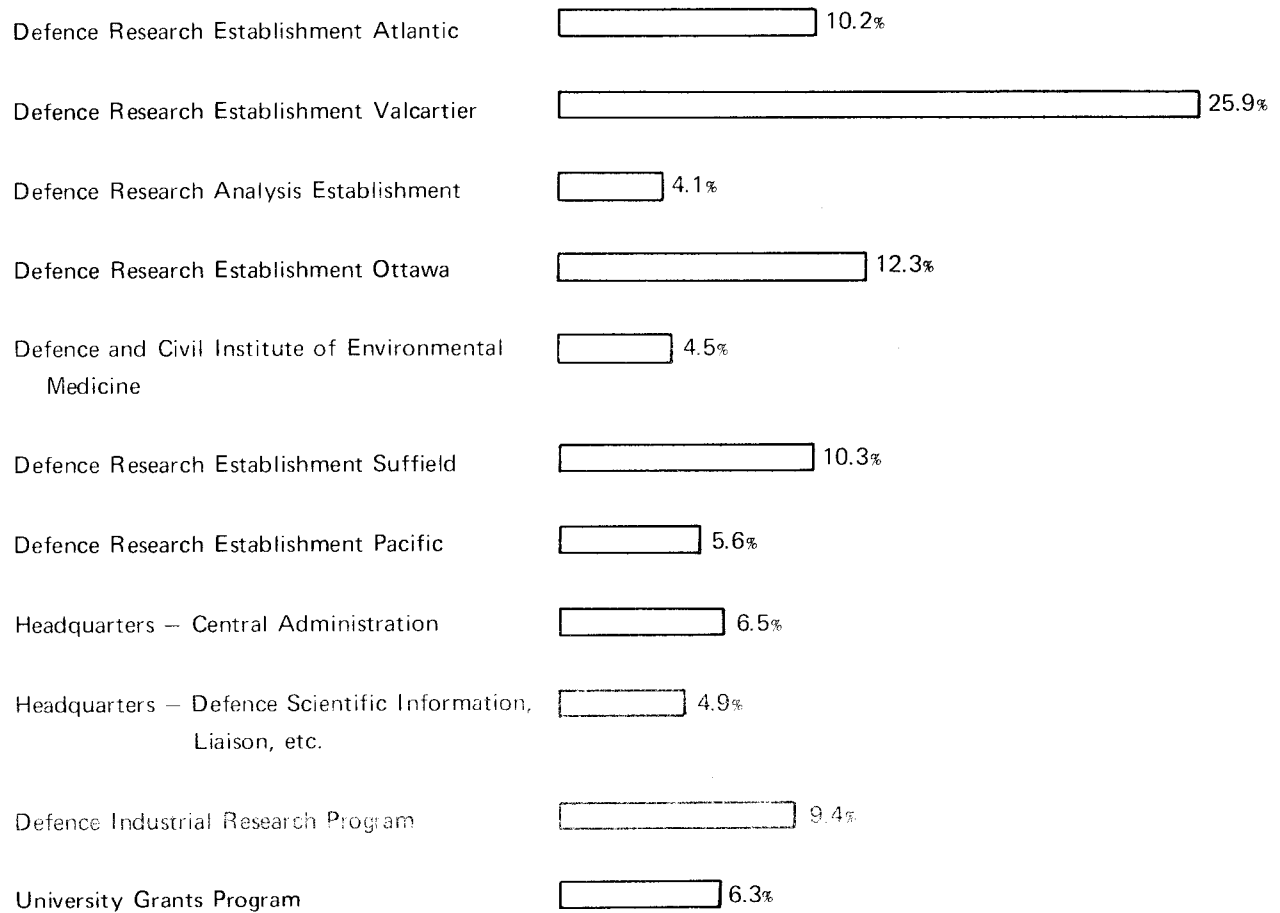
The formation of DCIEM required, in the first instance, an agreement between the Chief of the Defence Staff and the Chairman, Defence Research Board; this was signed on April 1, 1971. It was followed by an agreement between the Chairman, Defence Research Board and the Deputy Minister of Health, Department of National Health and Welfare. The Defence Research Board/Canadian Armed Forces agreement for the operation of Suffield was signed on October 27.

With the signing of these agreements, it was possible to start detailed administrative arrangements including such items as personnel transfer, equipment, buildings, and transport.

In 1971-72 a new financial management policy was introduced with the objective of providing management control of finances through allotments related to technical programs rather than through objects of expenditures.

Of the total of \$47,400,000 allocated to the Defence Research Board for the fiscal year 1970-71, the actual expenditure was \$45,861,792. For the fiscal year 1971-72 a total of \$47,650,000 has been allocated to the Board - a budgetary allotment of \$47,400,000 plus estimated revenue of \$250,000. Diagram 1 shows the distribution of funds among the Board's activities and establishments in 1971-72. In addition to the foregoing, a supplementary estimate has provided \$359,000 for the labor intensive winter works program.

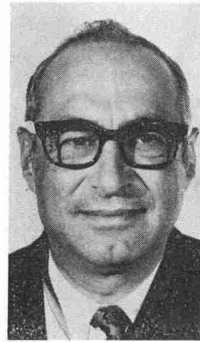
DIAGRAM 1
PERCENTAGE DISTRIBUTION OF FUNDS — 1971-72



THE DEFENCE RESEARCH BOARD — 1971



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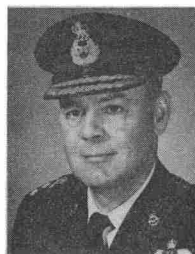
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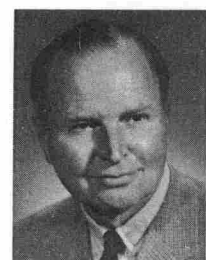
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