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INTERDEPARTMENTAL COMMITTEE ON SPACE

Third Annual Report

1 February 1972

DEPARTMENT OF COMMUNICATIONS

CANADA

MINISTÈRE DES COMMUNICATIONS

IN REPLY QUOTE:
RÉF. À RAPPELER:

1 February, 1972

The Hon. Alastair Gillespie, P.C., M.P.,
Minister of State for Science & Technology,
House of Commons, Room 233S,
Ottawa, Ontario

Dear Mr. Gillespie:

Interdepartmental Committee on Space
Annual Report - 1971

I have the honour to submit to you the Annual Report of the Interdepartmental Committee on Space for the year 1971.

Yours sincerely,

J.H. Chapman,
Chairman,
Interdepartmental Committee
on Space

Encl.

INTERDEPARTMENTAL COMMITTEE ON SPACE

ANNUAL REPORT - 1972

1. Introduction

The Interdepartmental Committee on Space met once in 1971, since the last report was submitted by the ICS on 18 January, 1971. The Committee did not find a basis for a positive reply to the NASA invitation to join the Post-Apollo program, within current policies of the government. In the area of international activities, the Committee was quite active during the year. The Sub-Committee covering this aspect has continued to meet and to be concerned with an increasing number of international space matters requiring Canadian government action.

International space activities of specific importance to Canada during the past year were:-

A) the conclusion of an agreement with the U.S.A. providing for Canada's participation in the Earth Resources Technical Satellite program of the US/NASA.

B) the negotiation of an agreement (presently before Cabinet) authorizing the US/NASA to establish in Newfoundland a space tracking station for its SKYLAB project.

C) the negotiation of an extension of the Canada-Federal German Government agreement for the use of the Churchill rocket range.

D) the participation by Canada in the UN Committee on the Peaceful Uses of Outer Space and its associated legal and scientific sub-committees.

E) the participation by Canada in the UN sponsored intergovernmental working group on remote sensing of the earth by satellites.

F) the negotiation of a Memorandum of Understanding between Canada (represented by DOC) and the US (represented by NASA) covering the development, construction, launch and operation of a communication technology satellite. This agreement was signed in May 1971 and the development of satellite systems has already begun in Canadian industry.

2. Canadian Space Policy

Some of the previous guidelines for development of a Canadian space policy considered by the Committee were as follows:

..2

(i) The Royal Commission on Government Organization (January 1963), which made a recommendation concerning the consolidation into a single agency of all government non-military space research.

(ii) The Science Secretariat, which commissioned a technical study, Special Study No. 1, Upper Atmosphere and Space Programs in Canada (February 1967).

(iii) The Science Council of Canada, which made specific recommendations to the Prime Minister in its Report No. 1, A Space Program for Canada (July 1967).

(iv) Cabinet, which approved the formation of the Interdepartmental Committee on Resource Satellites and Remote Airborne Sensing in July 1969 and of the Interdepartmental Committee on Space in December 1969.

The Interdepartmental Committee on Space was set up as an interim measure intended to coordinate space activities. During the past two years, a major concern of the Committee was the Post-Apollo problem. In retrospect it may be reasoned that the Committee should have concentrated initially on developing a space policy rather than trying to cope with the Post-Apollo situation. However, at the time, the urgency to prepare a response to NASA overshadowed all else. The need is still for a well-thought-out policy and the initiative is now with the new Ministry of State for Science and Technology.

3. Summary of Expenditures

The expenditures on space programs (details appended) were approximately $24 million in 1971-72 and are estimated at approximately $27 million in 1972-73.

4. According to its terms of reference, the Committee should make this Annual report to the Chairman of the Cabinet Committee on Science Policy and Technology. This Committee no longer exists and the Minister of State for Science and Technology has been asked to receive the report on behalf of the Cabinet. The report consists primarily of a statement of expenditures, and a summary of Canadian space and upper atmosphere research activities of all departments prepared by the NRC. The terms of reference of the Committee, together with the list of membership, are attached as appendices.

1 February 1972

Statement of Federal Government Expenditures on Space Activities

($ Millions), 1971-72 and 1972-73 (estimated)

Department of Communications	1971-72	1972-73
Spacecraft Technology and Satellite Operations	9.772	15.792
Satellite Communications Systems	1.144 [1]	1.569 [1]
Scientific Research Utilizing Satellites and Rockets	0.550	0.550
Earth Resource Technology Satellite Ground Station	1.199 [2]	0.250 [3]
TOTAL	12.665	18.161

1
0.270 recoverable from DRB not included

2
1.127 capital recoverable from EMR included

3
0.214 O&M recoverable from EMR included

0.300 capital to be provided by EMR not included

Department of Energy, Mines and Resources	1971-72	1972-73
Earth Resources Technology Satellite (ERTS) experiments [1]	5.127	2.210

1
Includes airborne part of the program

Department of Industry, Trade and Commerce	1971-72	1972-73
Ground Stations for Satellite Communications Systems	0.200	0.200
Rocket Development	0.720	0.500
Reproducer for weather satellite pictures	0.070	0.070
Space environment simulator and test equipment	0.082	0.050
TOTAL	1.072	0.820

(All of the above expenditures are under the Defence Industry Productivity (DIP) Program)

..2

Ministry of Transport	1971-72	1972-73
Satellite Communications and Surveillance Systems	0.090	0.500 [1]
Space Related Meteorological Activities	0.229	0.468 [2]
TOTAL	0.319	0.968

1 In 1972-73 it is intended, subject to Cabinet approval, that a first payment will be made towards Canadian participation in the "Pre-operational Aeronautical Satellite Development Program".

2 Although Meteorology is now within the Department of of the Environment, it has been included this year under the Ministry of Transport. The sum of $240,000 is included in the 1972-73 estimates for the construction of two weather satellite read-out stations to be located at Halifax and Vancouver.

National Research Council	1971-72	1972-73
Intra-mural space oriented programs	3.150 [1]	3.450 [1]
Extra-mural (University) space oriented programs	0.800	0.800
TOTAL	3.950	4.250

1 Includes cost of work reported on in pages 51-65 inclusive of SRFB061 with the exception of astronomy.

Department of National Defence/Defence Research Board

Intramural Programs	1971-72	1972-73
Tactical Satellite Communications	0.273[1]	0.370[1]
Studies related to Remote Sensing	0.217	0.282
Other space related research	0.164[2,3]	0.157[2,3]
TOTAL	0.654	0.809

Extramural Programs		
Defence Industrial Research	0.122	0.114[4]
University Grants Program	0.283[5]	Figures not available
	1.059	

1 This work is conducted at the Communications Research Centre of DOC but funded by the Defence Research Board on behalf of the Department of National Defence.

2 Some programs include non-space oriented components. The figures given here are for the space oriented components only.

3 Includes $19,000 in 1971-72 and $11,000 in 1972-73 which are recoverable from DOC.

4 DIR programs for 1972-73 are subject to further review and approval. The estimate given here assumes approval at current rate of expenditure.

5 A total of 42 grants to Canadian Universities in 1971-72 under the DRB University Grants Program may be considered as space-related. The applications for grants in the 1972-73 fiscal year are still being processed and it is not possible to estimate the total expenditure at this time.

TERMS OF REFERENCE

INTERDEPARTMENTAL COMMITTEE ON SPACE

DEFINITIONS:

For the purposes of the Interdepartmental Committee on Space, space is defined as the upper atmosphere and space above a lower limit of 50 Kilometres altitude. Space activity includes research or other operations conducted by means of rockets, satellites, high altitude balloons, or other devices, and including associated ground-based activity.

ORGANIZATION:

1. The Committee shall be composed of senior officials, able to speak for their department on policy matters, and representing:

   Department of Communications
   Department of Energy, Mines and Resources
   Department of Industry, Trade and Commerce
   Department of Transport
   Department of National Health and Welfare (Health)
   Defence Research Board
   National Research Council

2. Observer status shall be accorded representatives of:

   Science Secretariat
   Treasury Board Secretariat
   Department of External Affairs

3. The Chairman shall be named by the Committee.

4. The Committee shall have the power to establish sub-committees in areas of special interest, and the sub-committees should include representatives of other departments and agencies, industry, and universities as desirable and necessary.

5. The Committee shall report to the Chairman, Cabinet Committee on Science Policy and Technology, through the Secretary, CCSPT.

DUTIES:

1. To review Canadian space activity including that of Federal Government departments and agencies, the universities, and industry and to make recommendations concerning the optimum use of resources, the coordination of space activity and the dissemination of information of such space activity.

2. To consider Federal policy for space activity in relation to national interests, needs and opportunities and to formulate and recommend appropriate plans and proposals.

3. To make recommendations for the promotion of cooperation in the space activities of national and international organizations.

4. To report annually, on February 1st, or more often if desirable, to the Chairman of the Cabinet Committee on Science Policy and Technology.

INTERDEPARTMENTAL COMMITTEE ON SPACE

MEMBERSHIP

Dr. J. H. Chapman (Chairman)	-	Dept. of Communications
Mr. John Gratwick	-	Ministry of Transport
Dr. L. W. Morley	-	Energy Mines & Resources
Dr. H. Sheffer	-	Defence Research Board
Mr. F. R. Thurston	-	National Research Council
Dr. S. Wagner	-	Dept. of Industry, Trade & Commerce
Mr. W. K. Wardroper	-	Dept. of External Affairs

OBSERVER

Dr. J. R. Whitehead	-	Ministry of State for Science and Technology

SUB-COMMITTEES

International Aspects of Space Policy

Mr. G. F. Bruce (Chairman)	-	Dept. of External Affairs

Space Vehicles and Propulsion

Mr. F. R. Thurston (Chairman)	-	National Research Council

Satellite Applications and Technology

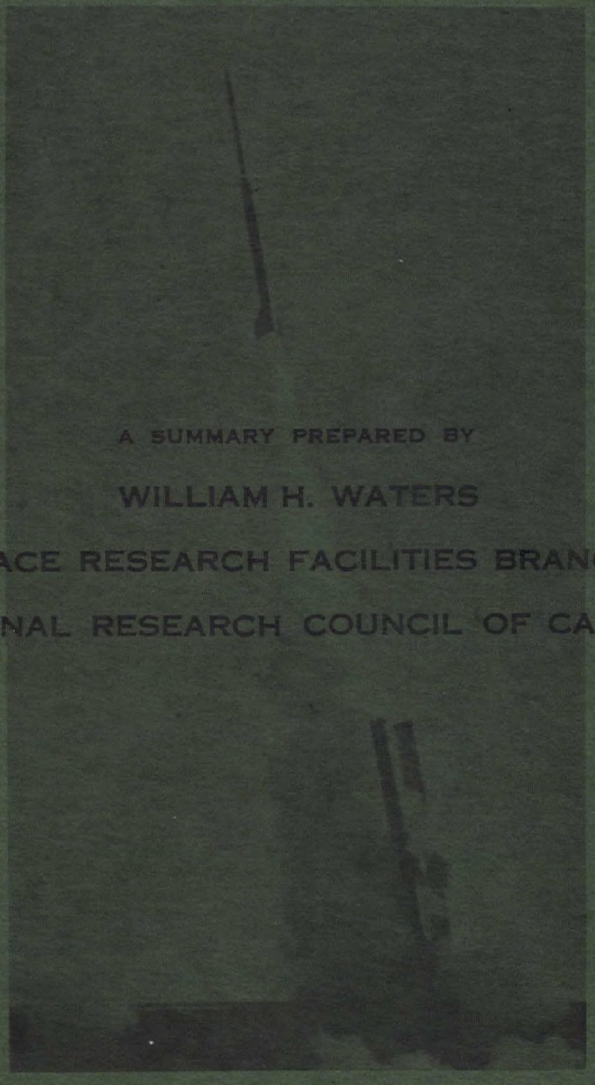
Mr. B. A. Walker (Chairman)	-	Dept. of Communications

Scientific Research

Dr. R. E. Barrington (Chairman)	-	Dept. of Communications

SRFB 061

Space And Upper Atmosphere Programs in Canada
Balloons, Rockets And Satellites
1971



A SUMMARY PREPARED BY

WILLIAM H. WATERS

SPACE RESEARCH FACILITIES BRANCH

NATIONAL RESEARCH COUNCIL OF CANADA

OTTAWA

JANUARY 1972

SPACE AND UPPER ATMOSPHERE PROGRAMS IN CANADA
BALLOONS, ROCKETS AND SATELLITES
1971

A SUMMARY PREPARED BY

William H. Waters

SPACE RESEARCH FACILITIES BRANCH

NATIONAL RESEARCH COUNCIL OF CANADA

OTTAWA

JANUARY 1972

FOREWORD

This report is published yearly to keep interested scientists, government departments and others informed regarding Canada's space programs. Contributions from participating and associated agencies are solicited and form a major portion of the publication. These contributions are in general up-to-date as of the end of December each year.

This is the fourth annual edition, with the first (SRFB 024) having been published in January 1969. As stated in earlier editions, this publications' introduction, and brief histories of space activities in balloons, rockets, satellites and associated activities will be included in subsequent editions in order to make these reports as complete as possible. Yearly changes and amendments will be continued to correct the record.

SRFB 024 (January 1969) is now out of print. A few copies of the English version of SRFB 036 (January 1970) remain, but the French version has been exhausted. Copies of last year's edition SRFB 048 (January 1971) in both English and French are still available. These publications may be obtained by applying to the Space Research Facilities Branch, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

Activities in Industry - Cont'd — Page

TABLES

TABLE OF CONTENTS (Cont'd)

Activities in Government Organizations - Cont'd — Page

TABLE OF CONTENTS (Cont'd)

INTRODUCTION

This document contains information regarding Canada's activities in space and her contribution to the international effort. It has been prepared as a result of written and verbal requests for such information and should not be construed as containing a complete digest. While not too well known, these activities are carried on by means of balloons, sounding rockets, satellites and ground-based research laboratories.

Canada, by reason of geography and history, has been able to take an active part in upper atmosphere research. With the assistance of the United States, in an outstanding example of international co-operation, a Canadian designed-and-built satellite was placed in orbit in 1962, and Canada became the third nation to build and operate its own space vehicle.

Balloons were first employed in upper atmospheric research early in this century, and ground-based research was used in the studies of the aurora borealis as early as 1867. The use of sounding rockets as tools for upper atmospheric research in Canada commenced in 1957 in connection with the International Geophysical Year (IGY). Satellite research was started in 1958 during the planning stage of Alouette I, shortly after the Space Age was opened by the launching of Sputnik I in October 1957.

Canadian space activities cover a broad range of scientific disciplines in the fields of basic and applied research and in the applications of space technology. Within the Federal Government, these activities are co-ordinated by an Interdepartmental Committee on Space, which was established in 1969. The Canadian National Committee on Space Research is a sub-committee of the Interdepartmental Committee on Space and is also an Associate Committee of the National Research Council of Canada. This committee, which is made up of scientists from universities, industry and government, acts as a consultative group on scientific matters related to space.

Canada is a member of the United Nations Committee on the Peaceful Uses of Outer Space, and the Canadian National Committee on Space Research is a member of the International Committee on Space Research (COSPAR). Canada is also represented by the Canadian Overseas Telecommunications Corporation on the International Communications Satellite Consortium (Intelsat), which is involved in a global satellite communications system placed in operation in 1965.

PREPARING A BALLOON EXPERIMENT FOR FLIGHT

BALLOONS

High flying balloons were first used by the Meteorological Branch of the Department of Transport following the First World War. They carried an aneroid-bimetallic device for recording pressure and temperature on a small glass plate. These meteorographs had to be recovered. John Patterson, later Director of the Meteorological Services, did some of the work which was useful in establishing stratosphere heights over Canada.

The next high flying balloon flights in Canada took place from the University of Saskatchewan during the summer of 1939 to measure cosmic ray intensities in the upper atmosphere, in co-operation with R. A. Millikan and V. Neher of the University of Chicago. They carried electroscopes which had to be recovered in order to get the data. Five balloons were spaced along a leader to which the instruments were attached. Four or five successful flights were made. (Some early Canadian flights were also made by Professor Demers of the University of Montreal.)

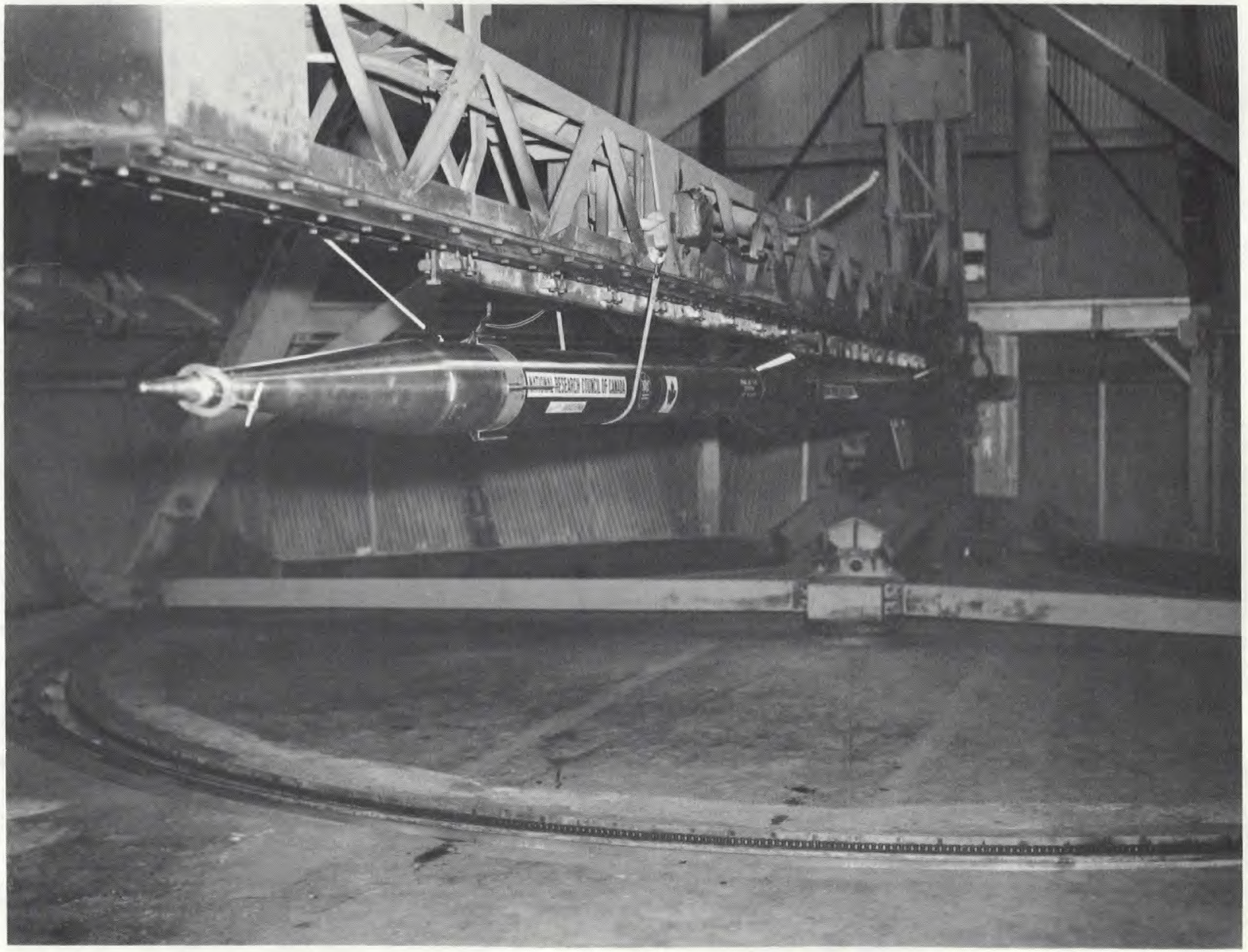
The first large scale Canadian balloon program, however, was that instituted by the Canadian Armament Research and Development Establishment (CARDE), Quebec, during the 1950's. Numerous important spectroscopic and photometric measurements have been made. The CARDE program also involved co-operation with other Canadian scientists, including Drs. H. P. Gush and A. Vallance Jones, and other guest experimenters from the Universities of Saskatchewan and British Columbia. The CARDE program was led by Drs. J. Hampson and C. Cumming.

During the 1950's and the early 1960's, scientists from the United States came into Canada frequently to use balloons for cosmic ray and X-ray observations.

The first Canadian flights for investigation of auroral X-rays were carried out by the University of Calgary in conjunction with the Defence Research Telecommunications Establishment of the Defence Research Board in the spring of 1963. More recently, a program has been instituted from the Universities of Calgary and Saskatchewan. Flights have been carried out at Cold Lake, Alberta, Waldheim, Saskatchewan, and also at Churchill Research Range, Churchill, Manitoba, some in conjunction with rocket launchings. In October and December 1965, the Institute of Upper Atmospherics, Physics Department of the University of Saskatchewan, made several successful flights from Saskatchewan. These carried photometers for detection of airglow emissions. During 1968, these universities launched twelve balloons carrying more than 25 experiments.

For the past several years, and with support from Canadian agencies and ground stations, the Office of Naval Research of the Department of the United States Navy has conducted a scientific ballooning program (SKYHOOK) in Canada.

BLACK BRANT ROCKET AAD-IV-23 ON THE AURORAL LAUNCHER



ROCKETS

Beginning with the International Geophysical Year (IGY) in 1957, rockets were first used by the Canadian Armament Research and Development Establishment (CARDE), now the Defence Research Establishment Valcartier (DREV), and later by the Defence Research Telecommunications Establishment (DRTE) now the Communications Research Centre (CRC) of the Department of Communications (DOC), to investigate spectroscopic and ionic characteristics of the upper atmosphere.

At DREV, direct high-altitude measurements began in 1957 - 1958 with rocket-borne measurements of the sodium airglow and hydroxyl profiles. More recent rocket flights were used to release nitric oxide into the atmosphere in order that ground-based observations of the resulting luminescence could be used to study the reaction of the nitric oxide with atmospheric atomic oxygen. This program produced a better understanding of the atmosphere and the possible role that catalytic chemical processes may play in adjusting the energy balance and composition of the atmosphere. Following these activities, vehicle development begun at DREV led to the production of the Black Brant I and II type rockets.

At CRC, this work was directed towards understanding the physics of the ionosphere with a view to improving communications. To this end, many ground-based measurements using radio wavelengths from a few millimeters to many kilometers were made in conjunction with rocket and satellite measurements.

As a result of the rocket research activities at DREV and with the assistance of the government, rocket building technology in Canada became available to civilian industry, and Bristol Aerospace Limited, Winnipeg, Manitoba, became the first Canadian rocket industrial developer. In 1964, with assistance and direction from DREV, a rocket propellant filling plant was established by Bristol at Rockwood, Manitoba.

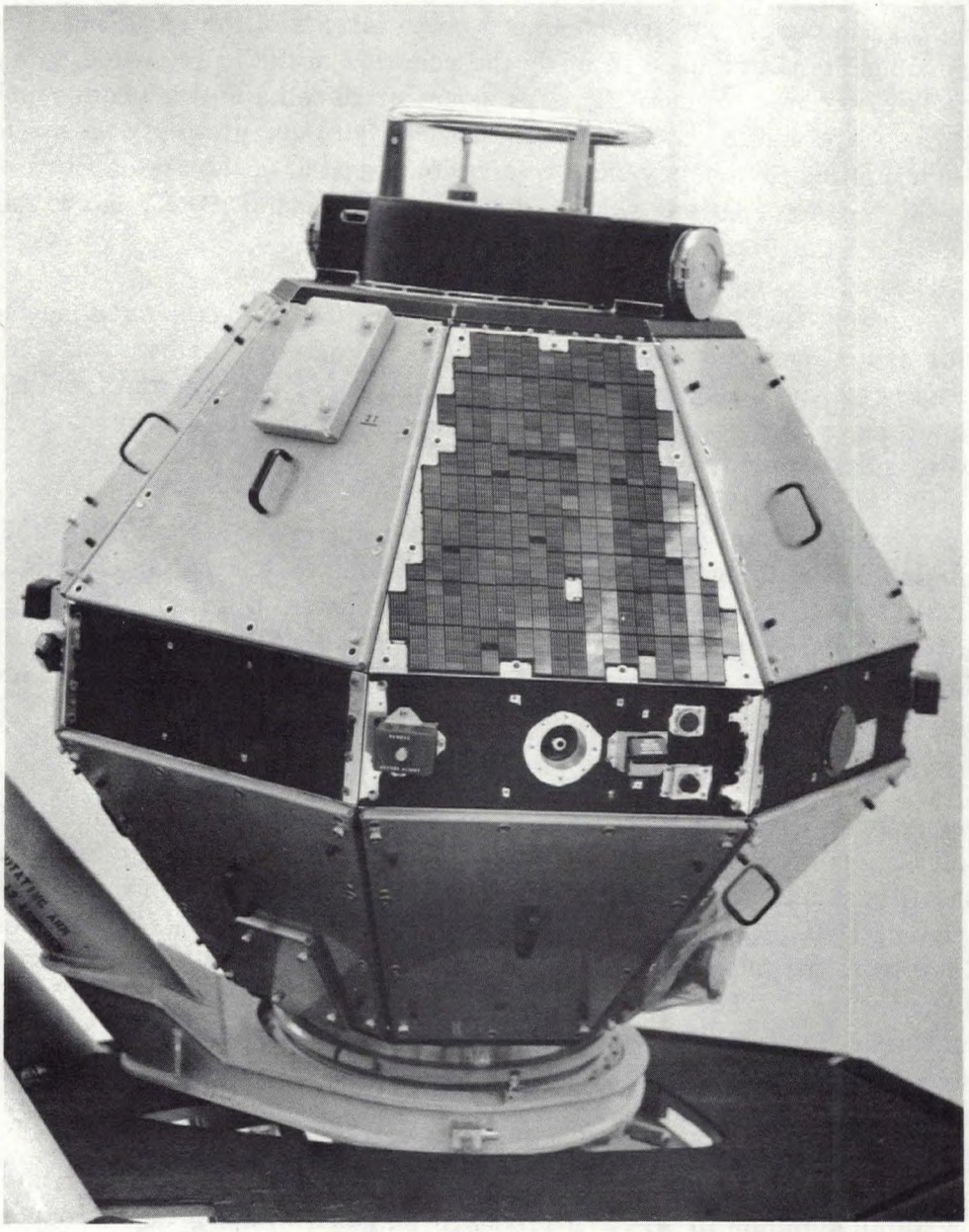
The Radio and Electrical Engineering Division (REED) of the National Research Council of Canada began its participation in the Canadian rocket program by undertaking the development of telemetry components (antennas, transmitters, and transmission line components) for Black Brant rockets in 1960. In January 1961, REED accepted the responsibility for supplying engineering assistance to the projected scientific program of upper atmosphere sounding rocket research at Fort Churchill, Manitoba. From that time until the formation of Space Research Facilities Branch (SRFB) in April 1965, REED performed this task, which consisted primarily of technical, but not scientific, co-ordination of the program.

Payload planning and construction of the electronic systems and subsystems common to all payloads were included in the group's responsibility. Telemetry equipment, engineering sensors, external and internal switching, and control systems are examples of the systems provided. A launch team for

engineering support at the launch site was also part of the assignment. In addition to the direct engineering support, this group carried out a continuing program of investigation into rocket instrumentation and telemetry problems.

The last vehicles in which REED participated in engineering and co-ordination were Black Brant rockets AAA-II-101, AAA-II-102 and AAA-II-105. These vehicles were launched in January 1967.

ISIS II



SATELLITES

Alouette I

This was the first satellite to be designed and constructed in Canada. It was launched from the Western Test Range, California, U. S. A., on 29 September 1962 and is now the oldest active vehicle in space. It still transmits data back to earth on command.

Alouette II

This was the second Canadian designed and constructed space vehicle. It was launched into orbit on 29 November 1965, also from the Western Test Range. Alouette I carried four experiments and Alouette II carried five. This vehicle continues to transmit data back to earth on command.

ISIS I

Canada's third space satellite, designated ISIS I for International Satellite for Ionospheric Studies, was launched into its prescribed orbit from the Western Test Range at 0646 GMT (0146 Ottawa time), 30 January 1969. This vehicle is instrumented with ten experiments to measure most of the important ionospheric parameters at the same time and in the same place. All experiments, with the exception of the ion mass spectrometer, which is at present producing degraded data, are performing as planned.

ISIS II

The fourth Canadian satellite ISIS II was launched from the Kennedy Space Center, Western Test Range, at 0257 GMT on 1 April 1971. This satellite is instrumented with twelve experiments including two to observe optical phenomena. All experiments to date are functioning as designed.

ANIK I

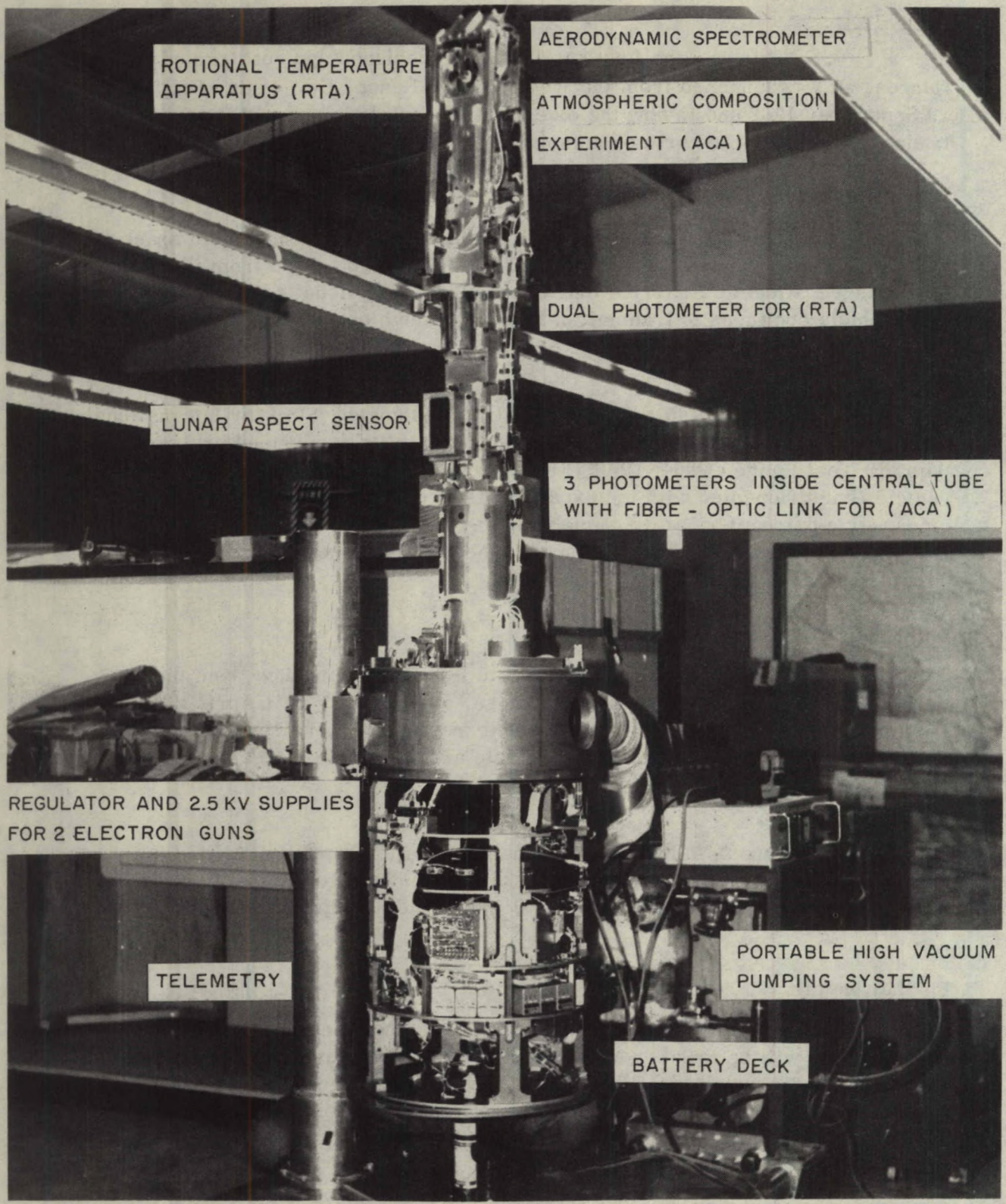
Canada's first domestic communication satellite, ANIK I (an Eskimo name for brother), is scheduled to be launched from Cape Kennedy late in 1972. Details will be found under Telesat Canada and Activities in Industry.

Further Details

Further details of these satellites, including instrumentation and experiments, will be found under the ISIS Satellite Program and Telesat Canada. The first four Canadian satellites listed above were designed and constructed by the Communications Research Centre of the Department of Communications, RCA Limited and Spar Aerospace Products Limited.

Alouettes I and II and ISIS I and II continue to be tracked and commanded by Canadian satellite telemetry/tracking stations and the United States STADAN network.

PAYLOAD LAYOUT BLACK BRANT ROCKET AEF-II-121



HIGH ALTITUDE SOUNDING ROCKET PROGRAM

Scientific instrumentation for the Canadian high altitude sounding rocket program is provided by groups from many universities and several government departments. Vehicles currently employed are in the Black Brant series, designed and manufactured in Canada. In addition, the British Skua II and the United States' Boosted ARCAS II rockets have been used on occasions in the past to supplement the program.

The Black Brant vehicles now include a family of nine different types. They are manufactured by Bristol Aerospace (1968) Limited, Winnipeg, Manitoba. At the present time, Black Brant rockets include both single and two-stage solid propellant vehicles, with lifting capabilities of 50 to 145 kilograms (110 to 320 pounds) to heights ranging between 165 to 1150 kilometers (100 to 715 statute miles). Additionally, and in conjunction with the United States, a meteorological rocket has been developed which will be capable of lifting a useful payload of 3 to 7 kilograms (6 to 15 pounds) to a height of 84 kilometers (52 statute miles). A vehicle designed to lift heavier payloads, which could be used as a satellite booster, has been considered, using clusters of Black Brant motors. Further details of the capabilities of these rockets will be found under Activities in Industry - Bristol Aerospace (1968) Limited.

The British Skua II rocket is a 12.7 centimeter (5 inch) diameter, solid propellant vehicle, measuring approximately 254 centimeters (100 inches). It is capable of carrying a payload weighing approximately 9 kilograms (20 pounds) to a height of 80 kilometers (50 statute miles).

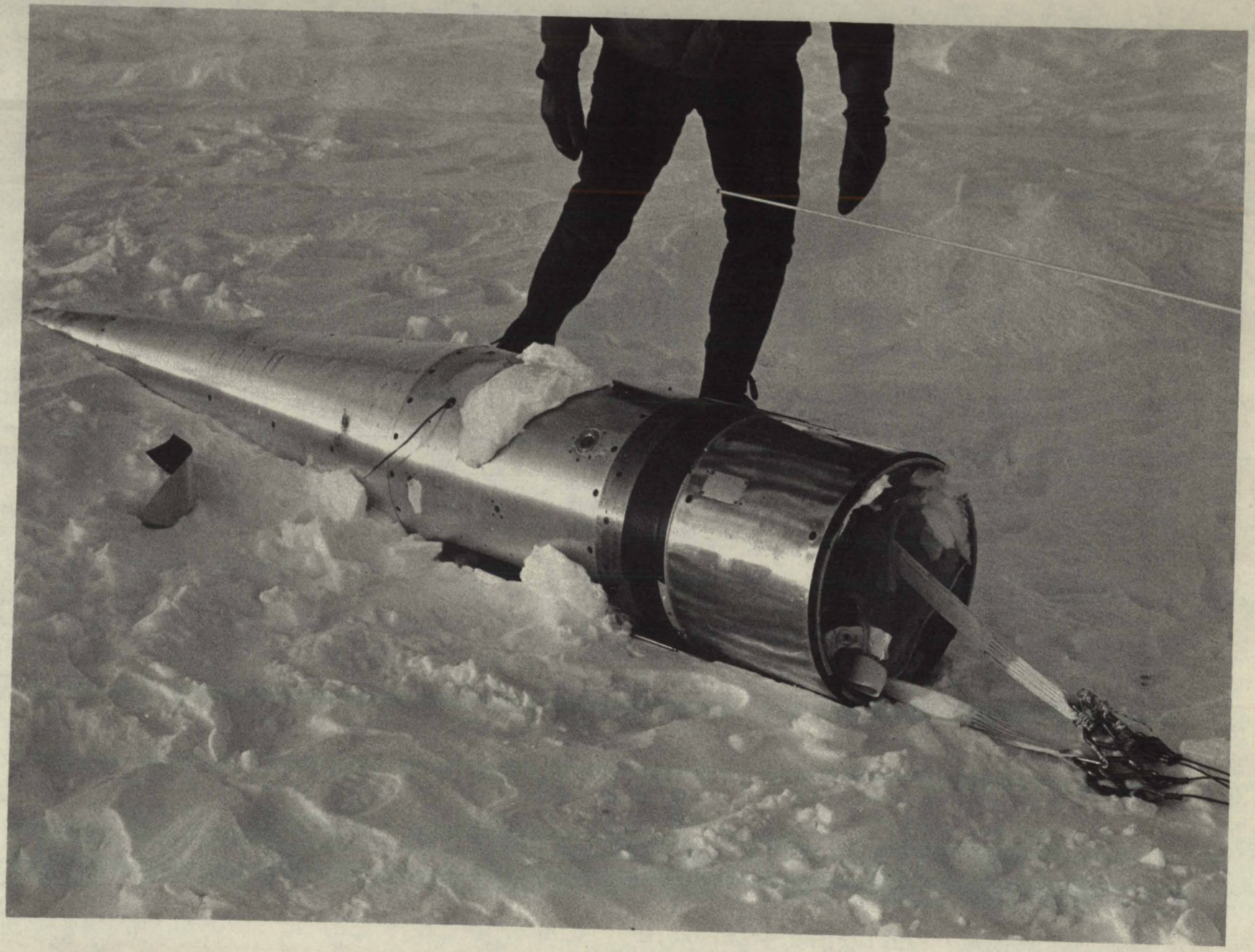
The United States' Boosted ARCAS II rocket is a 11.4 centimeter (4 inch) diameter, solid propellant vehicle with a booster stage, measuring about 405 centimeters (160 inches) in length. It is capable of lifting payloads of more than 9 kilograms (20 pounds) to heights of over 105 kilometers (65 statute miles).

Individual experiments are usually provided by the scientists concerned. The Space Research Facilities Branch of the National Research Council of Canada assumes overall co-ordinating responsibility and provides contract coverage for the integration of the payloads.

The integration of the experiments into vehicle payloads is carried out by Bristol Aerospace (1968) Limited, Winnipeg, the Space Engineering Division of the University of Saskatchewan, Saskatoon, and the Institute for Aerospace Studies of the University of Toronto.

By December 1971, the National Research Council of Canada had participated in 101 rocket launchings which carried aloft 748 different experiments. Eight of these rockets carried experiments from the United States, Sweden, the Federal Republic of Germany, Czechoslovakia, and the United Kingdom, in addition to the Canadian experiments. By the end of 1971, Canada had launched more than 170 scientific sounding rockets.

RECOVERED PAYLOAD BLACK BRANT ROCKET AAD-IIA-124



UPPER ATMOSPHERIC ROCKET AND BALLOON RESEARCH IN 1971

Prior to 1971, the Space Research Facilities Branch arranged for 72 scientific rocket launchings. These vehicles carried a total of 447 experiments from the National Research Council of Canada, the Communications Research Centre of the Department of Communications, and the Universities of Calgary, Saskatchewan, Western Ontario, Toronto, York and Montreal. In addition, twenty experiments from other countries were included in nine of these vehicles.

During 1971, nine Black Brant rockets sponsored by the National Research Council of Canada, carried 65 experiments to heights ranging from 80 to 800 kilometers (50 to 500 miles) to make measurements under quiet and disturbed conditions. All launchings took place at Churchill Research Range, Churchill, Manitoba.

The Office of Naval Research of the Department of the United States Navy again conducted "SKYHOOK" scientific balloon launchings in Canada during 1971. During this program, 27 balloons were launched from 6 sites carrying experiments from six U. S. universities and Goddard Space Flight Center. Canadian agencies and ground stations participated in this program.

Experiments Carried in Canadian Rockets

Since the NRC program was instituted in 1962, the following experiments, provided by the authorities indicated, have been flown.

National Research Council of Canada

Plasma probes to measure ionization density and structures, micrometeoroid, acoustic and ionization detectors and particle collectors, heat transfer and aerodynamic heating panel experiments, photometers, cosmic ray and proton spectrometers, and energetic particle detectors and angle of attack indicators.

Communications Research Centre, Department of Communications

Photometers, soft electron spectrometers, differential absorption and very low frequency experiments to measure ionization, radio frequency propagation studies and measurements of phase and amplitude of very low and low frequency signals.

University of British Columbia

Cosmic Radiation Measurements. This experiment was flown early in 1971.

University of Calgary

X-Ray detectors, neutron detectors, dual wavelength and scanning auroral photometers, magnetometers, proton detectors and cosmic ray collimators.

University of Saskatchewan

Electric and magnetic field measurements, single and two-channel photometers, X-Ray detectors, acoustic detectors, day and night glow spectrometers, infrared airglow photometers and spectrometers.

University of Western Ontario

Ionospheric inhomogeneity detectors, differential doppler and radio wave absorption measurement experiments.

University of Toronto

Pressure and density gauges, photometers, rotational temperature apparatus, photomultiplier lunar aspect sensors, micrometeoroid detectors, atmospheric temperature and partial density, molecular oxygen and nitrogen and atomic oxygen measurements, atmospheric composition and temperature detectors.

York University

Infrared 1.27 micron photometers, single channel photometers and auroral spectroscopes, vacuum ultraviolet and oxygen atom probe experiments.

University of Montreal

Thermal electron measurements and multi-grid velocity analyzers.

Experiments Carried for Other Countries

In addition, electric field probes, acoustic micrometeoroid detectors, OH dayglow instruments, barium cloud, ozone measuring instruments (above 55 kilometers), solar X-ray, Lyman alpha, and spectrometer experiments were carried in eight of the above rockets for the United States, Sweden, Federal Republic of Germany, Czechoslovakia and the United Kingdom.

Some of the above experiments were ejected from rockets during flights, while others remained with the parent vehicles.

ACTIVITIES IN UNIVERSITIES

Institute of Earth and Planetary Physics, University of Alberta

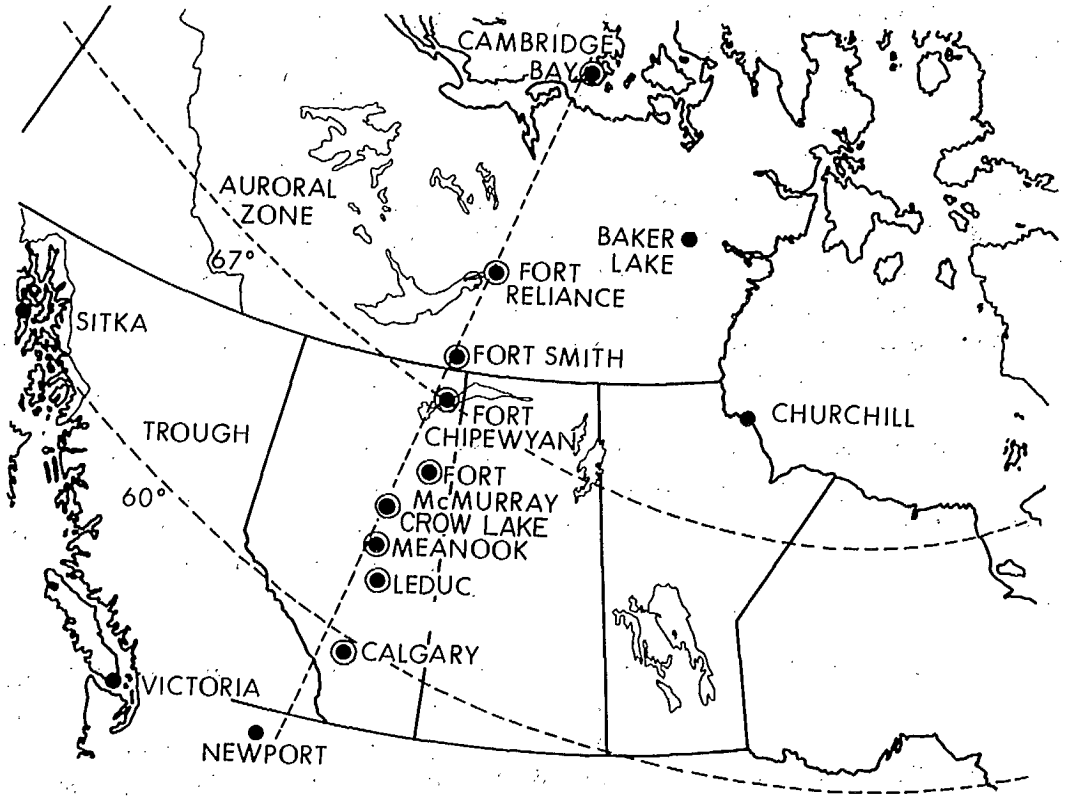
The Killam Earth Sciences group is operating a chain of up to nine three-component fluxgate magnetometers along the corrected geomagnetic meridian $\sim$ 302°E. Data are sampled at two-second intervals and are recorded directly on magnetic tape in digital form. The data are being used in the study of magnetospheric substorm activity and long period micropulsations. All-sky cameras are also being operated at two of the sites on the station line.

Magnetic and energetic particle data from the IMP and VELA satellites are being used in a study of the perturbations of the magnetotail associated with polar magnetic substorms. The study of the VELA energetic particle data is being carried out in co-operation with the University of California, Los Alamos Scientific Laboratory. The solar wind velocity and magnetometer data taken by the IMP-A satellite in the interplanetary medium have been used to study the response of the magnetosphere to the interplanetary electric field.

In co-operation with the University of Saskatchewan (Saskatoon), the Alberta group participated in a rocket launch into an auroral breakup in March 1971. The magnetic and electric field measurements obtained by the rocket borne probes will be correlated with ground based measurements obtained from the station line.

Theoretical studies are being carried out to try to explain the IPDP micropulsations through plasma instabilities. The formation of the plasmapause and plasma "tails" is being investigated through the study of the effects of time-dependent electric fields on magnetospheric convection. The thermalization of the solar wind is being investigated, and is found to occur through beat waves between the electron and ion acoustic modes of plasma waves. Variational techniques are being employed to extend the ray theory of reciprocity of radio wave propagation to explain the non-reciprocity of propagation paths which include the ionosphere.

ARRAY OF MAGNETOMETERS DEPLOYED BY INSTITUTE OF EARTH AND PLANETARY PHYSICS SPACE SCIENCE GROUP OF THE UNIVERSITY OF ALBERTA TO STUDY POLAR MAGNETIC SUBSTORM AND GEOMAGNETIC MICROPULSATIONS



Department of Physics, University of British Columbia

An experiment to measure the spectrum of the cosmic background radiation was launched from Churchill in February 1971. It consisted of a liquid helium cooled interferometer-bolometer capable of making spectral studies in the wavelength region 1 mm. to 0.1 mm., carried to an altitude of 150 km. by a Black Brant III-A rocket. The apparatus functioned properly but the signals received depended strongly on the orientation of the rocket and hence it is unlikely that they were of cosmic origin. The origin of the false signals has not yet been determined. The experiment will be repeated in February 1972 with various improvements incorporated in the design.

Department of Physics, The University of Calgary

Operation of the University of Calgary Scanning Auroral Photometer experiment on the ISIS II satellite commenced at the end of April. Reproduction of the data in pictorial form is done using a special display system.

The satellite configuration will be nearly optimum during December 1971 and January 1972 for observations of the northern auroral zone. Passes will occur every two hours, during each of which it should be possible to survey optical emissions at 5577 and 3914Å from a large portion of the auroral zone.

First data from the recent southern hemisphere winter solstice is from middle latitudes. In addition to providing detailed pictures of moonlit cloud structures, substantial variations in the intensity of the Van-Rhyn enhanced 5577 airglow limb are observed. It appears that it may be possible to obtain reliable estimates of airglow intensities from this limb data, even in the presence of moonlight.

A complementary study of the nighttime behaviour of the airglow and ionosphere is being carried out using data obtained while one member of the group was at the Arecibo Observatory in Puerto Rico. The quantitative comparison of photometric measurements with ionospheric parameters acquired via the incoherent scatter radar technique yielding information regarding the dissociative recombination of molecular ions in the F region, the dynamical behaviour of the upper atmosphere, and the maintenance of the nighttime ionosphere.

Solar Planetary Relationships

A study of the 11 year solar cycle variation has been carried out in collaboration with NASA-Goddard Space Flight Center, Greenbelt, Maryland. The following areas have been investigated:

(a) Cosmic Rays.
(b) The Great Red Spot of Jupiter.
(c) The Luminosities of Planets.

Radiation Belts

A study of the differential energy spectrums of trapped low energy protons, using Injun 5 data for the year 1969 has been carried out in collaboration with The Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Maryland. The existence of a quasi persistent peak with energy range 0.38 - 0.72 MeV in the L range 2.0 to 2.6 and its connection with geomagnetic disturbances discussed. The study favors diffusion from the solar wind as the primary mechanism for populating radiation belts.

Solar Particle Events

A study of ten prominent solar particle events using the lunar orbiting Explorer 35 data, during June 1968 - June 1969, has been carried out in collaboration with The University of Iowa, Iowa City. The results deal with, in particular, the variability of intensity ratios proton/alpha, and alpha/medium nuclei during an event and from event to event. Mechanisms are being investigated to explain these ratio changes. A paper was presented at the 12th International Cosmic Ray Conference at Hobart, Tasmania, Australia.

Solar X-rays

Analysis of ionospheric data for November 1966 to July 19, 1968 indicates the relation between solar x-rays in the ranges 8-20Å and 44-60Å and the E and E_s layer at a typical latitude station like Washington.

Cosmic X-rays

The development of a multi-anode, multi-layer proportional counter for measurement of cosmic x-rays for the coming rocket shot early in 1972 is continuing.

Auroral X-rays

Two packages for measurement of auroral x-rays in the ranges 20-40, 40-60, and > 60 keV are being readied for flight in January 1972 in conjunction with ground measurements of pulsating aurorae and ISIS II observations.

During the past winter the Image Intensifier - TV system was operated at Cold Lake to record pulsating auroras in both single and double imaging modes. Analysis is nearing completion of the spatial coherency at different frequencies within a pulsating patch and for several isolated patches. Further work is also being done on general morphology and the lifetime of O('s).

In 1972 the II-IV system will again be operated at Cold Lake and co-ordinated observations are planned with the ISIS II satellite, balloon-borne x-ray detectors and image orthicons located at College, Alaska. A second II-TV system is presently being developed at Calgary incorporating an electrostatic intensifier with an S25 photocathode for imaging emissions in the near - IR region.

Cosmic Rays

Various aspects of cosmic ray intensity modulation in interplanetary space are investigated with the aid of super neutron monitors at Calgary and Sulphur Mountain and meson telescopes in an underground laboratory. Differential

intensity modulations up to the energies of 50 GeV can be studied with these facilities. The low energy end of primary spectra is measured by balloon-borne charged particle telescopes, especially after special solar events.

Recent results of work in this field show that solar cycle variation over the energy range where neutron monitors have their principal response can be described by means of a time varying parameter, whose value changes by a factor of two or more over the 11-year period. Solar wind does not show this variability over the same period. Hence, long-term changes in solar wind speed cannot be responsible for the year to year changes in cosmic ray intensity at the earth. Further study of the mechanism of cosmic ray modulation processes is in progress.

The University, in conjunction with a post-doctoral fellow and graduate students, is interested in the dynamics of the ionosphere-magnetosphere transition region. They hope to use the data from "the top sounder" and study the plasma physics of this region in the near future. This study complements the hydromagnetics of the magnetosphere actively being pursued.

Study and Interpretation of the Sidereal Diurnal Variation of Cosmic Radiation

A study of the sidereal anisotropy observed by muon telescopes at tt different depths underground in both the northern and southern hemispheres has lead to observed sidereal maxima at 18 hours sidereal time in the northern hemisphere and 6 hours sidereal time in the southern hemisphere. The amplitude and phase are strongly dependent on the direction of the interplanetary magnetic field, and the amplitude appears to decrease with increasing rigidity, pointing to the anisotropy being of solar origin (perpendicular to the ecliptic plane) rather than a genuine galactic effect. The feasibility of an experiment to observe genuine sidereal anisotropies is being studied.

Cosmic Ray Density Gradiants Near the Earth

Data from underground muon telescopes, arranged according to the direction of the interplanetary magnetic field, have been analysed in solar and in sidereal times. The analysis in solar time permits observation of the $\vec{B} \times \vec{\nabla} N$ anisotropy, in the ecliptic plane, due to a cosmic ray density gradient perpendicular to the ecliptic plane. The sidereal analysis permits observation of the $\vec{B} \times \nabla N$ anisotropy perpendicular to the ecliptic plane, due to a radial heliocentric cosmic ray density gradient. From the amplitudes of these anisotropies estimates of the radial and perpendicular gradients can be obtained at rigidities above about 20 GV.

The Antenna Laboratory, Department of Electrical Engineering University of Manitoba

Analytical and experimental work with a 35 GHz scanned microwave radiometer is in progress at the University of Manitoba in connection with a wide range of applications extending from arctic reconnaissance to oil pollution, mineral exploration, off-shore drilling, ice-thickness, surveying, detection of subsurface water and permafrost level, weather forecasting, etc.

It is expected that Canadian satellites will soon employ multifrequency scanned microwave radiometers as basic tools for surveying of agriculture, ice and water levels, mineral resources and for surveillance of arctic and coastal regions of Canada.

McMaster University, Hamilton, Ontario

Analyses of sulphur concentrations and isotope abundance ratios in Apollo 12 samples have been completed. The results will be published shortly in Earth and Planetary Science Letters. Samples from the Apollo 11 and 14 missions are currently being analyzed. Magnesium isotope measurements have been made on feldspar extracted from some Apollo 12 rocks.

University of Montreal

The work at the University of Montreal is centered around the development and use of an electron velocity selector. This instrument is composed of grids on which a radio frequency signal is applied, and a particle collector to which a retarding potential is applied.

During the reporting period, a laboratory plasma has been investigated with the selector and fairly good agreement has been obtained between the measurement of the plasma parameters with a Langmuir probe, and those obtained from the selector. This work has confirmed that it is possible to measure the velocity distribution functions of electrons by means of the RF selector.

Also during the reporting period, an experiment has been flown in the aurora, however, a malfunction of the RF section has prevented the collection of useful data. The program has been temporarily suspended by Dr. Brooks departure from the University of Montreal.

Plans for the immediate future call for a new experiment in the aurora. It is believed that experience gained in the previous flights and laboratory investigations will make the next flight a most useful one.

University of Saskatchewan

Department of Physics

The rocket program at the University has maintained its level of former years with the development of new instrumentation to measure parameters associated with auroral and airglow phenomena.

A 0.25 m Ebert spectrometer, designed for vacuum ultraviolet studies of the aurora, is nearing completion and is to be flown during 1972 in the vehicle ADD-II-114. The spectrometer uses a stepping grating drive and digital recording of the spectral information. It is also intended to construct a large instrument (0.5 m) of similar design for ground-based studies. It is intended that these measurements will provide new information to supplement the observations from the rocket VB-24 which was launched in January, 1971.

The analysis of the observations of other rocket flights is also progressing and an important result has been the observation of low energy electron spectra which are similar to those observed from satellites in the plasma sheet at 18 R_E.

The infrared observations from both rockets and ground-based studies has been continued and during 1971 an experiment to measure the oxygen emission at 1.27 μ and the OH emission in the $\Delta v = 2$ sequence near 2 μ was flown three times. One of the flights (ADD-II-124) was from Churchill and used the solar azimuth pointer which had been flown previously; the data from this experiment is presently being analyzed. The remaining two flights were made with French Centaur rockets launched from Kiruna, Sweden, as part of an extensive investigation of noctilucent clouds. The preliminary analysis of these observations has indicated that the cloud particles are extremely small, comparable to molecular aggregates, and that the airglow emissions may be changed from that in the absence of clouds. It is intended to make similar observations at some future date to permit a complete interpretation of these results.

The Kiruna observations have also suggested the need for the inclusion of non-equilibrium (relaxation) phenomena in the analysis of rocket observations of emission height profiles. This hypothesis is based, in part, on the attempt to relate the rotational intensity distribution of molecular airglow feature to the excitation mechanism. To confirm this interpretation, experiments to measure emission height profiles for different parts of an emission band are planned and a new type of photometer is being designed at the University for this purpose.

Another important development during the past year has been the design of an aspect system for a spinning rocket using a simple photometer. The method relies on the relative phase change of the signal from the airglow layer

as the rocket precesses. The first flights of the system are scheduled for early in 1972 and will offer the advantage that accurate aspect determination may be made in the absence of the moon.

Ground-based auroral studies in conjunction with the ATS-5 satellite have also been made and it is intended to make extensive measurements of the optical emissions and particle influx on the same field line.

Studies of the ionosphere and neutral atmosphere below 120 km continue. Analyses of partial radio wave reflection data has yielded profiles of winds 60-120 km which match well with meteorological winds up to 60 km. First analyses of tidal components 75-100 km have been completed. Further analyses have been made of partial reflection data, and a first identification of the origin of structures of reflecting regions has been made. Theoretical and experimental studies of particle influx at L $\tilde{}$4 are continuing.

Space Engineering Division

The spin probe experiment has been designed to measure magnetic field changes by means of a spinning coil magnetometer and vector electric fields by means of a dipole detector. The dynamics of the self contained, ejected, spin stabilized probe are such that the precession period is typically less than one second: this facilitates resolution of vector parallel and perpendicular electric fields every one half second.

Electric field measurement near eastward and westward auroral electrojet currents indicate that these current systems are most likely driven by Hall electric fields. Westward movements of a current system have been closely correlated with a rotation of the perpendicular field approximately from north to south. Magnetic field perturbations measured near horizontal currents correlate closely with magnitude fluctuations of the perpendicular field. Perpendicular field strengths in one negative bay event increased above 120 km from the detector threshold of several millivolts/meter to in excess of 110 millivolts/meter. A decrease in perpendicular field strengths in or near auroral forms has been observed.

Another feature of electric field measurements associated with electrojet currents is the existence of parallel fields greater than the expected runaway field. In one experiment it is believed that these fields were confined to a region above 110 and below 225 km.

Analysis is presently being carried out to determine whether or not observed magnetic fluctuations are due to field aligned currents.

Simon Fraser University

A new program of astrophysical research has been initiated within the Faculty of Science. The research group includes Dr. B.G. Wilson, Dr. G.A. Baird (on leave from University College, Dublin) and Dr. R.J. Francey, a P.D.F. from the University of Tasmania. Initial areas of interest include low energy cosmic X-rays (an extension of Dr. Wilson's research at the University of Calgary) and ground based techniques for the detection of energetic stellar phenomena (e.g. X-ray flares, SN outbursts and gravitational events.)

Considerable effort has been devoted to the re-evaluation and improvement of detection techniques for low energy X-rays (40 Å - 200 Å). A new "self pressure-regulating" proportional counter has been developed to cope with problems associated with large area counters using extremely thin entrance windows. The first rocket flight of the detector system, which incorporates an electron/ion rejection system, will occur in April 1972 and, if successful, will provide a sensitive survey of the sky in the 40 - 100 Å region.

A second flight proposed for later in 1972 should provide fuller utilization of new detector techniques enabling detailed spectrometry of the 40 - 200 Å sky to be undertaken. Principal areas of concern are an unexplained galactic component of the diffuse X-ray background, structure of the interstellar medium and discrete soft ray objects (SN remnants, old pulsars, black holes?). Data reduction continues on Black Brant rocket IV-19, launched in December 1970. This flight produced a wealth of information on point X-ray sources as well as geophysical activity. This flight and previous flight records are being analyzed for pulsar activity.

Evaluation of radio methods for gravitational collapse detection has been continued. Use of ionospheric anomalies in low frequency radio transmission records in order to detect supernovas and possibly collapsing events has been reviewed.

An X-ray astronomy satellite proposal has been proposed.

University of Toronto

Institute for Aerospace Studies

Two different instruments to measure upper atmospheric density, temperature and composition have been developed and test flown. The first instrument is capable of making measurements over the altitude range between about 70 and 140 km. Its mode of operation is to excite luminosity in the ambient atmosphere by the impact of electrons at moderate energies (2.5 to 3 kV) and then to analyze the so produced light.

The rocket instrument is an adaptation of the technique used in the laboratory at UTIAS for many years. Practical problems relate to the production of a stable, high current electron beam, an optical analyzer which accepts only light from a volume in space at sufficient distance from the instrument and rocket to have acceptably small aerodynamic disturbances and a means of rejecting extraneous ambient light. The first version flown was a two channel device to measure rotational temperature by the ratio of the signals in two narrow band spectral regions within the rotational structure of the first negative band of nitrogen at 4278 A. This first flight was successful. However, the apparatus was large and heavy and subsequently a much smaller and lighter 5 channel version was developed and flown successfully in March 1971. The analysis in the 5 channels is done on a time sharing basis, allotting the time for a roll cycle to each channel in turn. This flight was performed as a passenger experiment and in spite of the much higher background light levels than those allowed for in the optical design, useful data were obtained on the partial densities of molecular nitrogen, molecular oxygen, and atomic oxygen in addition to the rotational temperature.

Instrumentation for a second flight in March 1972 is now completed, providing ten channels of information in two parallel instruments. These channels will give sufficient spectral information to determine population levels of the first few vibrational levels of molecular nitrogen, in addition to rotational temperature and species concentrations.

In parallel with development of the rocket instrumentation, a laboratory experiment is in progress to measure optical excitation cross-sections of gases of atmospheric interest. Especially, atomic oxygen is of interest because few data are available. Work has reached the stage where atomic oxygen data have been obtained at the electron energy used in the rocket work. Further measurements to provide information over a wide range of energies are being executed.

The second rocket instrument, the aerodynamic spectrometer, represents a new concept to measure species concentration and kinetic temperature at altitudes above about 110 km. It therefore complements the altitude range of the electron beam apparatus. Its principle rests on the fact that each constituent in the atmosphere has a thermal velocity dependent on its molecular mass whereas it has the same average speed with respect to the rocket as all the other gases.

After passing through a defining slit, the different thermal speeds produce a characteristic transverse density distribution in which the heavy constituents are concentrated near the original direction of flight and the lighter gases occur preferentially in the wings. Since the flow is collisionless at the altitude of operation, this distribution is readily predictable for known atmospheric temperature and composition, and conversely a measurement of the lateral spread pattern will upon analysis yield species concentration as well as kinetic temperature. It may be emphasized here that this measurement only requires a total signal and a knowledge of the relative effectiveness of each species contributing to this signal. The determination of the concentrations comes entirely from the shape of the pattern. The separation of the species in the pattern is caused by the properties of the aerodynamic configuration.

The pattern is measured by a high spatial resolution density gauge and in the rocket experiment it is scanned passively by the rolling motion of the rocket in conjunction with the significant angles of attack that exist at the higher altitudes of typical flights. Because density must be measured to very low levels the instrument is encapsulated and pre-evacuated. It has to be exposed and extended at altitude. A first version was flown in March 1971. This flight proved all systems to work satisfactorily, but in data analysis an anomolously high signal was noted. After laboratory simulation it was found that the effect most likely originated from a spurious collection of ionospheric ions. Extensive laboratory development has now provided an effective screening arrangement to prevent this from happening in further flights. In addition two alternative ways of making the pattern measurements with specially designed ionization gauges have been devised. Two separate aerodynamic spectrometers each based on one of the gauges have been built and these are ready for flight in March 1972.

Department of Physics

Report on ARGON-40/ARGON-39 Studies on Lunar Material

Since May 1971 ARGON-40/ARGON-39 studies have been carried out on Apollo 14 and Apollo 15 material. The samples have been neutron irradiated and then heated in a vacuum. The ARGON-40/ARGON-39 ratios in the evolved gases have enabled crystalization ages to be calculated. Such ages found for fragments of basalts, soils and breccias from the Apollo 14 mission all lie between 3.8 and 4.1 billion years and indicate that some significant thermal event occured on the moon at this time. This may be the excavation of the Imbrium crator. The one Apollo 15 sample dated so far is a basalt and it appears to have crystalized on the moon about 3.3 billion years ago.

The lunar age picture, therefore, still remains one of intense activity during the first 1 billion years or so followed by about 3 billion years of relative quiescence. This is in distinct contrast to the Earth which has undergone vigorous tectonic activity right up to the present time.

David Dunlap Observatory

The University of Toronto is the only Canadian member at present at the Universities Space Research Association, a consortium which operates the Lunar Science Institute in Houston, Texas. The purpose of this institute is to stimulate studies of the moon with special reference to the data, resources and personnel at the NASA Space center nearby.

Under contract with the Department of Energy Mines and Resources, an investigation of the properties of image tubes and their application in surveillance work from aircraft, rockets or satellites has been carried out.

Data from a low-frequency radio astronomy experiment carried on the British satellite Ariel III have been used to study radio noise emissions generated in the Earth's magnetosphere. Recent analysis has yielded a new type of radio emission which

is only observed when the planetary magnetic index K_p is large. A comparison of the radio data with simultaneous measurements of the local ionospheric electron density suggests that the radio emission is being focussed into a narrow beam by the mid-latitude electron density trough.

Further studies aimed at understanding the processes which give rise to meet these radio emissions will compare simultaneous measurements of radio noise and energetic charged particles, the data being obtained from the Canadian ISIS satellites. The studies are likely to be relevant to Jupiter's magnetosphere as well.

University of Western Ontario

Centre for Radio Science, Department of Physics

The number of principal investigators engaged in radio probing of the upper atmosphere under the auspices of the Centre for Radio Science is now eight. The presently active projects are summarised as follows:

Radio Aurora

This series of experiments is aimed at determining the role played by ion-acoustic waves in the formation of auroral scattering centres. A bistatic system with highly stable and coherent frequency sources is used to allow spectral analysis of the scattered signal while magnetometers are used to monitor the ionospheric currents responsible for the ion-acoustic waves. Latest results (Forsyth and Hofstee) indicate ion-acoustic waves propagating as much as 6° away from the preferred 'orthogonal' direction suggesting distortion of the magnetic field in the neighborhood of aurora. A new technique of investigation utilising satellite borne radio sources is being considered.

Wind Motions

Systems are being developed to measure winds at meteor heights by means of the signals scattered from meteor trails on bistatic scatter systems (Fulford, Forsyth, Hanff). A pilot system measuring one component of velocity and height has been tested in operation. An improved system giving two orthogonal wind components and height is under design.

Ionospheric Irregularities

The Minitrak system acquired last year is now fully operational. Phase scintillation and angle of arrival measurements are being made on the beacons from both ISIS satellites (Forsyth) and this permits deductions concerning the detailed structure of F region irregularities. A semi portable system for the same measurements has been designed and built to extend the observations to other latitudes. One system is presently being installed at the Lakehead University, Thunder Bay (Hajkowicz) and arrangements are being made for an installation in the West Indies.

Travelling Ionospheric Disturbances

A continuous following polarimeter has been recording the signal from the geostationary satellite ATS 3 continuously since March 1971 (Webster, Lyon). Preliminary data analysis indicates the presence of long lasting periodic fluctuations in electron content attributable to TIDs. A comprehensive program of power spectrum analysis of the data is now underway. A second receiving system to monitor the ATS 5 satellite is being built. This will provide a different 'look'angle from the same observing site and yield some information on direction of travel of the disturbances.

A new program of HF Doppler forward scatter measurements was started during the year (Lyon). A system monitoring the doppler shifts in the signals from CHU on two frequencies has been operating for some months. The doppler shifts are interpretable as changes in the height of scattering. With the assistance of CRC Ottawa these measurements will be supplemented by a new three frequency H F scatter system with transmitters at Ottawa and receivers at London.

Incoherent Scatter

Design and siting studies for a proposed new Incoherent Scatter Radar have been actively pursued for some time (Moorcroft). A proposal for a $13 million dollar facility has been formulated by a group of six North American Universities. These six institutions, of which U. W. O. is the only Canadian participant, have formed the Upper Atmosphere Research Corporation to further the project and hopefully eventually operate the facility. The earliest operating date for the facility, depending on funding, is early 1975.

Probe Studies

The behaviour of rocket and satellite borne probes is under investigation (Tunaley). The often used Langmuir probe for electron density measurements suffers from surface contamination. The effects of contamination with respect to probe characteristics and statistical fluctuations are being studied theoretically. Probe results are also influenced by the presence of photoelectrons from the vehicle; this effect is mainly of importance in the magnetosphere and is also a subject of theoretical studies.

Absorption Studies

A new system of absorption measurement has been developed. This system uses a matrix of electronically driven attenuators to compare amplitudes of signals scattered at three different frequencies from the individual meteor trails. Comparative studies of measurements by this method and by riometers at the path mid point have been completed (Abdu, Vogan). Not surprisingly the riometer is evidently incapable of measuring absorption accurately when this is inhomogeneously distributed and it appears that the variation in absorption from meteor to meteor is a measure of the inhomogeneity of the absorbing ionization.

Faculty of Science, Department of Chemistry

Lunar Sample Studies

Scientists in the Chemistry Department at the University of Western Ontario (Drs. G.M. Bancroft and P.G.L. Williams) have been determining the mineral and elemental content of lunar material from recent Apollo flights using the technique of Mossbauer spectroscopy. Many lunar samples have a very large titanium content (in the form of Fe TiO_3), and the distribution of iron in the silicate minerals indicates high temperatures of formation.

Department of Physics, University of Victoria

Measurements of twilight emission at a wave-length of 6700 Å by means of a ground-based birefringent-filter photometer have continued during the past year at Victoria. Few relatively bright emissions were recorded during 1971 in spite of several rocket releases of lithium vapour from U.S. air force bases. The level of intensity during the entire summer generally remained less than 10 rayleighs, and during the winter of 1970-71, between 40 and 50 rayleighs. Only on one occasion, on the evening of December 17, 1970, did the plateau intensity reach a high value of 127 rayleighs. This date is near the period December 19 to December 20, 1968, on which days the plateau intensities were 165 and 145 rayleighs respectively. Unfortunately no observations were available during the same period of 1969 because of cloudy weather.

Centre for Research in Experimental Space Science
York University, Toronto, Ontario

Auroral Spectroscopy in the Vacuum Ultraviolet

A successful launch was made into a bright aurora in March 1971. Spectroscopic data from the recovered payload were meagre, due, in part from the sustained vacuum environment to which the film was subjected for some days prior to launch.

Solar Rocket Eclipse Spectroscopy

Complete digital microdensitometry of the 35 solar eclipse spectra in the vacuum UV obtained at the 1970 eclipse by the Imperial College-Culham Laboratory-Harvard College Observatory-York University (CRESS) consortium was accomplished at Harvard by Mr. Yang of York. Some of these data have been studied and a number of papers on them were given at the COSPAR meetings in

Seattle. The comprehensive paper on the overall experiment has been published (Astrophysical Journal 169 515-614, 1971). Detailed studies on different aspects of solar physics are now being made on the digital data by members of the consortium. At York we are concentrating on stable prominences.

Laboratory Aeronomy and Astrophysics

Measurements were continued of band strengths of aeronomically and astrophysically important molecular transitions using the methods of emission (including shock tube), absorption and interferometrical (hook) spectroscopy. Further data have been provided on Ban systems of $+O_2$ Herzberg (and continua) NO beta and gamma, CO Fourth Positive and Cameron, C_2 Swan, CN Red and Violet. The hook method has been extended and its sensitivity has been increased (for molecular band systems) by two orders of magnitude. A definitive estima has been made through shock tube work on the dissociation energy of CN. Shock tube work continues on YO and ScO. The first really high dispersion shock tube spectrum of YO has been obtained using a 21 foot spectrograph.

Production of identification atlases of molecular spectra continues. The CN RedAtlas has recently been published and the CN Violet Atlas should appear within two months. Excitation mechanisms and energy transfer processes are being studied, particularly as they apply to CO_2 lasers and active nitrogen. The intensity distribution of the CO_2^+ spectrum has been measured. New vibrational and rotational analyses of the NH_3 spectrum have been made.

The associated theoretical programme has included studies of the application of computer-generated synthetic spectra to aeronomical and astronomical spectra. Optimum conditions for auroral vacuum ultraviolet spectroscopy have also been studied. Extensive calculations of realistic Franck-Condon factor, r-centroids and related integrals have been made and are being regularly distributed for many band systems in report form. Similar work is in progress on Franck-Condon factors for polyatomic molecules.

Auroral and Airglow Photometry

Work has been continued in three main areas. A mobile observatory has been established, experiments are being set up and experience is being gained with local observing conditions. A spectral scanning photometer was used to observe the OI 5577 Å emission from theYork University campus during the summer, and with this device there was no difficulty in operating near a large metropolitan centre. Sporadic post-midnight enhancements were observed but not identified. For much fainter emissions and for aurora, it will be necessary to move further afield. A 10-channel dual-etalon Fabry-Perot spectrometer and wide-angle Michelson interferometer are being brought into operation.

In the rocket program, vehicle VB-26 was launched to observe the visual dayglow. The 5200 Å NI line and the OI 5577 Å emission were studied but data are still being analyzed. For the coming winter, a scanning photometer is being flown in II-114, an auroral launch, and together with R. A. Young, an atomic oxygen flourescence probe is being flown in VB-28, to measure the atomic oxygen concentration profile.

On April 1, 1971, the ISIS II spacecraft was launched, and on April 21st the atomic oxygen 6300 Å photometer was turned on for the first time. The device is working as well as or better than expected, and maps of emission intensity on a global scale are being obtained as the entire polar cap can be viewed in a single pass. Together with data from C. D. Anger's scanning auroral photometer in the same spacecraft, systematic information of particle energy precipitation patterns and airglow excitation processes will become available as the data collection progresses.

Excited Molecular Oxygen Emissions

A Boosted ARCAS 2 rocket carrying a two-channel photometer was used to measure the 1.27μ emission of $O_2(^1\Delta_g)$. The results show a surprising amount of structure in the volume emission rate in the 80-85 km region. There is some evidence of structure in the 70 km region as well, but the quality of the data is not sufficiently high to draw definite conclusions. The results indicate that the eddy diffusion coefficient De must be less than 10^6 cm^2 sec^{-1} to be consistent with the photochemical model for the observed height distribution.

Oxygen Atom Probes

The simple O-atom probe, consisting of a thin film of silver deposited on a small pyrex rod, has been flown successfully by Dr. W. Henderson at White Sands. Similar probes are being prepared for launchings from SKUA Rockets.

ACTIVITIES IN GOVERNMENT ORGANIZATIONS

ATOMIC ENERGY OF CANADA LIMITED

Physics Division

Cosmic Ray Monitoring

The work at Atomic Energy of Canada Limited has not hitherto been included. In 1961 it was recommended by the Cosmic Ray Commission of IUPAP in preparation for IQSY that the size of the neutron monitors of the world observational network should be increased "by a factor of about 100" and in 1962 a large monitor developed at AECL was selected as the basis for the new standard design. AECL arranged to have the components of the monitor made available from manufacturers in Canada. Now, there are some 50 of these Canadian IQSY type NM-64 monitors in operation worldwide. Three of the new monitors were installed by AECL at selected locations in Northern Canada, Alert, Inuvik and Goose Bay, in new buildings of designated form, provided by NRC. A fourth monitor, the largest in the world weighing 100 tons, was installed in a specially constructed AECL building in Deep River. Data from these 4 monitors has been published regularly since 1964-65. The outputs of the Deep River and Alert monitors are also presented graphically on a monthly basis in "Solar Geophysical Data" . Since 1967, after the occurrence of a large solar proton emission on the far side of the sun had demonstrated the value of a high latitude neutron monitor for early warning, the pressure corrected counting rate of the Deep River monitor has been transmitted every 10 minutes by unattended teletype via the SOFNET line to NORAD Cheyenne Mountain Complex, Colorado and to other space agencies in the USA.

Latitude and Altitude Survey

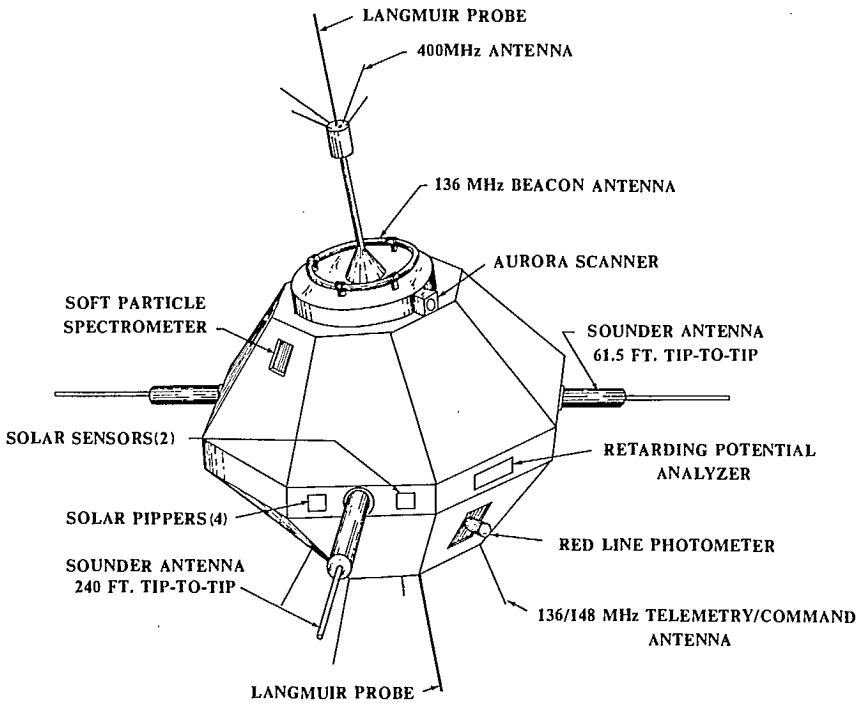
To make better use of the variations of cosmic radiation for the study of solar terrestrial physics, it was desirable to determine with good precision the atmospheric coupling functions of the new monitor by the well known method of latitude survey. A 6 ton monitor with an automatic digital data logging system was operated in a transport van at some 80 different sea level and mountain sites in Canada, the USA and Mexico in 1965 and 1966. Then the transport was taken to Hawaii where measurements were made at still higher magnetic rigidity cutoff (13.3 GV) between sea level and 10,000 feet on Mt. Haleakala. Dr. R.W. Peterson of the University of California, USAEC Los Alamos Scientific Laboratory, collaborated using an airborne neutron monitor which he operated at different levels in the atmosphere between 10,000 and 40,000 feet while the transport was on Mt. Hood, Palomar and Mt. Haleakala. Dr. Peterson also made measurements in Alaska and in 1970 the airborne measurements in Alaska and all the measurements at Haleakala were repeated

near the time of solar maximum activity. Dr. M. A. Shea of the USAF Cambridge Research Laboratories, Bedford, Mass., carried out essential geomagnetic cutoff calculations and also assisted with the measurements in 1966. Analysis of these measurements is still in progress. Eight joint papers have so far been published.

Cosmic Ray Modulation

When not being used for survey, the transport has been operated as a fixed station at Kula, Hawaii. Since no wholly reliable data from other monitors at equatorial high cutoff sites exist for the year 1966 to 1971, the Kula data have been of unique importance. When the Kula monthly means were compared with those at Deep River, which is a low cutoff station (1.0 GV), the regression curve was found to be discontinuous indicating unexpected steplike changes in the form of the rigidity dependence of the solar modulation of galactic cosmic radiation. The steps have been confirmed by comparisons of neutron monitor data with data from the standard cubical muon monitors, also operated by AECL at all its stations. Evidence for similar steplike alterations during solar cycle 19 (1954-65) was found in collaboration with the Cosmic Ray Group at NRC in the data from the Ottawa IGY neutron and muon monitors.

ISIS-II



DEPARTMENT OF COMMUNICATIONS

Communications Research Centre, Ottawa, Ontario

The ISIS Satellite Program

The general objective of the ISIS program is to conduct comprehensive studies of the ionosphere. It involves making measurements over a range of heights and latitudes sufficient to determine conditions in the ionosphere and to achieve a full understanding of this region out to the magnetospheric boundary.

For this purpose it was arranged by means of a Memorandum of Understanding between the United States and Canada that Alouette I should be followed by up to four satellites, to be built in Canada and launched by the United States.

Alouette I

This spacecraft was launched from California on 29 September 1962. It was the first satellite to be designed and constructed in Canada and was launched by a U. S. Thor-Agena rocket as part of a joint space program between the U. S.A. 's National Aeronautics and Space Administration (NASA) and Canada's Defence Research Board (DRB). The satellite was designed and constructed by the Defence Research Telecommunications Establishment of the Defence Research Board, now the Communications Research Centre of the Department of Communications.

The satellite is spheroid-shaped, contains 4 experiments and is in a circular orbit at a height of 1,000 kilometers. The experiments are as follows:

Ionospheric Sounder: The ionospheric sounder is used to measure the electron density of the ionosphere as a function of height over the frequency range 1 MHz to 12 MHz with 100 watts transmitted power. The sounder antennae consist of 2 dipoles, 36.6 meters (120 feet) and 22.9 meters (75 feet) tip to tip.

VLF Receiver: The VLF experiment is carried to investigate the generation and propagation of very low frequency waves within the ionosphere.

Cosmic Noise: Since the ionosphere acts as a screen at frequencies below the critical, the receiver works against a background of cosmic noise, and this is measured by monitoring the AGC voltage from the sounder receiver.

Energetic Particle: The energetic particle experiment was supplied by the National Research Council of Canada. Six particle counters are used to record the number of particles within the energy ranges: (a) protons 0.5 to 700 MeV, (b) electrons 40 keV to 3.9 MeV, (c) Alpha 5 MeV to 2.8 BeV.

At time of writing, useful data are still being obtained from Alouette I for periods of 1 to $1\frac{1}{2}$ hours daily.

Alouette II

Alouette II was successfully launched on 29 November 1965. Orbital parameters are: inclination 79.8°, perigee 502 kilometers, apogee 2,983 kilometers. Although it resembles its predecessor outwardly, Alouette II developed into a substantially different spacecraft because of the change in orbit and because of further information on the ionosphere gathered by Alouette I. The spacecraft contains the five experiments shown below:

Ionospheric Sounder: The sounder covers the frequency range 0.2 MHz to 13.5 MHz with 300 watts transmitted power. There is also a 100-watt transmitter which is essentially the same as the one in Alouette I. The 300-watt transmitter failed in May 1969; the 100-watt transmitter is still operating.

VLF Receiver: The VLF experiment covers the frequency range 50 Hz to 30 kHz.

Cosmic Noise: Same experiment as Alouette I.

Energetic Particle: Same coverage as Alouette I.

Langmuir Probe: The experiment measures electron density from 10^3 to 10^6 e/cc and electron temperature from 400° to 5000° K.

Relative to Alouette I, the Alouette II sounder receiver bandwidth was extended at both ends of the range, the sounder transmitter power was increased, the pulse repetition frequency decreased, and the frequency sweep rate modified. The VLF receiver was also given an extended bandwidth and a greater immunity to interference was provided by re-design of the sounder receiver.

All experiments and facilities worked as planned. Results indicate that the capacitive antenna coupling combined with the ion guards have been successful in reducing considerably the effect of the plasma sheath. The bandwidth extension of the VLF experiment has yielded new information, while the re-designed sounder system suffers less interference than did Alouette I. After 40 months in orbit, the 300-watt sounder transmitter became defective. The back-up 100-watt transmitter was then switched on, and much useful data are being obtained during a $4\frac{1}{2}$-hour day operating schedule.

ISIS I

ISIS I was launched from the Western Test Range, California, at 0646 GMT, 30 January 1969, into its prescribed orbit. Orbital parameters are: apogee 3,522.54 kilometers, perigee 573.72 kilometers, inclination 88.43 degrees, period 128.3 minutes. This was the third satellite to be designed and constructed in Canada and is the second in the ISIS (International Satellites for Ionospheric Studies) series. This spacecraft contains the following ten experiments:

Swept-Frequency Sounder: This topside ionospheric sounding experiment covers a frequency range of 0.1 to 20.0 MHz.

Fixed-Frequency Sounder: The fixed-frequency radio sounder operates on six crystal-controlled frequencies within the range of the swept-frequency sounder - 0.250, 0.480, 1.000, 1.950, 4.00 and 9.303 MHz.

Mixed-Mode Sounder: This experiment uses a fixed transmitting frequency of 0.833 MHz simultaneous with a receiver which sweeps through the complete frequency range of the topside sounder.

VLF Receiver/Swept-Frequency Exciter: This is basically a low-frequency receiver covering the frequency range of 50 Hz to 30 kHz, which permits experimental studies of the upper ionosphere and exosphere and the complex interactions between the ionized media and low energy particle streams.

Energetic Particle Detector: This package contains two groups of detectors capable of identifying electrons and protons and measuring their angular distributions and energy spectra over the energy range for electrons from 8 keV to greater than 770 keV and for protons from 50 keV to 20 MeV.

Soft Particle Spectrometer: This spectrometer was designed to measure the energy spectrum, angular anistrophy and spatial and temporal variations of both positive and negative particles in the energy range of 10 eV to 10 keV.

Ion Mass Spectrometer: This is an instrument that is capable of analyzing the ionic composition of the ionosphere in the atomic mass range 1 to 20.

Cylindrical Electrostatic Probe: This is an instrument which measures electron temperature and density. The purpose of this experiment is to extend the satellite measurements into the period of solar maximum.

Spherical Electrostatic Analyzer: The objective of this experiment is the measurement of spatial and temporal variations in the concentration and energy distribution of charged particles in the altitude region of the satellite.

136/137 MHz Beacon: This instrument consists of two 100 mw transmitters operating at 136.410 and 137.950 MHz (the former being the tracking beacon) and measuring the scintillation in the total electron content of the ionosphere between the satellite and the ground station.

Cosmic Noise: This experiment measures the background radio noise levels with the sweep-frequency receiver orbiting substantially above the F-layer ionization maximum to obtain information on the galactic radio noise in various regions of the galaxy and the variation of this noise with frequency. In addition, and of particular interest to the ionospheric studies, the data contain information on the enhancements of solar radio noise when the sun is active.

ISIS I operates approximately $9\frac{1}{2}$ hours per day, and all experiments, with the exception of the ion mass spectrometer which is at present producing degraded

data, are performing as planned. As well, by using the onboard clock and programmer and tape recorder, much useful data are being obtained on the ionosphere over previously unexplored regions of the globe.

ISIS II

ISIS II was launched from the Western Test Range, California, at 0257 GMT, 1 April 1971, into near nominal orbit. Orbital parameters are: apogee 1,423 kilometers, perigee 1,356 kilometers, inclination 88.16 degrees, period 113.55 minutes. This was the fourth satellite to be designed and constructed in Canada and is the third in the ISIS (International Satellites for Ionospheric Studies) series. This spacecraft contains the following twelve experiments:

Swept-Frequency Sounder: The objective of the experiment is to determine the electron number density at and below the satellite down to the peak of the F-layer of the ionosphere along the orbit of the satellite. The electron density as a function of distance below the satellite is determined from the delay time of high frequency radar echoes reflected from the ionosphere as a function of frequency. From repetitive measurements, the height, latitudinal, longitudinal and diurnal variation of the electron density can be studied. Also, the data yield information about the size and location of irregularities in the ionosphere.

Fixed-Frequency Sounder: The fixed-frequency sounder is designed to provide observation of small-scale irregularities which are too limited in extent to be easily investigated by the swept-frequency sounder and to complement the swept-frequency sounder, particularly where rapid horizontal variations occur. The prime scientific objectives are:

a) The study of irregularities in the high ionosphere;

b) The study of the fine structure of the plasma resonance phenomena;

c) The study of plasma mixing processes by observing the swept-frequency receiver response while the transmitter remains at one of six selectable fixed frequencies.

VLF Experiment: This experiment is basically a low frequency receiver covering the frequency range from .05 kHz to 30 kHz. Because of the large range in amplitude of naturally occurring VLF signals, the receiver has a dynamic range of about 80 dB, which is achieved by the use of an AGC system. The AGC level is telemetered to the ground along with the broadband output of the receiver, which directly modulates the telemetry transmitter. Information is provided on:

a) The relative abundance of H^+, He^+ and O^+ ions in the vicinity of the spacecraft;

b) The harmonic mean mass of the positive ions in the vicinity of the spacecraft;

c) The propagation of VLF waves of natural origin and from ground-based transmitter.

d) The various ion and hybrid resonances of a plasma that lie in the VLF band.

e) The association between VLF noise or emissions and the intense fluxes of energetic porticles that precipitate into the lower ionosphere at high latitudes.

At low frequencies, the behaviour of the long sounding antennas of the ISIS spacecraft is profoundly affected by the plasma in which they are enveloped. Even when dealing with field strengths at which the antennas behave as linear devices, the plasma greatly changes their impedance characteristics. Thus if the intensities of VLF signals are to be measured within the ionosphere, it is mandatory that the impedance of the antenna be known. So far in the Alouette/ISIS program no measurements of antenna impedance have been made and hence only relative intensities of various types of VLF signals are known. With the ISIS-II experiment, it is hoped that it will be possible to derive absolute values of field strength.

Since antenna impedance is a strong function of the plasma characteristics, the possibility exists that the observed impedance can be related directly to some of the plasma parameters. If this proves possible then the impedance measurements become a new type of plasma probe. Of particular significance, in this context, is the fact that at low frequencies the ion composition of the plasma may be an important parameter in determining the antenna impedance, especially in the vicinity of the lower hybrid resonance frequency. These possibilities can be evaluated only when data from the satellite becomes available, since the theory of antennas immersed in a plasma medium is not sufficiently well developed to provide reliable answers.

Cosmic Noise: This experiment measures the so-called cosmic noise, or more specifically the natural background radio noise level, with a sweep-frequency receiver orbiting substantially above the F-layer ionization maximum. In general the background noise level is determined by galactic noise, and information on its variation with direction in the galaxy and with observing frequency is desired, particularly at frequencies that cannot penetrate through the ionosphere. In addition, there are occasional noise enhancements above the galactic level which are of solar origin. These are associated with the ejection of material from the sun that can drastically affect the earth's upper atmosphere and ionosphere: a monitor of such solar noise emissions at low enough radio frequencies can provide detailed information of the passage of the solar particles through the sun's outer corona and into interplanetary space. Moreover, it appears that a study of such noise emissions can lead to quantitative determinations of electron density and temperature in the interplanetary regions.

Yet another contribution to the background noise level comes from radio emissions generated within the ionosphere and such noise, often of exceptionally great magnitude, is commonly observed at high latitudes. A detailed study of this phenomenon as a function of location, frequency, ionospheric parameters is desired, and particularly in a satellite which measures the local ionospheric conditions at the same time.

Retarding Potential Analyzer: The objective is to measure the positive ion density composition and temperature in the vicinity of the spacecraft. The secondary objective is to measure the thermal election density and temperature, and the flux of suprathermal electrons. The effect on the measured quantities of special ionospheric events such as magnetic disturbances, red arcs, etc., will be studied. The long-term dependance on the composition, densities and temperatures upon geophysical parameters such as altitude, latitude, longitude, local time and season will be determined.

Ion Mass Spectrometer: The ion mass spectrometer is a magnetic deflection instrument with two ion detector systems. The instrument scans the mass range 1-64 amu in two sections 1-8 and 8-64, and measures the relative abundance of the ions collected in this mass range from the ambient ionosphere in the vicinity of the satellite.

Soft Particle Spectrometer: Intense fluxes of low energy particles, mainly electrons and protons, are the cause of auroral phenomena and related geophysical disturbances. This experiment is an improved version of the experiment flown on ISIS-I which provided good detailed information on the fluxes and energy spectra. The energy resolution has been improved to provide better data on the spectral line width and shape. Particles are detected in two separate beams to provide a check on the variability of the flux on a short time scale.

Energetic Particle Detector: The objective of the energetic particle experiment is to provide data which will aid in the understanding of:

a) The mechanisms responsible for the production and control of the particles which populate the outer radiation zone and which sometimes precipitate into the atmosphere.

b) The related problem of entry into the earth's magnetic field of solar flow particles.

c) The nature of the distortions which occur in the earth's magnetosphere as a result of its interaction with the solar wind.

The experiment is designed to measure intensity, angular distributions and energy spectra of electrons and protons. An energy range of 1 KeV to 1 MeV is covered for electrons. There are two energy

ranges for protons, auroral energies 2-20 KeV and "solar flare" energies 0.8-30 MeV.

Beacon Experiment: The beacon experiment aboard ISIS-II is an improved version of the equipment aboard ISIS-I. The purpose of the experiment is to detect and measure inhomogeneities in the ionosphere between the spacecraft and a number of ground stations. The inhomogeneities are detected by the modifications in direction of propagation, amplitude and polarization imposed on the radio waves in propagating through the irregularities. These are detected by angle-of-arrival (relative phase), amplitude and polarization measurements made in the ground equipment. When the orbits of the ISIS-I and ISIS-II satellites are suitable, the beacons on both satellites will be used to obtain data in quick succession on the same volume of ionosphere.

Cylindrical Electrostatic Probe: The objectives of the experiment are:

a) To extend through the waning phase of the 11-year solar cycle the study of the global behavior of electron temperature and density that was begun with data from the ISIS-X*(Alouette II and Explorer XXX1) and ISIS-I satellites.

b) By use of the extended resolution of this instrument, to examine in greater detail polar cap and magnetosphere/plasmasphere interactions, and

c) To look at global behaviour of the ionosphere from a circular polar orbit, thus avoiding mixing the effects of altitude and latitude.

Red Line Photometer: The purpose of this experiment is to map the global distribution in the intensity of the 6300 Å line emission from the D level of atomic oxygen. This upper level lies only 2 eV above the ground state; hence it can be excited by a number of mechanisms and the emission is useful in interpreting the physical processes of the F-region. (The emission is strongly collisionally deactivated by N_2 and does not appear at lower altitudes.) The mechanisms to be studied are auroral excitation by electrons and protons, mid-latitude red arcs, photodissociation of O_2, dissociative recombination of O_2^+, excitation by photoelectrons generated both locally and at the magnetically conjugate point, and thermal electron excitation. The global behaviour patterns and the simultaneous measurements of other experiments aboard ISIS-II should make it possible to delineate these mechanisms.

ISIS-X Refers to launching of Alouette II and Explorer XXX1 in the same vehicle.

Aurora Scanner Photometer: The scanning photometer is designed to map the distribution of auroral emissions at 5577Å and 3914Å over the portion of the dark earth visible to the spacecraft. A combination of internal electronic scanning and the natural orbital and rotational motions of the spacecraft causes a dual wavelength photometer to scan systematically across the earth. The data will be reproduced directly in the form of separate pictures representing emissions at each wavelength. The pictures will be used to study the large-scale distribution and morphology of auroras, to study the ratio of 3914Å to 5577Å emissions (thought to depend upon the energies of exciting particles), and to compare auroral activity with phenomena recorded by other instruments on board the spacecraft and on the ground.

Satellite Support Services: In addition to spacecraft design, the ISIS program provides support services in the form of two telemetry stations and a data processing centre. One telemetry station is situated at Resolute Bay on Cornwallis Island and the other, as well as the data centre, at Ottawa. The Ottawa station is also the control station for all Canadian satellites.

Communications Technology Satellite

The Department of Communications, in co-operation with the U. S. Space Agency, have embarked on an experimental project that will carry Canadian technology into the second generation of communication satellites.

The project to launch a high-powered communications satellite into geostationary orbit in 1975 was the subject of a Memorandum of Understanding signed by officials of the Department of Communications and the NASA.

The Communications Technology Satellite (CTS) will be designed and built in Canada. DOC's Communications Research Centre at Shirley Bay will provide Project Management, R&D support and a spacecraft assembly and test facility; detailed design and fabrication of subsystems will be the responsibility of Canadian industry. The NASA will provide the launch vehicle (a Thor-Delta rocket), access to some advanced electronic components and spacecraft environmental test facilities.

The program offers Canada the following advantages:

- maintaining Canadian aerospace industry abreast of the latest developments in subsystems for communications satellites and the associated ground installations,
- the opportunity to conduct communications experiments with small ground terminals in remote parts of the country.

The significant difference between the CTS project and satellite systems such as Intelsat and ANIK, is in the power of the signal transmitted by the space segment. In the ANIK series 6W TWTs provide a radiated (EIRP) of approximately 33 dBW power while in the CTS a 200W TWT will provide an EIRP of 55 dBW. Consequently, for the CTS, comparatively inexpensive ground terminals will be required allowing more communities to be served.

The heart of the CTS is a super-efficient, high powered Travelling Wave Tube operating in the 12 gigahertz frequency range. This tube is being developed and procured by the NASA.

Another feature in the CTS is an experimental electrically vectored ion-thruster which will be used for stationkeeping operations. The use of electrically accelerated ions instead of pressurized propellants, reduces the weight of the auxiliary propulsion system for long duration missions.

The spacecraft will be assembled at CRC in a new high-bay facility.

Rocket Program

On 5 February 1971, a Black Brant IV rocket containing a VLF experiment was launched from the Churchill Research Range. The experimental package was ejected from the main payload at a height of about 100 kilometers. The ejected package contained instruments to measure the impedance of a 50 foot dipole antenna, that was deployed from the ejected package. All systems functioned well, but the anomalously low values of impedance that were obtained suggest that the antennas were probably not fully deployed during the flight.

The SHF Propagation Program

The objective of the SHF propagation program is to study the effect of the earth's atmosphere on radiowave propagation, at frequencies between about 4 and 30 GHz, particularly as these effects relate to the design of satellite communications systems. Successful utilization of new bands above 10 GHz will require a sound knowledge of atmospheric propagation effects which become increasingly important as one moves to higher frequencies.

Precipitation Attenuation

This program is primarily concerned with the study of attenuation due to precipitation. Given the drop-size distribution and the distribution of rainfall intensity along the propagation path, a reasonable theoretical estimate of attenuation can be made. However, little is known of the distribution in time and space of these meteorological parameters or of the variation of the statistics of occurrence of attenuation due to rainfall with location and elevation angle as required by the systems designer.

Aircraft Beacon Experiment

During 1967 and 1968, CRC conducted an experiment to measure precipitation attenuation using aircraft-borne beacon transmitters at 4, 8 and 15 GHz. A direct measure of the transmission loss along the propagation path was obtained. In addition, a weather radar at 2.9 GHz was used to obtain radar backscatter measurements from precipitation along the propagation path. From the radar data, it is possible to estimate attenuation using empirical relations between radar reflectivity and attenuation coefficient per unit distance. CRC has a contract with McGill University to use radar data for developing the statistics of occurrence of rainfall attenuation. Measurements obtained from the aircraft experiment provide a means for investigating the accuracy of radar predicted attenuation values.

ATS-5 Experiments

Since September 1969, CRC has been carrying out precipitation attenuation measurements using the 15.3 GHz beacon on the NASA ATS-5 satellite. The beacon signal is received on a 30-foot antenna, and the transmission loss data obtained provide a direct measure of precipitation attenuation. The 30-foot antenna is also fitted with a 15.3 GHz radiometer for simultaneous measurement of atmospheric emission temperature. An estimate of attenuation can be obtained from the sky noise temperature measurement.

A 2.9 GHz weather radar is used to obtain backscatter data along the propagation path in the direction of the satellite. The radar is also used in a scanning mode to provide information on predicted attenuation in other directions

and a measure of storm cell size.

Considerable work has been done in comparing radiometer-predicted attenuations with those measured directly using the ATS-5 beacon. It has been found for a wide variety of storm types that attenuations calculated from the radiometer measurements are in excellent agreement with those measured directly up to values of about 8 dB, the expected limit of reliable radiometer predictions.

Simultaneous measurements of ionospheric fading at frequencies near 136 MHz, 250 MHz and 1550 MHz were made at CRC during the period January to June 1970. Satellites employed in this program include the ATS-5 and the TACSATCOM-1 satellites. The major objectives of this program were to accumulate statistical data on fading amplitudes and their frequency dependence to permit satellite communications systems margins to be specified accurately in the VHF/UHF range.

Attenuation Statistics

In order to determine statistics of precipitation attenuation for various geographic regions, radiometers operating at a frequency near 13 GHz will be placed at several locations across Canada. The antennas will be directed at a likely position for a geostationary communications satellite, and the equipment will run continuously for about three years, beginning in 1972.

Low-Angle Tropospheric Scintillations

It is common practice to limit operation of satellite communication systems to elevation angles, at the earth's surface, greater than five degrees. However, in Canada it may well be necessary to consider operation at very low angles to achieve coverage of the Canadian North from the geo-stationary orbit.

Signal amplitude fading results when SHF signals are propagated through the troposphere. The depth of fading is dependent on the length of the path in the troposphere and, hence, on the elevation angle of a satellite communications circuit. Amplitude fading statistics are important for system designers who must make allowances for propagation margins. A continuing series of measurements of low angle tropospheric fading is being carried out by CRC employing a fixed 30-foot ground terminal and a transportalbe 6-foot ground terminal.

Tactical Satellite Communications Program

During 1971, a continuing program of propagation measurements at 250 MHz was carried out using the beacon signal from the LES-6 satellite. Data on the short-term statistical behaviour of ionospheric scintillations is being gathered to provide information necessary for satellite communications system design in this frequency range. These measurements are being carried out at Ottawa.

In addition, signal fading measurements at 250 MHz are also being recorded at Churchill, simultaneous with beacon measurements from ATS-5 at 1550 MHz. This data will be used to establish the frequency dependence of ionospheric scintillations.

FORT CHURCHILL

DEFENCE RESEARCH BOARD

Defence Research Establishment Valcartier (DREV)

Atmospheric Radiative Processes

The Upper Atmosphere Research Program at DREV comprises observational measurements on infrared airglow and stratospheric abundances of minor atmospheric constituents. A laboratory program seeks to explain the photochemical mechanisms controlling ozone concentration in the stratosphere and mesosphere. These photochemical processes are also responsible for the airglow emissions due to OH and excited states of atomic and molecular oxygen.

Results from project COLD CAN, a joint Canada/United States study of atmospheric processes, have provided O_2 ($^1\Delta_g$) airglow intensities and measurements of stratospheric abundances of water vapour, carbon dioxide and methane over North and South America.

A Field trial at Fort Churchill, Manitoba, during March 1971 used a Michelson interferometer and infrared photometers to investigate variations in O_2 ($^1\Delta g$) and OH airglow intensities and OH rotational temperatures in the presence of auroral activity. Photometric measurements of night sky radiation were made with two OH photometers at Alert and Resolute, N.W.T. during February 1971.

High resolution solar and lunar spectra were obtained using ground-based Michelson interferometer to detect trace atmospheric constituents.

The laboratory program includes investigations in the following areas:

(a) Mechanism of formation of O_2 ($^1\Delta_g$) and O_2 ($^1\Sigma^+_g$) by ultra-violet photolysis of ozone;

(b) Measurement of rates of deactivation of O_2 ($^1\Delta_g$) by atmospheric gases;

(c) Measurements of relative rates of reaction of excited atomic oxygen O (^1D) with oxygen, nitrogen, water vapour, carbon dioxide, methane and ozone.

Rocket Motor Technology

At DREV there exists a well demonstrated capability in the development of new binders for solid propellants, the transferral of laboratory studies to plant scale operations, the evaluation of the combustion characteristics of propellants, the complete design of solid propellant rocket motors, the development of all components except flight-weight casings, and the static testing of rocket motors. This capability is continuously updated by studies in polymer chemistry, analytical techniques, chemical engineering, the internal ballistics of rocket motors and fundamental combustion processes. Recent improvements include digital computer programs covering ballistic design and stress analysis, a digital data acquisition system and a static test spin rig.

The development of the Black Brant series of rocket motors was based largely on DREV technology and was conducted jointly by DREV and the industrial firm now known as Bristol Aerospace (1968) Ltd. More recently, a second joint program with BAL has been concerned with the development of two small rocket motors to be used for meteorological soundings. These high performance motors must withstand extremely severe environmental conditions with exceptional reliability, all at an unusually low production cost. Having completed the major portion of its contribution to this program, DREV continues to provide engineering support to BAL, where the two vehicles are now in an advanced stage of development.

DEPARTMENT OF THE ENVIRONMENT

Atmospheric Environment Service

Weather Satellite Activities

The Satellite Data Laboratory, of the Atmospheric Environment Service, Research and Training Division, continues to evaluate in relation to the Automatic Picture Transmission (APT) system Research and Development Project.

APT mode data has been acquired from the TOS series of operational weather satellites, from the NIMBUS series of experimental spacecraft, and more recently, from both the Improved TOS series, I-TOS-1 and NOAA-1 satellites. Additionally, APT mode re-transmissions from ATS-1 and ATS-3 in geostationary orbits, have been acquired to obtain WEFAX data.

The acquired data, both visual and IR, is being used for meteorological research, weather forecasting, ice reconnaissance operations, and is distributed for applications to provide hydrological information and other information to various government agencies and university groups, for operations of research use relating to earth and environment scientific studies. Distribution amounts to approximately 30,000 photo copies of daily routine receptions per annum.

Data from routine receptions or from magnetic tape archives is utilized to provide observational support for research studies relating to current or past meteorological phenomena or conditions, at specific periods, or to supply information of a climatological nature in respect to surface or atmospheric conditions prevailing in an area.

The Satellite Data Laboratory facilities will shortly be moved to continue operations at the new HQ of the Atmospheric Environment Service in Toronto.

Airglow Studies

Results of the analysis of measurements of the intensity fluctuations of night sky emission of OI green line (5577 Å) and background radiation, made at Meteorological Research Station, Woodbridge and Dunlop Observatory, Richmond Hill, Ontario, have revealed that such observations at only two stations are inadequate to give any information on drifts at the emission level. Installation of a third station at Albion Hills, Ontario, was planned, but due to operational difficulties the project was terminated.

Measurements of light, scattered during twilight to study dust content and its variation in the atmosphere, continue. Instruments are being developed to measure sky light polarisation.

Noctilucent Cloud Activities

The visual and photographic observations to study the noctilucent cloud are continuing, and the processed data being published.

Theoretical Studies

Further theoretical studies have been carried out to investigate the dynamics and photochemistry of the region from stratosphere to lower thermosphere. Particular emphasis is directed toward the potential hazards arising from the effect of SST pollution on the global environment.

Rocketsonde Studies

Study of the practicability of interring thermal profiles from density-altitude data shows that realistic temperatures are obtainable from density measurements, from about one or two scale heights below the maximum altitude of density results and downwards, provided the densities are measured with reasonable accuracy.

Recently available information on heat transfer processes in rarefied air flow have been incorporated into the heat transfer equations of the thin-film-thermistor temperature sensors as they fall through the different flow regimes of the upper atmosphere from about 65 km to about 20 km. The results show that it is feasible to use the thin-film-thermistor to make realistic measurements of temperature up to mesospheric levels.

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Geological Survey of Canada

Participation in the Apollo Lunar Sample Studies

1. Apollo XII - Only three of the original five teams continued their work on the Apollo 12 material.

Detailed descriptions of the mineralogy and petrology of some Apollo 12 samples were presented at the Second Lunar Science Conference at Houston in January 1971, together with a joint account with other investigators of a new mineral, tranquillityite. In addition, work done on terrestrial impact craters was presented at the Lunar Science Institute Conference on Meteorite Impact and Volcanism. Additional work, as yet unpublished, has been done on samples of both lunar breccia and surficial fines, with attention concentrated on fragments of the anorthositic-noritic suite and their derivatives, commonly interpreted as derived from highlands or pre-mare sites. Several unusual rock types have been recognized, including noritic granular rocks in which partial melting has produced a glass rich in potassium and phosphorus, and a unique shocked and partly recrystallised olivine-clinopyroxene rock possibly derived from a highlands layered complex.

Studies of the electrical properties of Apollo 12 samples, and of Apollo 11 material as well, were completed. Chemical analyses of two rocks and a portion of the <1 millimetre fraction of surficial material, including the determination of major, minor and trace elements, were presented at the Second Lunar Science Conference. These results, together with the mineralogical-petrological studies, will be published in the Proceedings of the Second Lunar Science Conference, Geochim. et Cosmochim. Acta, Supplement 2, 1971.

2. Apollo XIV - Two teams, those concerned with studies of the mineralogy-petrology and of the chemical composition, have been appointed as Principal Investigators for the Apollo 14-17 missions. Chemical analyses are being made of both rock and surficial fines. The mineralogical-petrological work is concerned with the classification of rock and mineral fragments in Apollo 14 breccias and their comparison with analogous impact melts and breccias. Results will be communicated in the Third Lunar Science Conference at Houston in January 1972.

Earth Physics Branch

The Division of Geomagnetism operates 10 permanent magnetic observatories in Canada, and supplies microfilm copies of the magnetograms to World Data Centers on a monthly basis. By early 1972, eight of these

observatories will be equipped with digital recording systems, which sample the magnetic field once per minute. Tapes are sent to Ottawa at the end of each month.

A new unattended magnetic observatory at Cambridge Bay, NWT, will begin operation early in 1972. The observatory at Alert, NWT, will be closed in September 1972.

The four unattended magnetic recording stations in Manitoba which operated from October 1969 in support of the magnetic program of satellite ATS-5 were closed in November 1971. It is planned to move some of them east to the meridian of Churchill and resume recording in January 1972.

Canadian Centre for Remote Sensing

The Centre

On February 11, 1971, Treasury Board approved the establishment of an Organization, to be known as the "Canadian Centre for Remote Sensing", to carry out a program of remote sensing of resources and the surface environment. This organization had been recommended by the "Program Planning Office for Resource Satellites and Remote Airborne Sensing" in compliance with the mandate given to it by Cabinet in 1969.

ERTS Program

The U.S. National Aeronautics and Space Administration plans to launch a series of experimental Earth Resources Technology Satellites starting with ERTS (A) in March 1972. An agreement between EMR and NASA has been achieved for a joint experimental program of remote sensing of resources from aircraft and satellites. Canada will be reading out ERTS and to this end the Centre has been co-ordinating work that will convert the Prince Albert Radar Laboratory for ERTS use. The Centre is also developing a Data Handling Centre that will process the received data and convert it to imagery. The Air Photo Production Unit and the National Air Photo Library of the Surveys and Mapping Branch of EMR will handle image reproduction and dissemination.

Airborne Remote Sensing Program

An airborne remote sensing program which is complementary to and integrated with the ERTS satellite program has been initiated. An agreement between EMR and DND , whereby DND provides aircraft services, on a cost recoverable basis, for two aircraft is being negotiated for 1971/72. Two aircraft - a CF-100 and a C-47 - have been flying during the past summer providing Canada-wide services to 26 user agencies.

Sensor Development Program

This program has the specific objective of promoting remote sensing sensor and instrument development in Canada, involving university and industrial contractors. This is part of the Centre's "innovation guiding" mission. An average of 11 contracts have been continually funded since May of 70. This involves research in active as well as passive sensors, with lasers playing a role of major importance.

MINISTRY OF TRANSPORT

Telecommunications and Electronics Branch

International Aeronautical Satellite Program

The following include some details concerning the Pre-Operational Aeronautical Satellite Program and associated research projects in which Canada intends to participate.

The aeronautical satellite programme will be international in nature and will be funded by the ESRO, the U.S.A. and other interested nations. The purpose of the programme is to permit technical and operational evaluation of voice, and data transmission between aircraft and a ground station.

There are two satellites proposed for each oceanic area, the Atlantic and Pacific. The use of a two satellite system allows one to perform surveillance of aircraft within the mutual coverage of the two satellites. Each satellite will have at least six voice channels and one surveillance channel and be capable of operating with aircraft having a G/T of -24 db.

The launch of the first satellite should be early in 1975.

AURORA SOUTH OF CHURCHILL, MANITOBA

NATIONAL RESEARCH COUNCIL OF CANADA

Division of Physics

Auroral Particle Studies

Rocket measurements of charged particles associated with various types of auroral events have continued during the past year.

The first results were obtained from a rocket flight into a polar cap aurora over Resolute Bay, N. W. T. Soft electron fluxes were detected above a relatively stable 1 kilorayleigh auroral arc which was aligned in the earth sun direction. The electron precipitation was slowly varying in time, had an isotropic pitch angle distribution, a differential energy spectrum peaked in the 1.5 to 2.0 keV energy range and a peak intensity of $\sim 10^7$ cm^{-2} sec^{-1} str^{-1} keV^{-1}.

Results were also obtained from flights in the auroral oval over Fort Churchill. One flight carried the rocket over the two most northerly arcs in a band of parallel east-west oriented arcs, into a region of low activity to the north of the band, and then into a large fold to the north-east of the launch site. Several times during the flight intense field aligned electron pitch angle distributions were observed. These regions were found to be coincident with the northern boundary of the band of auroral precipitation. No equivalent distributions were observed between arcs to the south. Most of the characteristics of the particle precipitation observed in the boundary region can be shown to be consistent with a local acceleration from a parallel electric field with a potential drop greater than 7 kV.

Further results were also obtained on the composition of low energy auroral ions. In particular, the ratio H^+:He^{++}:He^+ was found to be consistent with earlier measurements which suggest a solar wind origin for auroral particles.

Magnetosphere Studies

Analysis of particle data from the Alouette II and ISIS-I satellites continues. A number of studies have been carried out on the latitude profiles of solar particles. Solar electron measurements have been compared both with outer zone electron measurements and with solar proton measurements in an attempt to determine the dayside limit of closed geomagnetic field lines. The measurements suggest that at magnetically quiet times the dayside limit of closed field lines occurs at the position of the electron knee latitude ($\Lambda \sim 78°$) and that as magnetic activity increases solar electrons scatter or diffuse across closed field lines so that at these times the electron knee latitude lies equatorward of the high latitude limit of closed lines.

Cosmic Ray Studies

A number of studies are underway in which ground based cosmic ray measurements are used along with interplanetary magnetic field measurements to study the density gradients and streaming of cosmic rays.

Atlantic Regional Laboratory

Lunar Sample Studies

Lunar fines material is currently being studied by a group of NRC scientists in Halifax, to determine discrete silicate anions in the fines and selected lunar glasses. The broad object of this work is to gain information on the thermal history of the lunar glass by studying its ionic constitution. The method involved is to dissolve the fines and glass fragments in a suitable chloride medium and then to determine the identity and concentration of the discrete anions by a gas-liquid chromatographic technique. Ionic species are identified by comparing with chromatograms of materials of known structure and also by mass spectrometric analysis. The complex nature of the lunar fines also requires that a detailed examination and modal analysis be carried out by optical microscopy. The absence of chemical weathering on the moon suggests that types of discrete silicate ions, normally subject to leaching in terrestrial soils, might be present in lunar fines and part of the aim of the study is to attempt to identify such species. In addition, comparison of ionic constituents of lunar glass with terrestrial glass of the same composition may yield valuable information about the origin and thermal history of lunar material.

To date samples of fines from Apollo missions 11, 12 and 14 have been studied. In several samples careful optical examination has revealed the presence of rare melilite-group minerals; as far as is known this is the first reported finding of such species from lunar samples. The chromatographic analysis has revealed the presence of a cyclic tetrameric silicate ion ($Si_4O_{12}^{8-}$), suggesting, by analogy with recent findings on terrestial silicate glasses, that it may be a product of devitrification of lunar glasses.

The principal investigator of the group conducting these studies is Dr. C. R. Masson of the Atlantic Regional Laboratory of the National Research Council, Halifax, Nova Scotia. Co-investigators on the project are Dr. I. B. Smith, responsible for the chemical extraction and chromatographic analyses; Dr. W. D. Jamieson, responsible for the mass spectrometric analyses; Dr. J. L. McLachlan, who performs photomicrographic studies of the fines and Professor A. Volborth, a guest research worker at the Atlantic Regional Laboratory and a geology professor at Dalhousie University. Professor Volborth's task is to characterize the specimens and perform the modal analyses by optical microscopy.

Astrophysics Branch

Upper Atmosphere Research Section

Rocket Measurements of Type-B Aurora

A A three-channel photometer package has been developed to be flown on rockets. Its purpose is to measure the vertical emission profiles, at selected visible wavelengths, of electron auroras having lower borders in the height range of 80 to 150 km. It is planned to obtain data from at least one type-B aurora which can in turn be compared with the vertical emission profile of a normal aurora. Two of these photometers will be flown in January, 1972 on Black Brant VB and IIIB rockets. Further flights are planned for 1973.

Auroral Photometry and Spectroscopy

An expedition was made to Gillam, Manitoba in February 1971. Good data were obtained on type-A red line enhancements during magnetic disturbances. Studies of substorms are continuing but a detailed analysis awaits the completion of a digital data acquisition system. This system will also be used to analyse H_β line profiles obtained with the tilting filter photometer.

A 0.5 m Ebert scanning spectrometer has been completed and was used in February and March 1971 from the Auroral Observatory at Churchill Research Range for observations of the red and infrared spectrum of the aurora using an S-25 photomultiplier tube. The spectrometer was used in conjunction with the 11-channel photometer described last year. Both instruments had an identical field of view. The photometer could be used either slaved to the spectrometer (for correction of intensity variations during scans) or as a meridian scanner. All data were recorded on digital magnetic tape which could be processed in the computer. Excellent auroral spectra were obtained even from individual scans.

A program of theoretical calculation of the height profiles of auroral emissions was started. Profiles of λ 6300, λ5577 and λ4278 have been calculated for various assumed initial electron energy spectra and atmospheric parameters. This is to be extended to other features excited by primary and secondary electron impact.

The auroral intensities from the 1969 auroral airborne expedition have been analysed to compile statistics on the occurrence of values of the intensity ratios between different features as a function of auroral intensity. These tables provide reliable indications of the values and variations of these ratios and hence of the total intensities of the N_2^+ 1N, N_2^+ N, N_2 1P and OI λ 6300 emissions.

A series of observations of low-intensity auroral red arcs (LAR-Arcs) have been analysed from the results obtained with the meridian scanner in 1970 and with the help of the theoretical model. These arcs appear to be excited by soft electrons with energies between 500 and 1000 eV.

The scanning spectrometer is being modified to employ a digital encoder and stepping drive system to provide external control of the wavelength drive and digital read-out of the grating position. It is hoped to use this system in a further campaign at Churchill in January 1972.

Infrared Aeronomy

A three-channel infrared photometer was used to look at auroral and airglow emissions during 1971. The wavelengths selected were 1.23, 1.27 and 1.50 microns. Auroral enhancements were observed in all three channels; these could be explained as emissions from the nitrogen First Positive and Meinel bands. The seasonal behaviour of the 1.27 μ oxygen band was also investigated but the results have not yet been fully analysed. More airglow and auroral observations of the same type are planned for 1972. A spectrometric investigation into the intensity distribution of the hydroxyl rotational lines is also planned to check for the possible occurrence of distributions which are affected by hydroxyl formation mechanisms rather than by the usual Boltzmann mechanism.

Conjugate-Point Auroral Research

Multichannel auroral photometers were operated at Byrd Station during the antarctic winter (March to September 1971) and at Great Whale during August and September 1971. An attempt was made to deploy three automatic photometers on islands in Hudson Bay, but due to equipment troubles of various kinds, no data were obtained from any of these remote stations. Since Byrd Station is now closing as a winter station (due to a dangerously large accumulation of snow) the observational phase of this conjugate-point program has come to an end.

Rocket Probes of Ionospheric Plasma

During 1971, plasma probes were flown on seven rockets from Churchill. Five of these flights were in active auroral conditions, and two were in daytime. One of these latter two happened to take advantage of a PCA event although this was not prescribed in the launch requirements.

During the early months of 1972 probes are to be flown on seven rockets from Churchill.

Radio Aurora

Considerable effort has been expended in the past year on a study of periodically varying radio aurora. Of a number of types of events observed, four have been studied in detail. Two of these have periods longer than one minute and although they have been reported previously in the literature, some new facts have been discovered concerning them. The other two types have periods less than one minute and usually occur in the midnight sector. All four types occur primarily during geomagnetic storms. The relationship between these events and geomagnetic micropulsations is under investigation.

Meteor Astronomy

The combined meteor observations at the Springhill Meteor Observatory were continued during the favourable peak periods of annual meteor showers in 1971. Photometry of the meteor spectra of the 1946 Giacobinid shower, combined with new laboratory determinations of the luminous efficiencies in atomic spectra made at the Ames Research Laboratory, have made possible a start in the quantitative determination of the composition of cometary meteoroids.

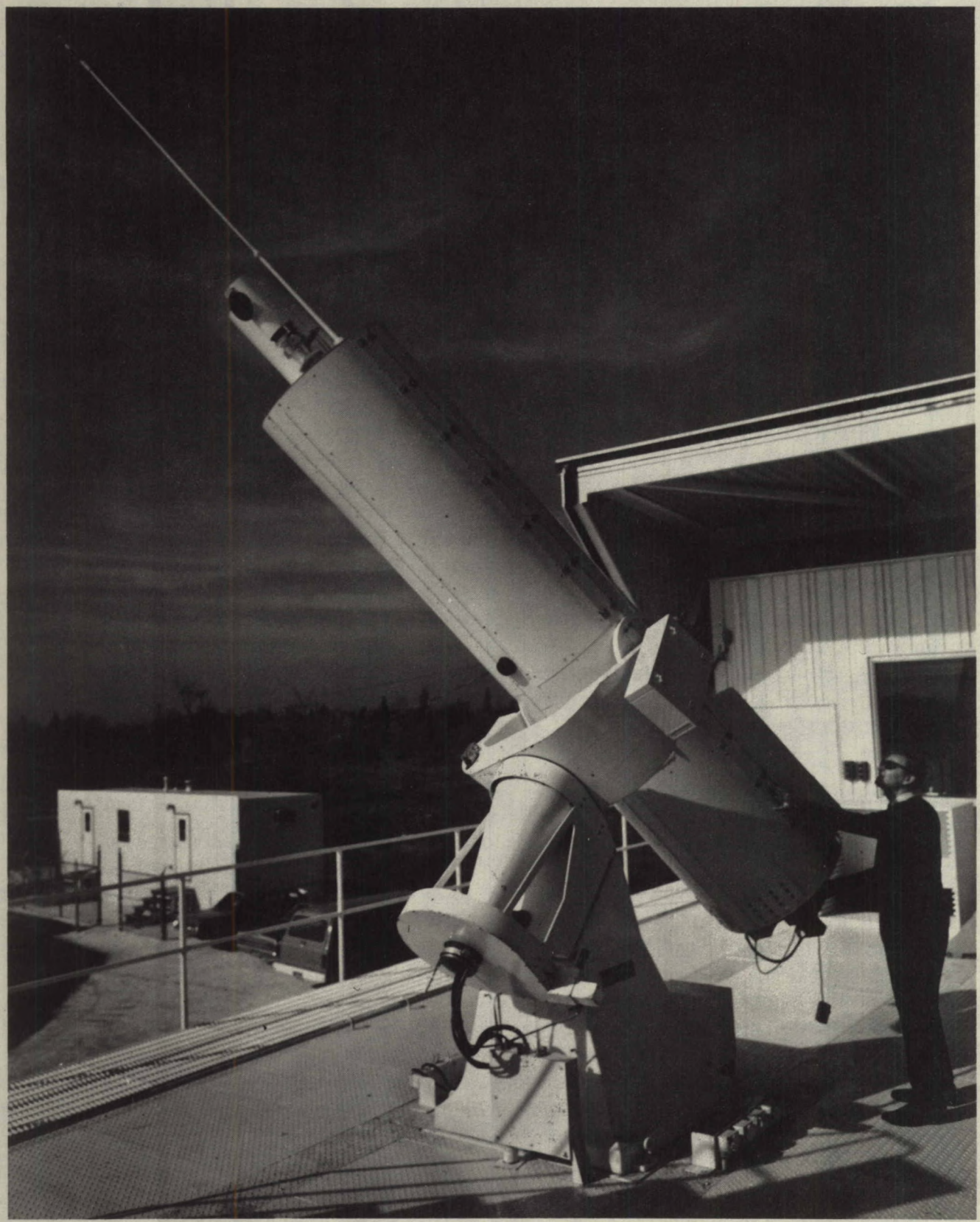
A new meteor observing site known as the Shiels Meteor Station has been established west of Ottawa near Almonte (lat. 45° 15.0' N, long. 76° 18.3'W). Photographic meteor observations are conducted in conjunction with the Springhill Meteor Observatory on a baseline of 65 km length.

The Meteorite Observation and Recovery Project (MORP) is in full operation in the prairie provinces with 12 camera stations photographing the night sky for bright meteoric events. A modest search has been conducted for a meteorite from a marginal event in August 1971 which might have dropped a small meteorite in central Saskatchewan.

Micrometeoroid Detection

During the past year, three models of acoustic detectors, two models of ionization-impact detectors, and samples of thin films which have been used as elements in the ionization-type of detector, have been flown on several rockets. The recovery of the sample films from Black Brant II and VB payloads has indicated that damage to these films from vibrations experienced on these vehicles, is small. The major vehicle, AAD-VB-30, flew successfully as scheduled. Though all experiments functioned, interference was present and appears to be due to RF probably largely brought on by the extension of packages in the vicinity of the antennas. All data have now been plotted on a graph for intercomparison purposes and copies of the graph have been sent out to the participating scientists for evaluation purposes. A proposal has been submitted to extend the program by particle collections in the 25 to 60 km altitude range by means of meteorological rockets.

OTTAWA RIVER SOLAR OBSERVATORY TELESCOPE



Radio Astronomy Section

Daily Observations of Solar Radio Flux

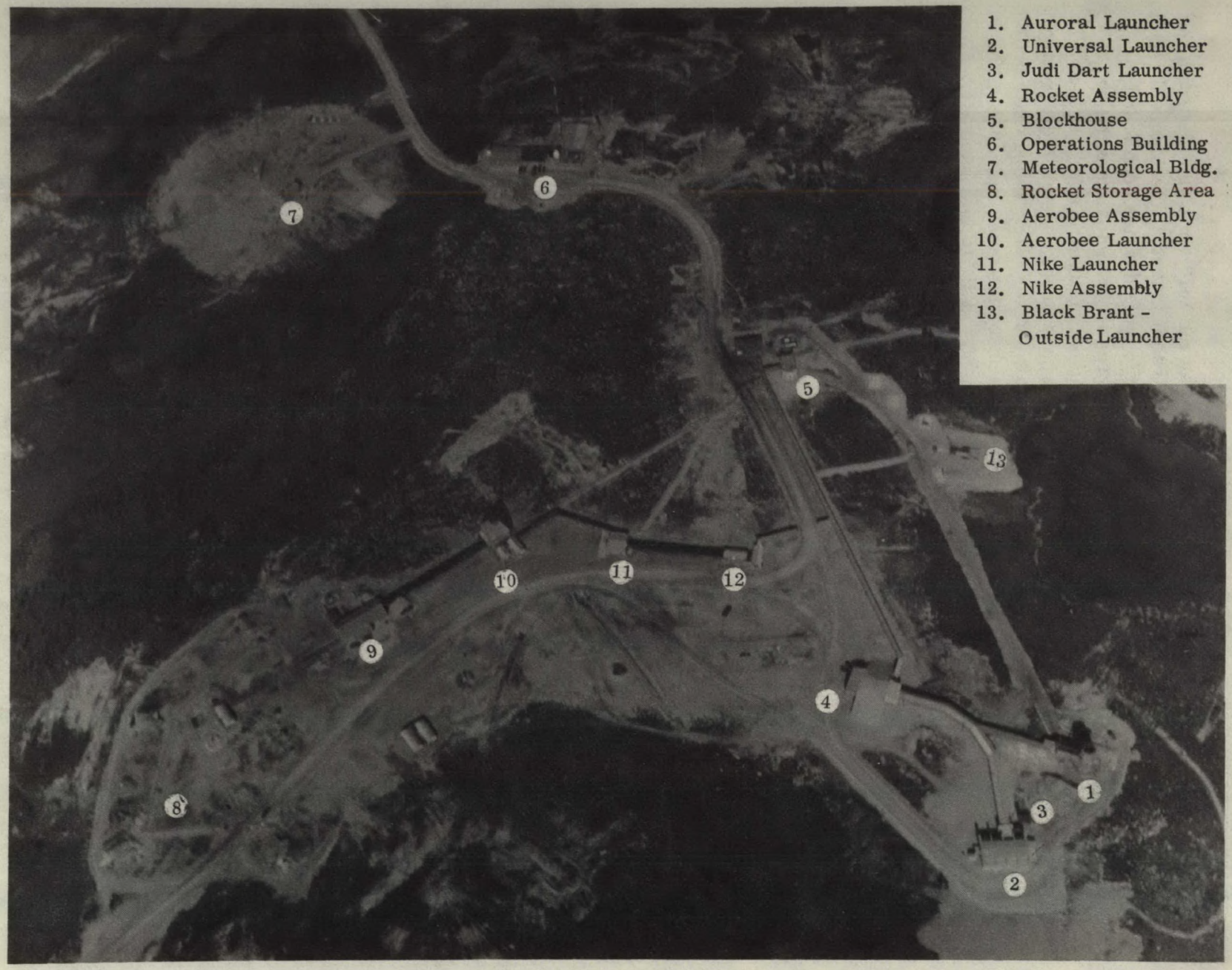
Daily measurements of the intensity of the 10.7 cm radio flux from the sun and any unusual variations in this intensity are measured at the Algonquin Radio Observatory, Lake Traverse, Ontario. This radio emission has been found to accompany the X-rays, ultra-violet light and energetic particles from the sun, which are the major factors in the space environment of planet Earth. In view of this close relationship, solar radio observations have proven useful in describing the solar condition for the operation of spacecraft and for determining that portion of the ionization of the earth's upper atmosphere under the solar influence. The radio information from the observatory is contributed daily to the Space Disturbance Center in Boulder, Colorado, and the measurement of the radio flux at 17:00 U.T. appears in their daily forecast of solar weather conditions as the Ottawa 10.7 cm flux. The basic data are also available in daily URSI grams. The continuous nature of the watch of solar conditions, as well as the complexity of the solar phenomena, requires co-operation among various observatories on earth. The lack of 10.7 cm solar noise observations between stations on the eartern coast of North America and in Japan was met by the installation of equipment by the National Research Council at the Dominion Radio Astrophysical Observatory near Penticton, B.C. The observational material is collected in monthly reports and published in divisional reports at six-month intervals. These are entitled "Observations of Solar Flux at the Algonquin Radio Observatory on 2800 MHz and at the Dominion Radio Astrophysical Observatory on 2700 MHz". The issue for July-December, 1967 (Divisional Report ERB 780) contains details of the method of observing and selected bibliography.

The Astrophysics Branch has constructed and is operating at Algonquin Radio Observatory an E W array of 3 meter reflectors which produces high resolution fan beam scans of the solar surface. At this time of declining solar activity, the emission from individual sunspot regions can be studied during various stages of their evolution.

Optical Solar Patrol Telescope

The optical solar patrol telescope at the Ottawa River Solar Observatory is now in partial operation for high resolution studies of active solar regions. Preliminary photographic observations have been made with the H-Alpha system of this multiple refractor in which the major component is a 0.25 Å Zeiss narrow band filter fed by a 10 inch aperture objective lens. A minicomputer was installed in October, 1971, to trigger 35 mm cine cameras at accelerated rates during moments of good seeing sensed by an image monitor. The computer also controls the bandpass setting of the H-Alpha filter and performs auxiliary data logging functions.

CHURCHILL RESEARCH RANGE LAUNCH SITE



1. Auroral Launcher
2. Universal Launcher
3. Judi Dart Launcher
4. Rocket Assembly
5. Blockhouse
6. Operations Building
7. Meteorological Bldg.
8. Rocket Storage Area
9. Aerobee Assembly
10. Aerobee Launcher
11. Nike Launcher
12. Nike Assembly
13. Black Brant - Outside Launcher

Space Research Facilities Branch (SRFB)

General

The function of the Space Research Facilities Branch (SRFB) is to develop and provide facilities to meet the needs of the upper atmosphere and space research programs of Canadian scientists in universities and government agencies. At present, its work is primarily concentrated on the use of sounding rockets. The major launching site is the Churchill Research Range (CRR) in Manitoba. On 1 July 1970 the Range became a completely Canadian facility, which is operated for the benefit of both Canadian and foreign scientists. The Range has facilities for the launching of many types of sounding rockets and balloons carrying scientific experiments to investigate the earth's upper atmosphere. Associated ground-based instruments are available at CRR to study the aurora borealis by photographic and spectro-photometric methods. There is also, for occasional use, a small launching facility at Resolute in the Northwest Territories, and another temporary facility at East Quoddy, Nova Scotia, which was established for use during the solar eclipses of 1970 and 1972. The Branch also operates the Great Whale Geophysical Station at Poste-de-la-Baleine in Quebec, which records auroral and geophysical phenomena for Canadian and American scientists.

In the implementation of the sounding rocket program, the Branch is responsible for providing the vehicles and incorporating the scientific experiments into suitable payloads with associated telemetry and other devices. This work is carried out mainly by industrial contracts. The work of the Branch also includes the reduction of flight data to provide vehicle trajectory and attitude information to experimenters, and the provision, from the telemetered information recorded on magnetic tape, of data required by individual scientists in appropriate forms.

In the past the assessment of the merits of proposed experiments was made by the Scientific Evaluation Panel, a subcommittee of the Associate Committee on Space Research. The advisory role of the Associate Committee with respect to SRFB has now been assigned to the recently formed Canadian Sounding Rocket Planning Group (CSRPG). This group, in addition to considering the scientific aspect of the rocket program on the advice of its Scientific Evaluation Panel and approving proposals for experiments and allocating priorities, will recommend the undertaking of engineering developments and the updating of support facilities. The CSRPG will consider recommendations of its Scientific Evaluation and Engineering Panels and set out a program which the Branch will carry out within the limits of available resources.

Range Section

The Range Section is responsible for the administration and supervision of all NRC operated sounding rocket ranges. This involves liaison with foreign government agencies regarding their use of the range facilities. At present, there are three locations in use: The Churchill Research Range in Manitoba, an

expeditionary facility at Resolute, NWT, and a temporary launch facility at East Quoddy, Nova Scotia, An additional temporary launch site is being prepared at Gillam, Manitoba for a launching in 1972 to investigate an auroral sub-storm.

Although the Churchill Research Range is now staffed at a minimum level, it has the capability of launching more rockets than are entailed in the Canadian program. The surplus range capability is available at agreed costs to foreign government agencies on the basis of non-interference with the Canadian program. United States agencies making use of the CRR facilities include the U. S. Air Force Cambridge Research Laboratories (AFCRL), the Naval Research Laboratory (NRL), and NASA. Scientists from several American universities participate. To facilitate launch scheduling and financial arrangements, an NRC/NASA Working Group was established in January 1971 to implement the 1970 Canada/US agreement governing the support of US upper atmosphere research activities in Canada.

Canada also has an agreement with the Federal Republic of Germany which provides for the launching of rockets and the operation of a satellite tracking station at the Churchill Research Range.

Churchill Research Range (CRR)

In its new posture, depending on workload, this range is manned by 55 to 60 contractor personnel, and a resident staff of 4 NRC personnel. CRR can be used to launch all Canadian and most American sounding rockets. Determination of trajectories is done by tracking radars and payload data is recovered by the telemetry ground station. Manpower economies have been achieved by discontinuing some peripheral services such as remote out-stations, the aircraft section and the removal of the resident scientific staff. Additionally, operational efficiency was enhanced by moving essential support services from Fort Churchill to the launch site.

The Range now has the capability of launching 30 to 35 major sounding rockets per year, and of supporting a continuing meteorlogical rocket program for the Atmospheric Environmental Services and the World Meteorological Rocket network. Details of Range facilities and services are contained in the July 1970 edition of the "Handbook for Range Users, Churchill Research Range", which is provided for the use of scientists using or contemplating the use of CRR facilities.

Resolute - Northwest Territories

During 1966, a requirement to launch scientific payloads in a region not influenced by the Van Allen Belt led to the establishment of a temporary launching facility at Resolute Bay, NWT. With the exception of 1970 - 71 Canadian launchings of Black Brant III rockets have taken place at this site yearly since its activation. NASA, under an agreement with NRC, conducted launchings of Boosted ARCAS rockets at Resolute during 1967, 1968 and 1969.

Although Canada has no plans for a rocket program for Resolute in 1971-72, NRC is sponsoring NASA launchings of Black Brant IIIB rockets during September/ October 1971 and April/May 1972. These launchings are connected with the sub-satellites in the Apollo 15 and 16 programs and will provide complementary information with sounding rockets during the times when the sub-satellites are operating. The scientific objectives are concerned with the entry of charged particles into the magnetosphere and, thence, with the fundamental problem of magnetosphere convection.

NRC support is limited to the provision of existing facilities, co-ordination of services, and support from agencies at Resolute. An NRC representative acts as project co-ordinator and range safety officer during operational periods.

The first and second rockets were launched on 4 and 5 September 1971. These rockets carried magnetic experiments for the University of California and Goddard Space Flight Center for the purpose of correlating measurements with similar experiments carried in the sub-satellite. The specified launch times were met and the scientific objectives were achieved.

East Quoddy, Nova Scotia

In 1969 a temporary rocket launching site was established at East Quoddy, Nova Scotia to provide a facility for studying upper atmosphere phenomena associated with solar eclipses. The site was located at East Quoddy because of its proximity to the intersection of the paths of two total solar eclipses, one in 1970 and the other in 1972. On 7 March 1970 four Black Brant III rockets were launched from this site, prior to and during the eclipse. These rockets were instrumented to make measurements of the D region ionization and of the sun's radiation in the x-ray and Lyman alpha segments of the spectrum. During the eclipse of 10 July 1972, these experiments will be repeated to obtain comparative data. The day of the 1970 eclipse was marked by unusually strong solar activity with numerous "hot spots". If normally quiet solar conditions prevail in July 1972, a valuable comparison with the 1970 data will be possible.

Gillam, Manitoba

In December 1970, the Branch received a proposal from a group of Canadian scientists for the launching of three scientific sounding rockets to study the breakup phase of an auroral sub-storm. These rockets would be launched in January 1972. To make measurements over as wide a latitude spread as possible two of the rockets would be launched from Churchill Research Range - one in a northerly and one in a southerly direction. The third would have to be launched from an off-range location near the southern edge of the auroral zone. The latter requirement led to the selection of Gillam as the location for the temporary launch site. In July 1971, authority to use an expanded CRR impact area for this purpose was obtained from the Manitoba Government and the preparation of the temporary launch site was undertaken.

Skylab Tracking Station, Pouch Cove, Newfoundland

Negotiations are underway between Canada and the United States to establish a tracking station in Newfoundland to assist in the support of the United States "SKYLAB" project. The station will be located at the site of the former STADAN station near St. John's. NASA and NRC are named as the co-operating national agencies. NASA will install and operate the station, and NRC will co-ordinate Canadian involvement and will arrange for site construction.

Rocket Systems Section

The Rocket Systems Section is an amalgamation of the former Research Support Section and the Data and Reports Section. It is concerned with the provision of rocket payloads and rockets to meet the requirements of Canadian experimenters and with the recording and distribution of processed telemetered data and other pertinent information.

At time of writing, 18 rocket payloads are in various stages of planning and manufacture. Nine of these are intended for launching from CRR during the 1971-72 winter auroral season. The largest number of Canadian rockets to be launched on a single day is planned for 10 July 1972. A total of 8 rockets, 4 at CRR and 4 at East Quoddy, will be employed to take advantage of the total solar eclipse to investigate the effects on the upper atmosphere of the sudden shielding from the sun's radiation.

Proposals for scientific experiments to be carried in the 1972-73 auroral season were submitted by the end of August 1971. The CSRPG and its panels have the task of evaluating these and deciding on the content of the continuing rocket program. Among innovations which may be considered are recovery of payloads from water and the provision of accurate pointing systems for certain experiments.

Development of an improved design for the deployment of clamshell nosecone fairings is in process at Bristol Aerospace (1968) Limited, Winnipeg, Manitoba. The Space Engineering Division of the University of Saskatchewan has completed a Pulse Code Modulation telemetry system to serve the need of increasing PCM requirements.

An analogue to digital translation system capable of providing the experimenters with a digital record of their data in a form suitable for computer processing has been designed and built by the Data Systems Section of the Radio and Electrical Engineering Division of NRC. The equipment has now been transferred to The Churchill Research Range. In addition the CRR can digitize the analogue recorded radar data which results in a format which is suitable for smoothing, correction, and tabulation on the IBM-360 in Ottawa. Further expansion of the equipment will provide the facility to digitize PCM signals received from the rockets into computer-compatible formats.

As soon as possible after individual rocket flights, the Rocket Systems Section issues brief reports of rocket launchings in order to keep all interested scientists and engineers informed of the success of the various experiments. The participating scientists include the experimental results in papers submitted, to appropriate journals, for publication.

By December 1971, 60 publications had been written, which reported the launchings of 78 rockets sponsored by the National Research Council of Canada since the Space Research Facilities Branch was formed in April 1965. Included in these reports was the third edition of Space and Upper Atmosphere Research in Canada (SRFB 048) and a third bibliography of scientific papers resulting from the Canadian Upper Atmosphere Research Program (SRFB 049). At time of writing more than 500 scientific papers have been written as a result of this program.

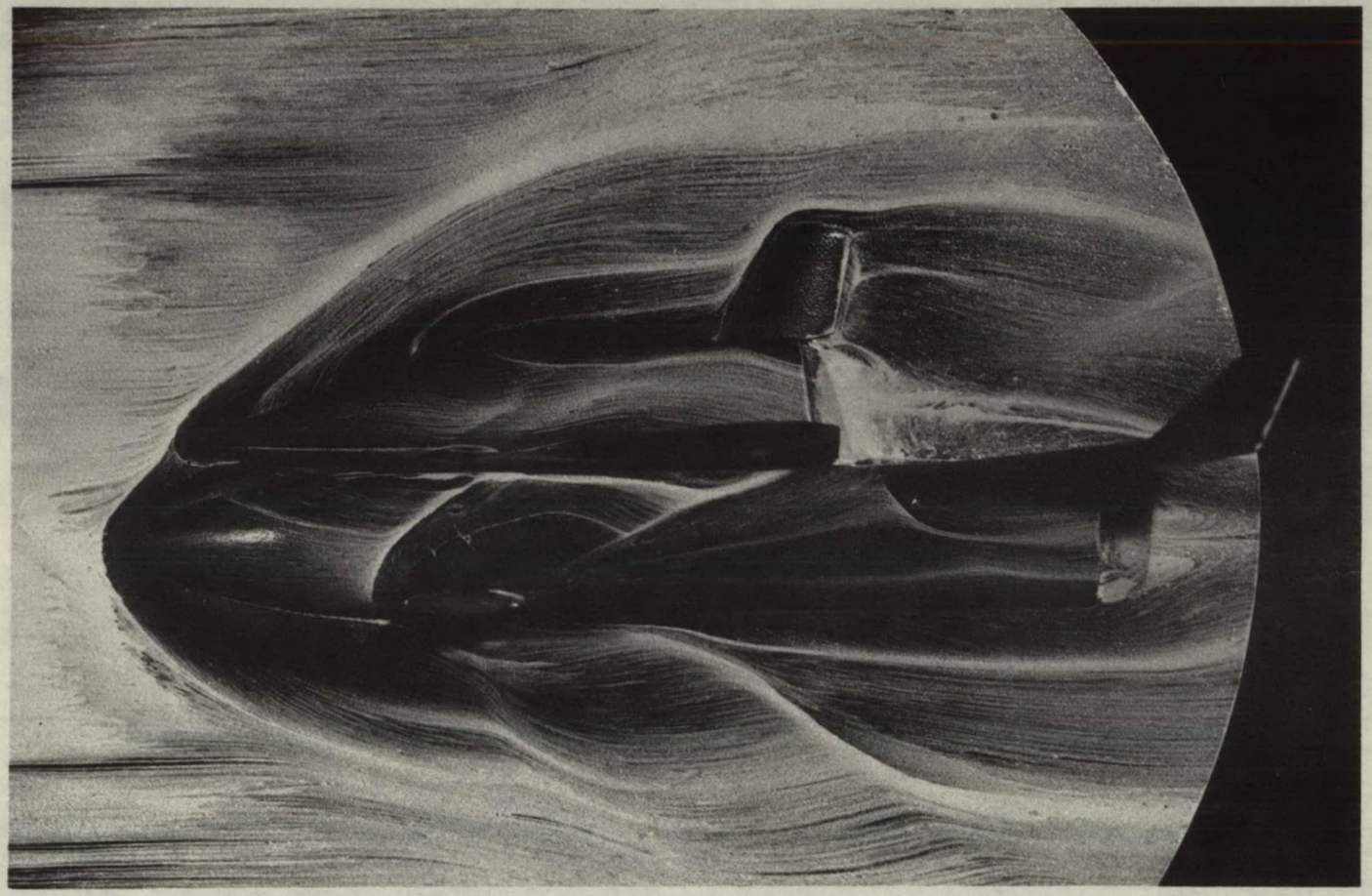
In addition, SRFB publishes yearly reports on space activities for the United Nations and the International Committee on Space Research (COSPAR).

Great Whale Geophysical Station

SRFB continues to operate the Great Whale Geophysical station at Poste-de-la-Baleine, Quebec, in close proximity to the seismic and geomagnetic recorders of the Department of Energy, Mines and Resources. At this station various physical quantities are recorded for Canadian and American scientists on a continuous basis. For the Radio and Electrical Engineering Division an auroral radar, two all-sky cameras and photometers record the different aspects of this phenomenon. For American scientists measurements are made of the ionospheric absorption of cosmic radio waves, the low and very low frequency atmospheric noise, and the micropulsations of the earth's magnetic field.

Great Whale was also one of the important ground stations in an international experiment involving a Scout rocket launched from Wallops Island, Virginia, which produced a cloud of barium vapour high (7 earth radii) above the equator. Visual and photographic recordings were made at key observatories in the United States and in South America. Both the permanent instruments at Great Whale and others specially installed provided data on the earth's magnetic field. Effective communications of the wide spread network of ground stations was maintained via the ATS 3 synchronous satellite. Analysis of the successfully received data is proceeding.

Mach 2 Surface Flow Visualization on the Launch Configuration of the Delta-Wing Space Shuttle Model in the NAE 30-Inch Wind Tunnel



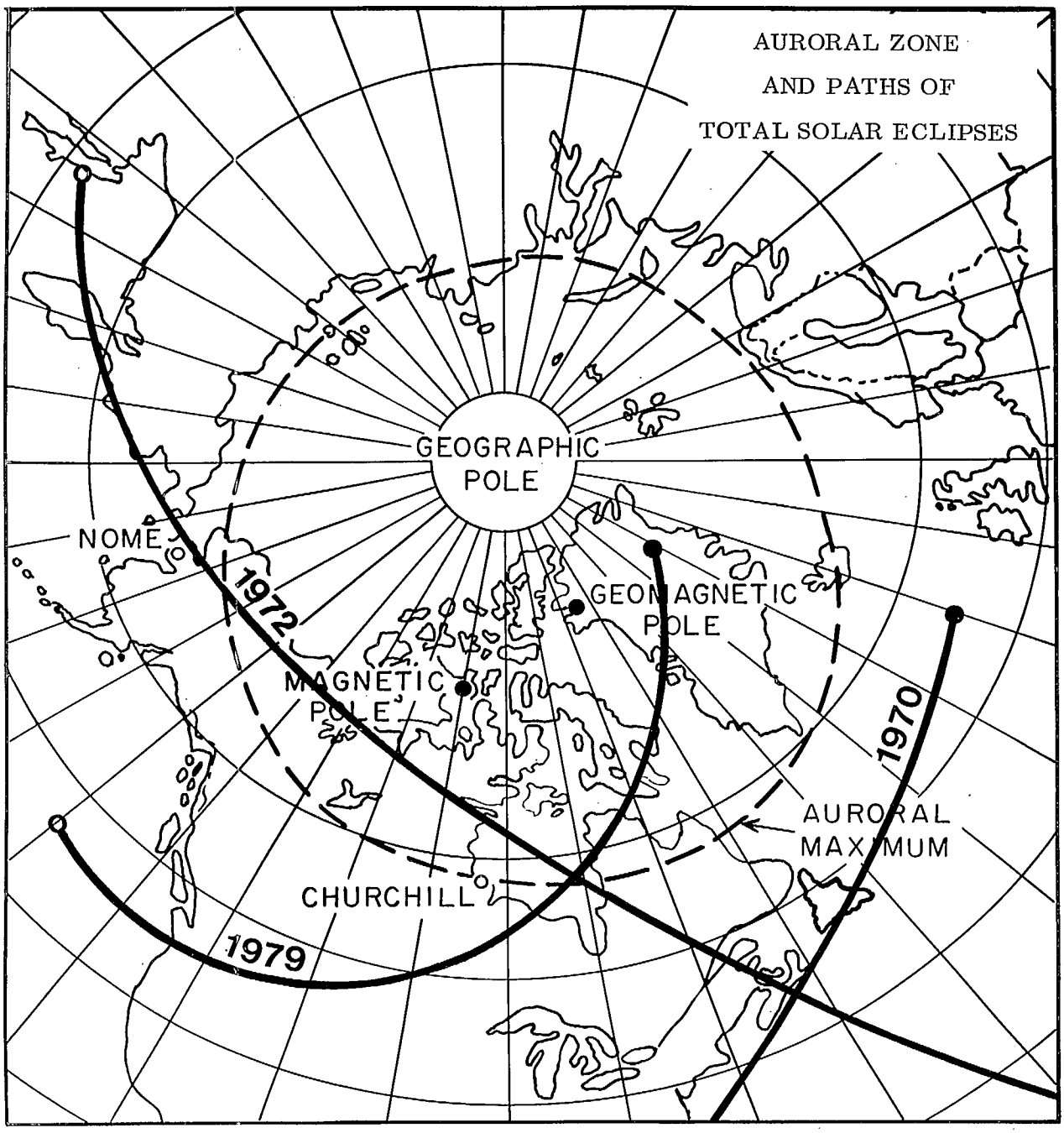
National Aeronautical Establishment (NAE)

Pending high-level decisions on Canadian participation in the post-Apollo research and development programme, technical contacts have been established between certain members of the ICS Sub-Committee on Space Vehicles and Propulsion, for which NAE is largely responsible, and the seven now existing NASA Working Groups on Space Shuttle. The contacts are particularly good in the field of Aerothermodynamics where a Canadian representative has been accredited to the pertinent US Working Group and where a small scale co-operative technical programme was undertaken on a trial basis. The programme consisted of a study of the dynamic stability of the shuttle spacecraft and involved a series of experiments in the NAE 30" x 16" supersonic wind tunnel, employing the special equipment for dynamic experiments available in that facility. Static and dynamic interference effects between the two components of the shuttle system during an abort separation were studied as well as the dynamic plume interference effect. The dynamic interference effects have been found to be large and in some situations quite important.

In the field of Structures and Materials, work has been continued on finite elements for structural analysis, including both development of new elements and application of finite element methods to dynamic problems. On the development side, two new computer codes bearing the names CURSHL and TRISHL have been produced. CURSHL is a program for a compatible triangular element for an arbitrarily-shaped thin shell. TRISHL is a program for a compatible triangular element for flat plates, shallow shells, and cylindrical shells. Both elements are so-called "high-precision" elements and have been shown to give excellent accuracy in numerous example problems. Finite elements for the analysis of steady creep have been developed. Large-deflection problems are being explored, and in this connection a survey of available methods for solving large non-linear equations has been carried out. On the applications side, high-precision elements have been used to study the vibrations of shallow spherical shells and integrally-stiffened panels, and the random response of integrally-stiffened panels. Finite element methods are currently being used in an analysis of stresses around holes in cylindrical shells. The potential of the finite element method for solving aircraft flutter problems which are amenable to two-dimensional aerodynamic theory, was demonstrated using as examples a square simply-supported panel in supersonic flow, and certain cantilever delta wings for which experimental flutter results were available.

NAE has functioned as monitoring and co-ordinating agency on two research programmes on the aerodynamics and flight dynamics of sounding rockets. The first one, which was sponsored by the Department of Defence Production, consisted of ballistic range experiments on the Black Brant V sounding rocket and was performed at Computing Devices of Canada. The second was a dynamic stability analysis of the Black Brant V sounding rocket, that was carried out by Bristol Aerospace Limited using partly a quasi-steady analysis of planar motion and partly a six-degree-of-freedom computer analysis. The results of these programmes were correlated in a couple of summary articles.

AURORAL ZONE AND PATHS OF TOTAL SOLAR ECLIPSES



DEPARTMENT OF EXTERNAL AFFAIRS

Scientific Relations and Environmental Problems Division
Legal Operations Division

United Nations Committee on the Peaceful Uses of Outer Space

During 1971, Canada participated actively in the work of the Outer Space Committee (which held its resumed 14th session in New York from September 1 - 10) and its two Sub-Committees (the Scientific and Technical Sub-Committee met in New York from July 6 - 15, and the Legal Sub-Committee in Geneva from June 7 - July 2).

The most important development on the scientific and technical side was the decision of the Scientific and Technical Sub-Committee to establish a Working Group on Remote Sensing of the Earth by Satellites. The Working Group held its first organizational meeting in New York on September 9 and elected Mr. Franco Fiorio (Italy) as its Chairman. The Canadian representative was Dr. A. F. Gregory, Consultant, Remote Sensing Centre, Department of Energy, Mines and Resources. The Working Group will begin its substantive work in 1972 once the results are available from experiments such as the launching of the USA Earth Resources Technology Satellite, ERTS-A, which will test the feasibility of remote sensing of the earth from space platforms.

The most important development on the legal side was the endorsation by the United Nations General Assembly, on the recommendation of the Outer Space Committee, of the Convention on International Liability for Damage caused by Space Objects. The Convention will now be open for signature and ratification and will enter into force on the deposit of the fifth instrument of ratification. Canada, Iran, Japan and Sweden were the only countries who abstained in the vote endorsing the Convention. These countries took the view that the Convention is not sufficiently "victim-oriented" as it does not refer specifically to the law of the place where the damage occurs as the applicable law to determine the measure of compensation, and does not provide for binding arbitration in the event that the states directly concerned cannot reach agreement on responsibility for damage and the amount of compensation. These features were not included in the "compromise package" agreed to between the USA and USSR at the June session of the Legal Sub-Committee.

Most countries, while willing to endorse the Convention on the grounds that it was the best compromise achievable, would have preferred arbitration awards to be binding rather than merely recommendatory. Accordingly, Canada proposed in the General Assembly's First Committee that states consider making declarations, when they sign or ratify the Convention, to accept arbitration decisions as binding vis-a-vis any other state which makes a reciprocal declaration. This option was incorporated in the General Assembly's resolution endorsing the Convention.

The two main priorities for the Legal Sub-Committee's 1972 work programme will be the registration of objects launched into space and questions relating to the moon (including consideration of the draft treaty concerning the moon submitted by the USSR to the 1971 session of the General Assembly). The Canadian representatives in the Outer Space Committee and the General Assembly's First Committee announced that Canada intends to submit a draft registration convention for consideration by the Legal Sub-Committee in 1972.

THE INTERDEPARTMENTAL COMMITTEE ON SPACE (ICS)

The formation of an Interdepartmental Committee on Space was announced in January 1970. The committee was established to meet a need for improved co-ordination of the planning, the optimum use of resources and the balance of development of all federal government space activities.

Membership of the committee is made up of senior officials representing:

Department of Communications
Department of Energy, Mines and Resources
Department of External Affairs
Department of Industry, Trade and Commerce
Ministry of Transport
Defence Research Board
National Research Council of Canada.

Observer status is accorded to representatives of:

Ministry of State for Science and Technology
Treasury Board Secretariat.

TELESAT CANADA

Telesat Canada, the Canadian company charged with the responsibility of establishing and maintaining the world's first domestic satellite communications system using synchronous satellites, marked the second year of its existence in September 1971.

During the year, the company executed the remaining major contracts for the implementation of its initial system. The Spacecraft Contract was awarded to the Hughes Aircraft Company of California in 1970. Northern Electric Co. Ltd., of Montreal and SPAR Aerospace Products Ltd., Toronto are major Canadian subcontractors.

Telesat's schedule calls for the launching of the first of its three satellites in late 1972 and the beginning of commercial operations early in January of 1973, with a base line system of some 35 earth stations across the length and breadth of Canada.

Construction of the building for the Heavy Route station at Allan Park, Ontario began in July and was ready for occupancy by the end of 1971. The Allan Park station is a Heavy Route communications station and the master station in the system. It includes the telemetry, tracking and command station which will monitor the systems in the satellite, and through which the satellite will be maintained on station. The second Heavy Route station is located at Lake Cowichan, on Vancouver Island and was ready for occupancy in December of 1971.

In June, three contracts, worth a total of approximately $16 million, were issued for the equipment for all the earth stations in the initial base line system with which the company will go into commercial operations. RCA Limited, of Ste. Anne de Bellevue will supply the antenna and associate electronic components for the two Heavy Route stations and will build six Network Television (NTV) Earth Stations across the country and two Northern Telecommunications (NTC) Earth Stations at Frobisher Bay and Resolute in the far North. The RCA Contract is valued at approximately $11 million.

Raytheon of Canada, at Waterloo, Ontario, was awarded a $3.2 million contract to build 24 Remote Television (RTV) stations in the initial system. The RTV stations will permit the reception of live CBC Network Television in areas previously served by airlifted videotape recordings or not served at all.

The Telemetry, Tracking and Command (TT&C) station co-located with the Allan Park Heavy Route station will be supplied by Philco-Ford Corporation of Canada, of Toronto, at a cost of $1.8 million. Canadian content in all the contracts, save that with Philco-Ford, is in excess of 60 per cent. Much of the equipment required for the TT&C station is unavailable in Canada.

TELESAT TELEMETRY, TRACKING AND COMMAND EARTH STATION

Pictured here is a scale model of the Telemetry, Tracking and Command (TT&C) earth station being designed and built for Telesat Canada by Philco-Ford, of Canada. The $1.8 million station will be located at the site of Telesat's master earth station at Allan Park, Ontario, 90 miles northwest of Toronto. The 50-ton structure stands 56 feet high, and is topped by a 36-foot-diameter, shaped antenna. An electric heating system will prevent the accumulation of ice and snow, and the antenna is built to withstand winds up to 120 mph. The dish can be elevated from the horizon through 90 degrees and rotated in azimuth through 360 degrees. The station will transmit command and ranging signals to the satellite and receive ranging and telemetry signals from it, enabling Telesat to monitor and control the condition and position of the satellite.

Initial site preparation and foundation work began on the NTC and RTV station locations and at most of the RTV stations. The antennas and ancillary electronic equipment will be installed during the summer and fall of 1972.

SPAR Aerospace Products Ltd. delivered the first flight hardware, the spacecraft structure in August, and the remaining two structures were delivered to Hughes Aircraft before year's end.

On completion of its new plant at Lucerne, Quebec, Northern Electric Company began construction of the satellite's electronics package, including the communications sub-systems, telemetry and command, and antenna despin electronics. First performance tests of the satellite communications equipment are expected in late December 1971.

At Hughes Aircraft Company in California, the prototype model for the satellite successfully underwent vibration tests and the first test firings of the apogee motor were successfully carried out. Delivery of the first flight spacecraft is scheduled for October 1972.

Telesat reached agreement with National Aeronautics and Space Administration (NASA) and a contract was signed in late spring under which NASA will provide launching services for Telesat.

Development of the configuration of the thrust-augmented, Thor-Delta Launch Vehicle to be used by Telesat is underway. The 116-foot, 94-ton rocket to be used to carry Anik into orbit will have a redesigned shroud and will carry a cluster of nine, strap-on, solid propellant boosters on the first stage.

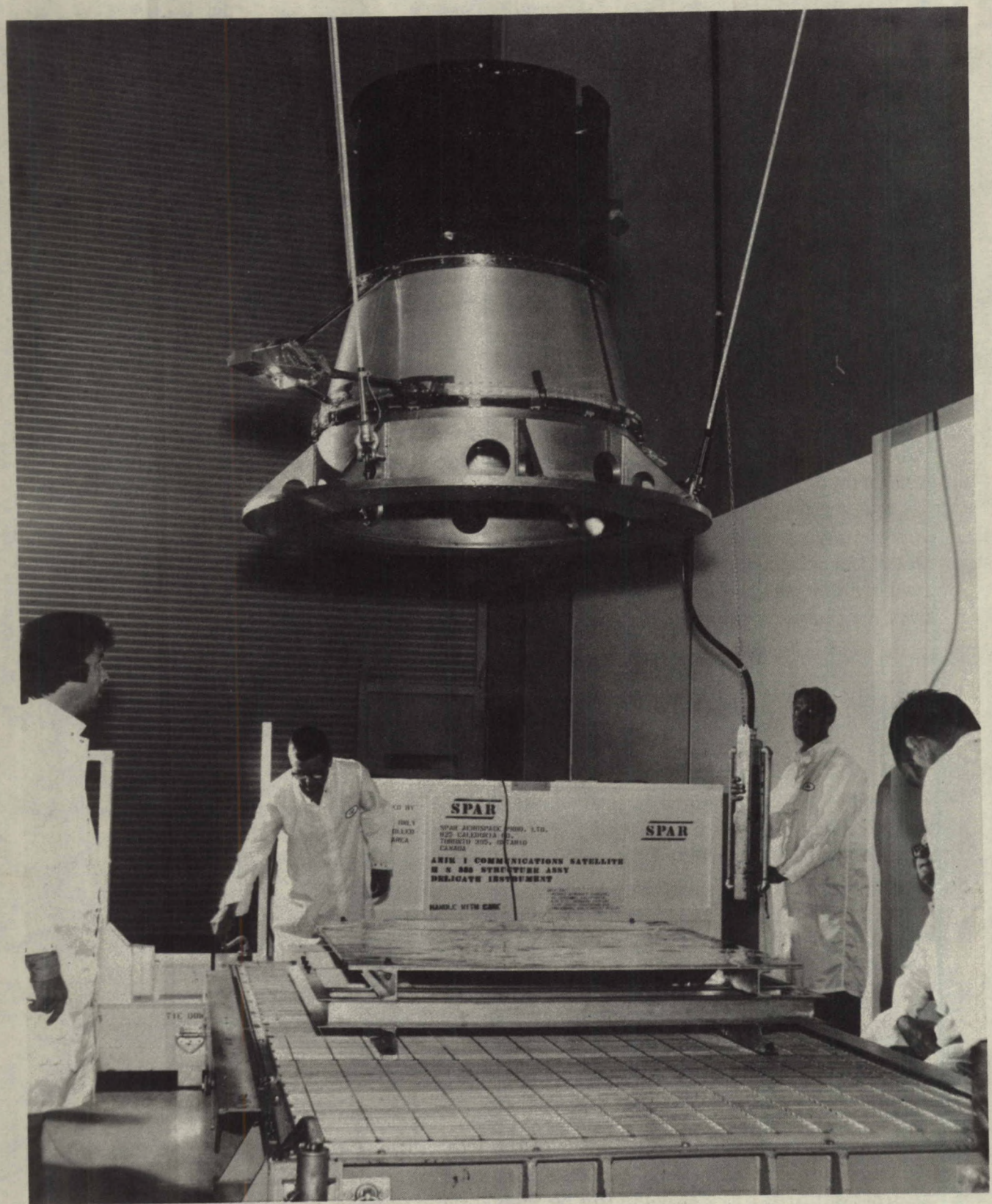
The Corporation also entered into a contract with Hughes Aircraft whereby Hughes will lease a portable tracking station, install and operate it on Guam in the Pacific. The station will be used to provide tracking services in the Eastern hemisphere during transfer orbit operations.

At Telesat's headquarters in Vanier, Ontario, the Corporation will shortly begin equipping its master control centre from which all satellite operations will be directed.

The Corporation is currently working with Bell Canada, CN-CP Telecommunications, the CBC and the Department of Communications studying the feasibility of establishing a system of Thin-Route Satellite Communications to provide low-density long distance telephone service and radio program service for a number of very small communities in Northern Ontario and Quebec, Labrador and the Territories. Construction of two such Thin-Route Earth Stations is expected early in 1973, with the possibility of building an additional 15 within a two year period.

Service contracts with the CBC, Trans-Canada Telephone System, CN-CP Telecommunications and Bell Canada for 8 of the 10 available channels on the first satellite, are expected to be signed by the end of 1971. At the same time, discussions have been held with a number of other potential customer organizations.

ANIK 1 STRUCTURE



INTERNATIONAL SATELLITE COMMUNICATIONS

The Canadian Overseas Telecommunication Corporation is constructing a new fully commercial satellite communication earth station at a site near Lake Cowichan on Vancouver Island. The new station which has a 100-ft. diameter fully steerable antenna is scheduled to commence operation via the INTELSAT IV satellite over the Pacific Ocean in mid-1972.

The Lake Cowichan Earth Station is being equipped for simultaneous reception of 10 frequency-modulated carriers located anywhere in the band 3.7 to 4.2 GHz and for simultaneous transmission of 3 frequency-modulated carriers in the band 5.925 to 6.425 GHz, including facilities for the transmission and reception of a television video channel.

On the East Coast of Canada, the Mill Village Earth Station complex has been providing direct communication via earth stations in the United Kingdom, France, Greece, Italy and Spain and new direct communication routes are planned for implementation via earth stations in Jamaica, Trinidad and Germany before the end of 1971.

The capability of the Mill Village No. 2 Earth Station has been expanded to afford an overall capability for the simultaneous reception of 14 RF carriers and transmission of up to 4 multi-destination RF carriers, all with frequency modulation. Additional facilities are also being installed for the transmission and reception of 12 pairs of PCM/PSK single channel RF carriers on a "demand assigned" basis. This latter facility has expansion capability to accommodate up to 60 pairs of "demand assigned" carriers in future.

LUNAR MATERIAL STUDIES

Several Canadian scientists are involved in research into the properties of lunar glass, moon rocks and dust which have been brought to earth by recent Apollo missions. Groups conducting this research include the universities of Toronto and Western Ontario, the Department of Energy, Mines and Resources, (the Geological Survey of Canada), and the National Research Council (Atlantic Research Laboratory) in Halifax, N.S.

The National Research Council of Canada in Ottawa acts as the co-ordinating authority for Canadian Agencies studying moon material.

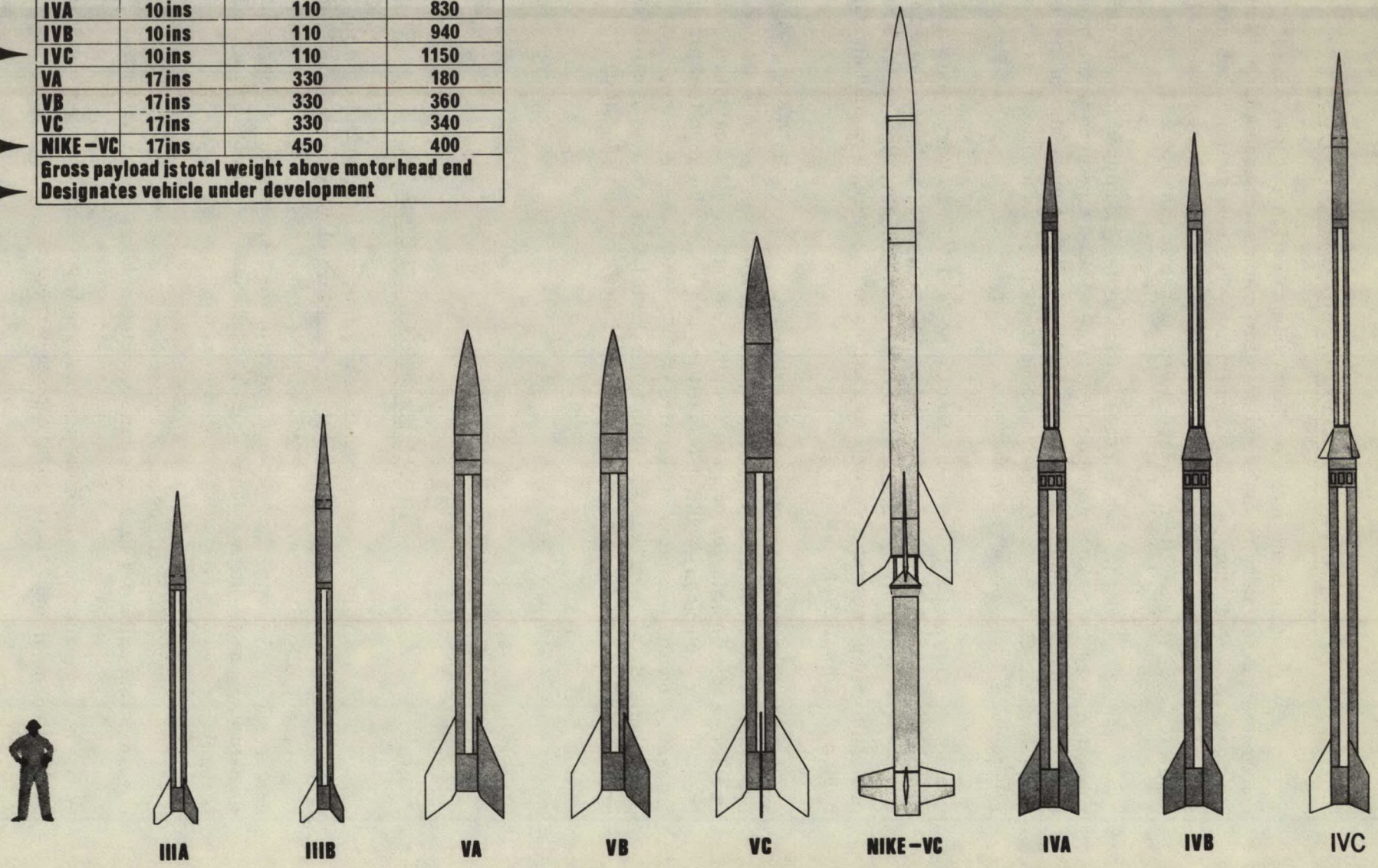
Further details of these studies will be found elsewhere in this publication under the title of the group concerned.

BLACK BRANT ROCKET SYSTEMS

VEHICLE	PAYLOAD DIAMETER	NOMINAL GROSS PAYLOAD (lbs)	ALTITUDE KILOMETERS
IIIA	10 ins	110	165
IIIB	10 ins	110	235
IVA	10 ins	110	830
IVB	10 ins	110	940
➤ IVC	10 ins	110	1150
VA	17 ins	330	180
VB	17 ins	330	360
VC	17 ins	330	340
➤ NIKE–VC	17 ins	450	400

➤ Designates vehicle under development

Gross payload is total weight above motor head end



ACTIVITIES IN INDUSTRY

BRISTOL AEROSPACE (1968) LIMITED, WINNIPEG, MANITOBA

Bristol Aerospace manufactures the family of solid propellant high altitude research rockets called Black Brants. These rockets have been developed over a period of 10 years and seven different models are now flight proven and available for scientific usage.

In addition to the production of rocket vehicles, Bristol also produces a complete line of airborne telemetry equipment, ancillary systems such as parachute recovery, payload separation, and despin as well as conical and ogival split nose fairings. Payload integration, checkout and environmental testing is carried out in the facilities of the Rocket and Space Division. Experienced range crews are available to provide field services for payload and vehicle systems.

During 1971 a new vehicle, designated the BB VC, was successfully flight tested. This vehicle is a four fin variant of the well proven BB VB and was developed in order to make it compatible with the Aerobee 150/350 towers at Wallops Island, Virginia and White Sands Missile Range, New Mexico. The vehicle is equipped with rubbing strips for tower operation or, if desired, the rubbing strips may be replaced by launch lugs allowing the vehicle to be launched in an underslung position from a rail launcher. Two flights have been carried out to date (October 1971); the first being rail-launched from Churchill Research Range, and the second tower-launched from Wallops Island.

Several attitude control systems are available for use on all models of the Black Brants. These provide two or three axis stabilization as well as solar and stellar capabilities.

Further Black Brant developments taking place are as follows:

1) Engineering evaluation is being carried out on Nike boosted versions of the Black Brant IIIB and VC. Performance of these vehicles is calculated to be 75 kg. to 460 km. and 204 kg. to 400 km. respectively. First flight of the Nike IIIB is scheduled for late 1972.

2) In the design concept is a new member of the Black Brant IV series, designated the Black Brant IVC. This vehicle will use the flight proven Black Brant IIIB motor as a second stage and the first stage will be the Black Brant VB motor having a modified propellant grain geometry to achieve high launch acceleration.

Fourteen Black Brant launches have been carried out to date in 1971. Included in these were two Black Brant IIIB rockets from Resolute Bay, Northwest Territories in support of the sub-satellite placed in lunar orbit by Apollo 15.

In July 1972 another National Research Council campaign of four Black Brant IIIA rockets from East Quoddy, Nova Scotia will take place during the total solar eclipse in that area.

A total of 203 Black Brants have been launched, comprised of the following:

Black Brant I	-	17
Black Brant II	-	52
Black Brant IIIA	-	44
Black Brant IIIB	-	8
Black Brant IVA	-	28
Black Brant IVB	-	2
Black Brant VA	-	21
Black Brant VB	-	29
Black Brant VC	-	2

Black Brants have proven themselves for their simplicity of launching and reliability. They are ideal for use from remote sites or ranges which possess only a minimum of support facilities. They have gained international recognition and have been used by scientific agencies in North America and Europe.

NORTHERN ELECTRIC COMPANY LIMITED

ANIK Satellite

The manufacture of the electronics portion of the ANIK Satellite is being carried on at the NORTHERN ELECTRIC Lucerne Centre near Ottawa. The first flight equipment will be assembled onto the electronics platform in December 1971. This equipment consists of the communication transmitters and receivers, the telemetry and command system, the antenna despin electronics, the power electronics and the batteries. In addition the "ground control electronics" required by TELESAT for control of the satellite from its Ottawa headquarters has been completed for testing and will be installed at the Allan Park and Lake Cowichan earth stations.

Sophisticated manufacturing and testing facilities were set up at the new Lucerne location. These consisted of "clean-room" assembly and test areas and special testing equipment to simulate vibration, temperature and vacuum encountered by communications satellites during launch and while in orbit.

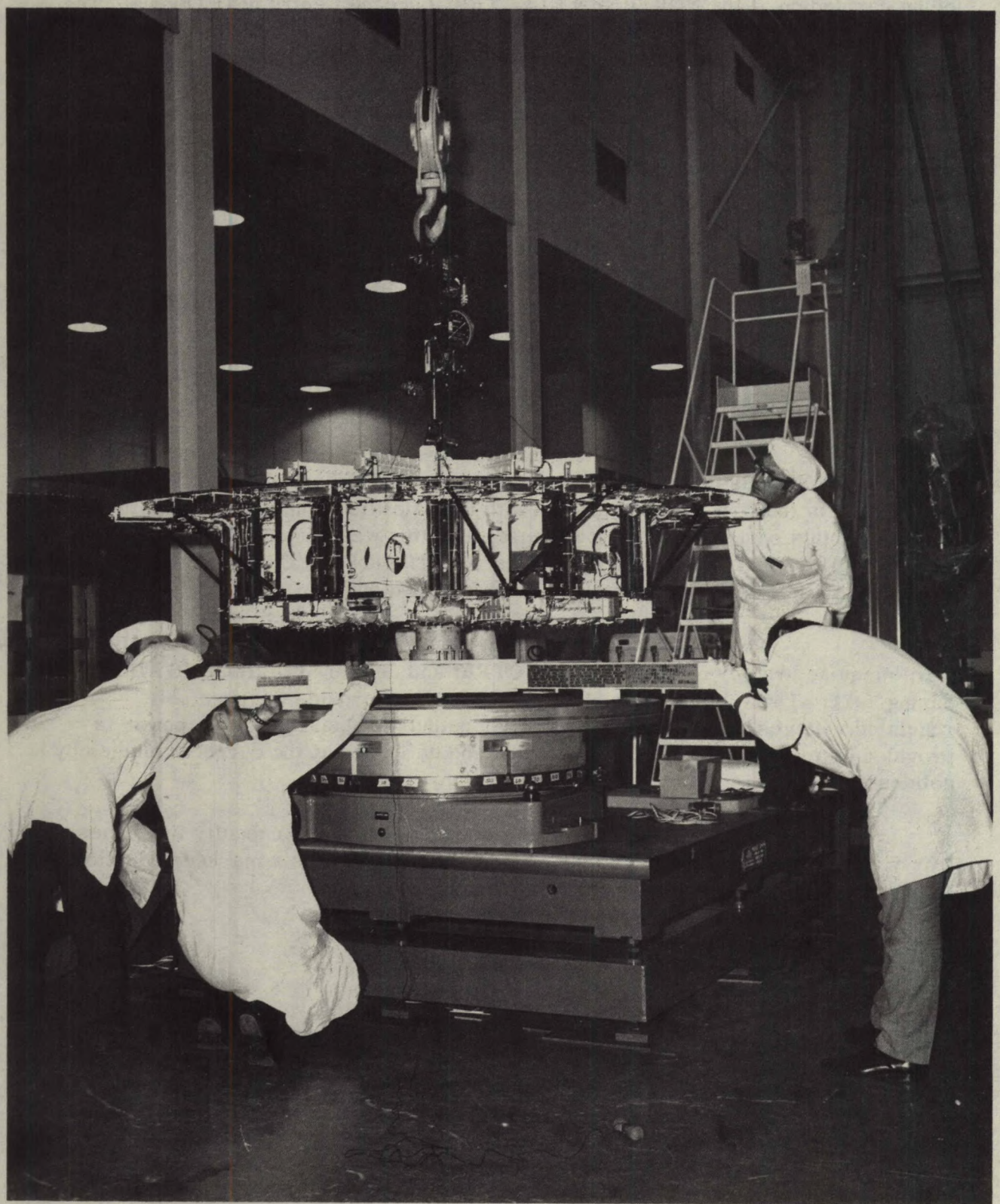
INTELSAT IV

The communications transmitters and receivers for one of the INTELSAT IV Series of Satellites were completed and delivered to BRITISH AIRCRAFT in the U.K. for integration into the satellite structure for the 4th satellite of this series. The first of these satellites was launched successfully by HUGHES AIRCRAFT in January 1971. The NORTHERN ELECTRIC communications equipment will be on board a satellite to be launched early in 1972.

Electronic power conditioners for three INTELSAT IV satellites were manufactured by NORTHERN ELECTRIC and delivered to HUGHES AIRCRAFT during 1971. These lightweight highly efficient units provide the precisely regulated voltages for the microwave power output TWT stages. This power is provided by the onboard satellite batteries and delivered at the correct voltages by solid-state inverters and regulators.

The INTELSAT IV Series of Satellites have a capacity five times that of those in the preceding series. This capacity provides a marked reduction in long distance satellite communications costs.

The Transponder for the INTELSAT IV F 4 Satellite manufactured by NORTHERN ELECTRIC COMPANY LIMITED is shown here being unpacked ready for integration into the Satellite by BRITISH AIRCRAFT CORPORATION in Bristol, England, under contract from HUGHES AIRCRAFT COMPANY of California



BELL-NORTHERN RESEARCH

Headquartered at its main laboratories in Ottawa and integrating additional research and development centres in six other Canadian locations, Bell-Northern Research has a budget of $36 million, a figure which ranks the enterprise as the largest industrial research organization in Canada and among the top one percent of research organizations in North America.

Achievement of corporate status on January 1, 1971 by the former Northern Electric Laboratories furthers a continuing development on the part of the telecommunications industry in general, and of Bell Canada and Northern Electric in particular, aimed at concentrating creative technology into indigenous Canadian design to meet Canadian needs. Equity in the new corporation is retained by the parent companies in the proportion of 51 percent Bell and 49 percent Northern.

Regional laboratories are located at Montreal and Lachine in Quebec; and at London, Bramalea, Belleville and Kanata in Ontario. Space and satellite research at Bell-Northern Research is concentrated mainly on the communications aspect.

Systems Engineering

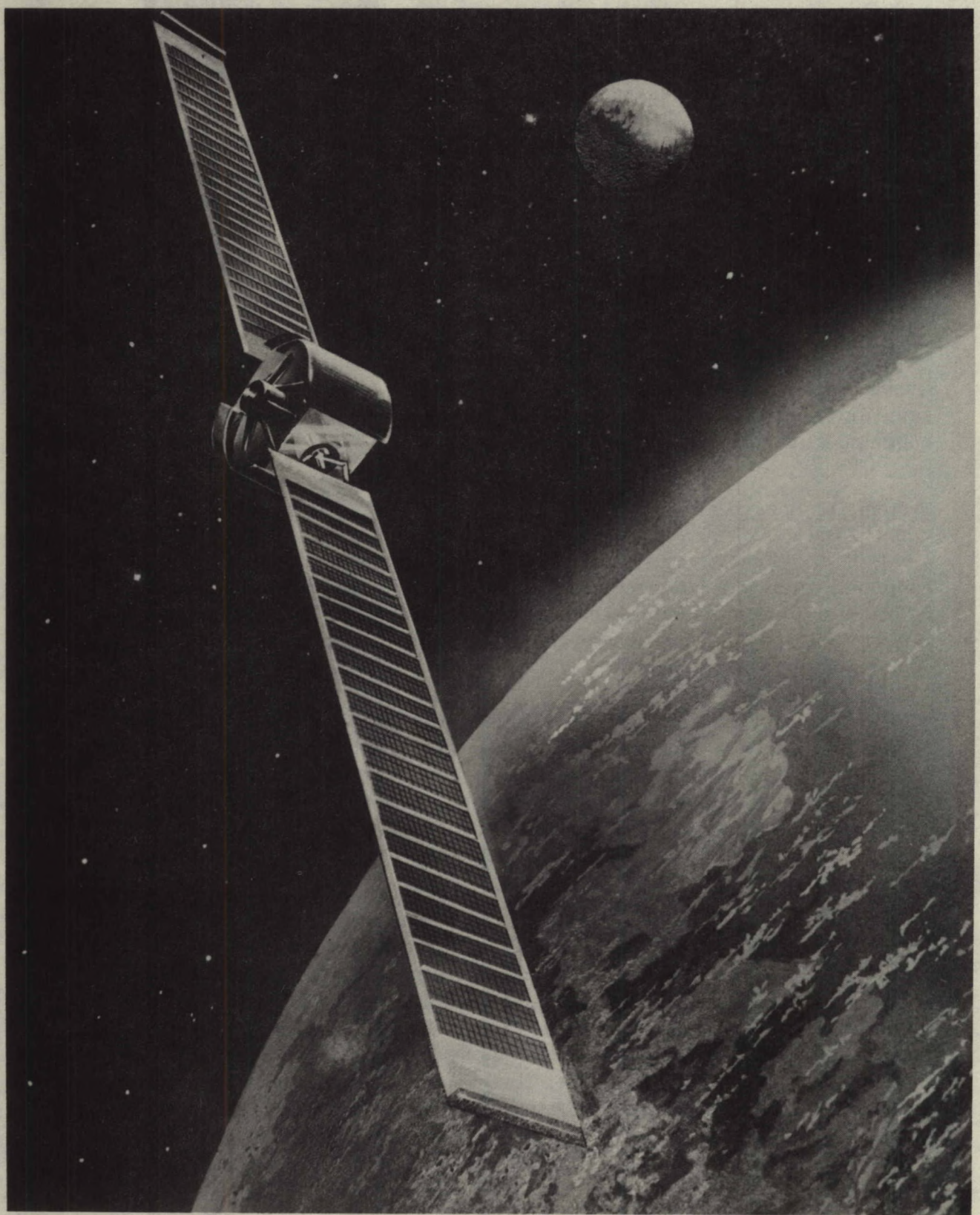
Continuing systems engineering studies related to aerospace communications are exploring such questions as the integration of satellite facilities into the Canadian telecommunications network. In addition, studies are in progress on communications by satellite to the far north and on digital communications by satellite.

At the end of 1971 systems engineering staff presented results of a systems study contract on super-high-frequency satellite communications to assistant deputy ministers and other senior members of the Department of Communications. The aim of the study was to evaluate the potential for satellite communications in the 12-18 GHz band in Canada, in the time frame 1977-1985 and to synthesize models of the communications systems.

Canadian Technology Satellite Project

A team from the Transmission Division was involved with the Communications Research Centre, Ottawa, in the project definition phase of the Communications Technology Satellite. The aim of this phase was to explore new technology which could be employed in this new generation of communications satellites. One of the team has been retained by CRC as a consultant on thermal design. One satellite is expected to be in operation in 1975, broadcasting television to small, scattered communities in Canada and linking them by two-way radio.

COMMUNICATIONS TECHNOLOGY SATELLITE (CTS)



Computer-Aided Design of Waveguide Filters

The company has extended its capability for computer-aided design and analysis of waveguide filters. The approach is based on an analysis program that automatically predicts the electrical performance of a cascade connection of waveguide obstacles. It is also applicable to multiport devices. This and associated programs provide a state-of-the-art capability in filter design to meet the demanding specifications for new microwave communication systems.

Terrestrial Microwave Radio

A new high-frequency microwave system has been developed to distribute the signals received from future Canadian satellite ground stations to main centres of population. The radio system, using the latest semiconductor technology, employs a different frequency spectrum from those presently assigned for satellite and earth station transmission in order to avoid interference. It will operate in the upper six band, employing frequencies from 6.425 to 6.590 GHz and 6.770 to 6.930 GHz.

Parametric Amplifier

To enchance the reliability and performance of communications satellite ground stations, a parametric amplifier which operates at room temperature has been developed. Featuring a 500 MHz bandwidth in the 3.7 to 4.2 GHz range, the amplifier is fully solid state. Low noise performance has been improved to 100°K with a gain of 30 db through a three-stage cascaded paramp. It achieves this performance without the use of mutiple-tuned broad banding circuits which, together with its simple straightforward design, enhances the system availability and complies well with the unattended operation philosophy of modern earth stations.

Common Waveguide Multiplexer

This multiplexer uses a new technique to simplify construction and tuning while also reducing the overall weight and size of complex microwave components used in the transponder portion of communications satellites. The heart of the new 3.7 to 4.2 GHz multiplexer is a complex filter which is a combination bandpass and bandstop design. The complex filter portion of the multiplexer is extremely versatile since the component blocks can be tuned independently and physically separated without affecting their electrical performance. This latter feature provides mechanical flexibility in the design and layout of the communications platform of the spacecraft.

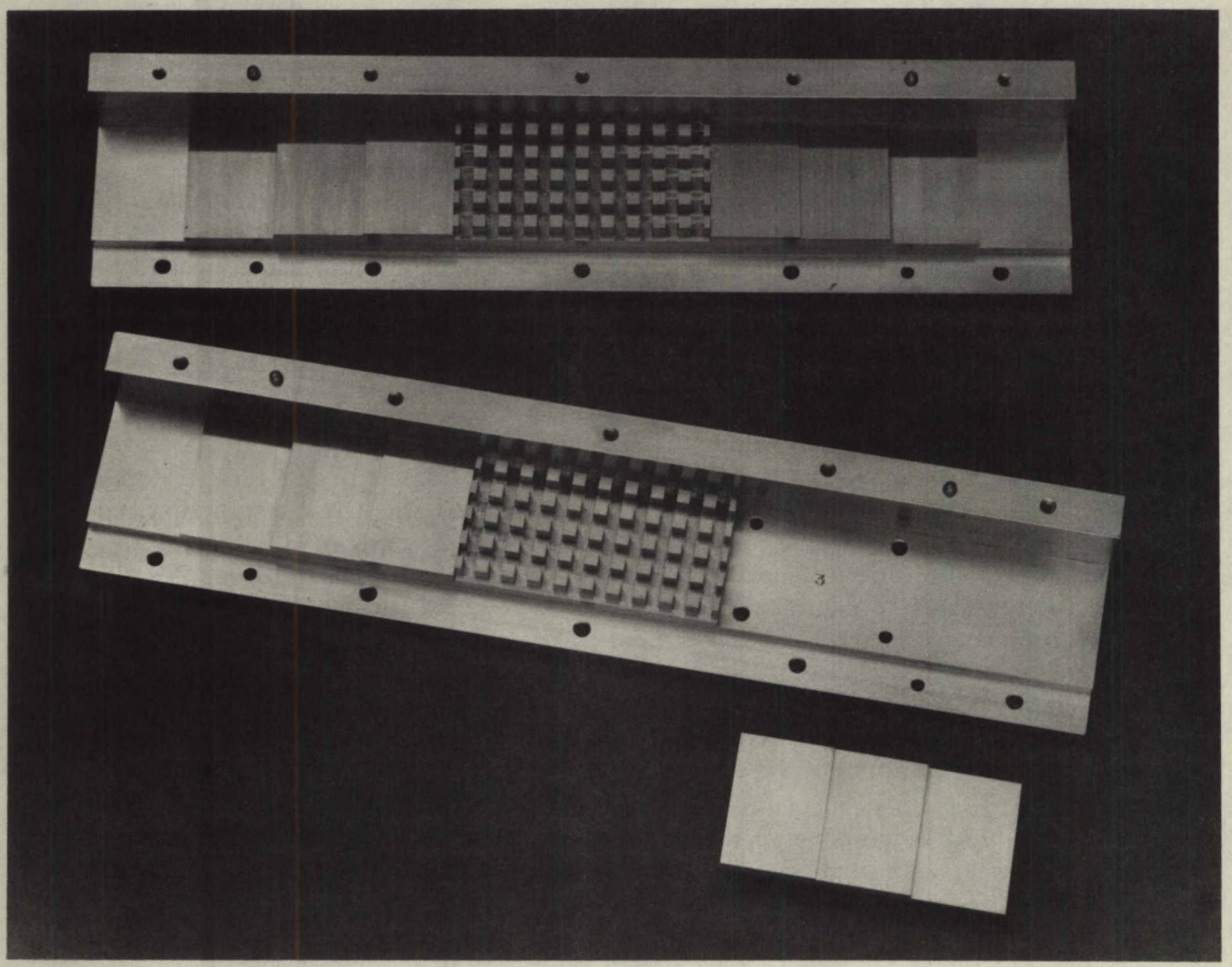
Although developed primarily for satellite transponder use, the new technique can be used in all systems where bandpass filters are required and will

find application in heavy route satellite earth stations where one common antenna is used for more than one transmitting channel.

Duplexer-Polarizer

A duplexer-polarizer for earth station antennas has been supplied for pilot program use for the proposed U.S. domestic satellite system, which could come into service in 1973, and for possible use with the Canadian domestic satellite system. The polarizer forms part of the earth station antenna and performs the function of combining and separating transmitters and receivers.

This 'waffle iron' waveguide filter, shown here disassembled, is one of the many types which can be designed using the computer-aided approach



SPACE RESEARCH AT RCA LIMITED, STE-ANNE-DE-BELLEVUE, QUEBEC

General

RCA has experience in space electronics extending from 1959 with over 49 programs fulfilled by the company since that time to a value of $79-million for 19 agencies in 12 countries -- $49-million for earth stations, $24-million for satellites, and $5-million for space electronic research.

The work has primarily been in the fields of earth stations and satellites. Additionally, RCA Research Laboratories in Montreal have discharged a large number of programs for the Canadian and U.S. governments and is the research base that enables the company's work in earth stations and satellites to meet changing world requirements.

Earth Stations

RCA experience in satellite earth stations began in 1959 with 6 successive contracts for Jet Propulsion Laboratory for investigation, study, development and supply of antenna feed systems for NASA's Deep Space Instrumental Facility in the Mojave Desert. This included work on the 210-foot diameter tracking facility. In succeeding years, over 26 other satellite earth station assignments have been performed.

Early earth station work included supply of equipment to NASA in 1963 for a network of stations involved in the RELAY and TELSTAR pioneer communication satellite systems. This was followed by design and supply of a 1200 channel AM/FM solid state receiving system for NASA's ATS experiment, in which the equipment was used at tracking stations at Rosman, N.C., Mojave, and Toowoomba, Australia.

Work on complete earth stations began in 1963 with the appointment of RCA as prime contractor for Canada's first satellite terminal at Mill Village, N.S. for commercial transatlantic service. Employing an 85 ft. diameter radome-enclosed antenna, this was one of the pioneer large earth stations, following ones established at Goonhilly, U.K., Andover, Plumeur Bodou, France, and Raisting in Germany. This station pioneered the use of cooled, wideband parametric amplifiers for earth stations.

In February 1969, RCA completed a second earth station at Mill Village, N.S. for Canadian Overseas Telecommunications Corporation to cater to expanding transatlantic satellite service. It has facilities for simultaneous reception of 22 multichannel RF carriers and transmission of 2 RF carriers, and employs a 97 ft. diameter exposed antenna with electrically heated surface panels to overcome effects of snow and ice.

In early 1971 RCA completed India's first satellite earth station at Arvi including a 120-mile microwave link from the station to the International Message Centre at Bombay.

In late 1971 RCA was completing the Karachi earth station of the 2-station requirement of the Government of Pakistan. Installation of the Chittagong station in East Pakistan was delayed pending resolution of the civil disturbances. The 2 Pakistan stations employ 30-meter diameter wheel-and-track antenna instead of the king post configuration.

In March 1971 RCA received a contract for an earth station at Cowichan Lake, B. C. from Canadian Overseas Telecommunication Corporation. Scheduled for completion in June '72 this station will handle Canada's trans-Pacific satellite service.

In June 1971 RCA won the award for 10 earth stations for Canada's domestic satellite communications system -- 2 heavy route stations at Cowichan Lake, B. C., and Allan Park, Ontario, employing 30-meter diameter wheel-and-track antennas, and 6 Network Television stations and 2 Northern Telecommunications stations both using 33 ft. diameter reflectors.

Additionally for the Canadian domestic satellite system, RCA is furnishing the feed and ground communications sybsystems to Philco-Ford for the telemetry-tracking-and-contral station at Allan Park.

With the 1971 orders received, RCA's earth station responsibilities extend to a total of 16 complete stations and with subsystems (ground communications and/or feed) in 12 theatres of the world -- Argentina, Australia, Brazil, Canada, France, Italy, Morocco, Panama, Phillipines, Thailand, U.S.A. and U.K.

RCA participated in NASA ATS-F program in 1971 by consignment to Hughes Aircraft of 3 ground communications subsystems for fitment into 3 30-foot diameter transportable terminals.

Satellites

RCA has maintained a Canadian industry leadership in the design and fabrication of unmanned spacecraft since 1961, when RCA Space Systems was selected to develop and supply the communications transponder system for the RELAY satellite, the first NASA satellite to provide transatlantic television service. The experience and organization developed on advance semiconductor device research were successfully used to furnish telemetry transmitters for Alouette 1 and for two NASA scientific satellites, Explorer XX and Pegasus.

In 1963 RCA was selected as the contractor to the Defence Research Board (now Communications Research Centre) responsible for

Canadian industry participation in the Alouette 11 program and, subsequently, as prime contractor, with full design, manufacture and test responsibility for the ISIS-I and ISIS-II satellites. ISIS-I has been in orbit since January 1969, and ISIS-II since April 1971.

In addition to its experience and achievements on equipment and services for scientific satellites, RCA Limited has performed basic and applied research studies on a wide variety of topics related to satellite design and application. Among these are included the Study for the Design of a Canadian Domestic Communications Satellite, completed in 1969 for the Canadian Department of Industry, and the work performed on the Project Definition Phase of the Telesat Canada Communications Satellite.

In 1971 RCA participated with Communications Research Centre of the Department of Communications in systems planning and program definition of the new Communications Technology Satellite -- a joint Canada/NASA project with satellite launch scheduled for 1974.

In 1971 RCA Limited was designated the skill centre within the RCA Corporation for all satellite transponder activity including research and forward development. In this capacity RCA Limited assisted its sister division, RCA Astro Electronics of Hightstown, N.J. in proposals for satellites for the planned U.S. domestic satellite systems.

New RCA Space Electronic Centre

RCA Limited moved to new facilities for aerospace earth stations and research work in 1971. The new facilities, located at Ste-Anne-de-Bellevue, 20 miles west of Montreal, provide clean air environment for assembly and test of aerospace and earth station equipment and include an extensive model shop equipped with numerical control machinery; an environmental laboratory; and laboratory areas for design and development. In addition to office areas for engineering, program management and general administration, the new RCA facility houses the company's Research Laboratories.

Research

Research related to space exploration and electronics has been conducted by the RCA Limited research labs for over 10 years. The knowledge and experience gained has been used in consultation and advisory services to several projects described above, particularly those related to satellites.

In the technological area, the Research Laboratories contributed the following: the telemetry transmitters for Alouette 1, the design of PCM encoders for ISIS-I, for ISIS-II the design and engineering models for the oxygen

red-line photometer (Dr. G. Shepherd) and the auroral scanning photometer (Dr. C.D. Anger) and the design and testing of a sealed-off CO_2 laser tube for space communications and laser radar. NASA has ordered samples of both glass and ceramic laser tubes for space evaluation.

In scientific areas, activities have covered a very wide spectrum. The Research Laboratories have obtained contracts from Canadian and United States government agencies for work on the following problems: the theoretical interpretation of the resonance relaxation spikes observed on Alouette ionograms, a theoretical and experimental investigation of the V x B sheaths surrounding the long Alouette antennas or a VLF long-antenna satellite transmitter, a laboratory simulation of the magnetosphere and investigation of the magneto-pause boundary, a study of the charging mechanisms and equilibrium potential of the proposed NASA outer planets explorer satellite, the accuracy of Langmuir probes on the NASA Atmosphere Explorer satellite, induced ionization produced by this satellite, experimental and theoretical studies of the impedance of a dipole antenna in a plasma, propagation of VLF and electrostatic whistler waves in the ionosphere, a large program to investigate the radar return from a turbulent plasma with direct application to bodies re-entering the earth's atmosphere, laser propagation in a turbulent media and antenna studies, along with an ionospheric model for a VLF, ELF satellite. A feasibility study has been completed on a promising technique for remote sensing of water vapour distributions from a satellite with a radiometer at 180 GHz. In progress are further antenna in plasma studies, a satellite borne CO_2 laser radar investigation, and consultation work, such as for the definition phase of the communications technology satellite. Feasibility studies have also been done for a UHF satellite for thin route communications.

SPAR AEROSPACE PRODUCTS

The year 1971 marks one of Spar's most active in space programs. Programs include the design of a complete Communications Satellite, design and manufacture of varied satellite subsystems, equipment for the Apollo space program, and a variety of STEM hardward for international space programs.

Anik Communications Satellite Program

As a subcontractor to Hughes Aircraft Co. of California, Spar has completed its part of Telesat, Canada's Anik Satellite Program. Beginning in 1970, Spar engineers worked with Hughes on the thermal, mechanical and structural design, propulsion and power systems. This work culminated in the manufacture of three complete satellite structures which were shipped to Hughes in August, September and December. Spar has a working agreement with Hughes to provide structures for up to 15 additional Anik satellites or derivatives which Hughes has estimated as follow on sales.

Communications Technology Satellite (CTS)

Under contract from Communications Research Centre, Spar has been commissioned to perform major Phase C detailed design tasks including the satellite's structure; deployable solar array subsystem complete with stowage, release, drive and tracking; attitude control subsystem and ground support equipment. A team of some 60 scientists, engineers and technicians will be required throughout Phase C which is scheduled for completion in late 1972.

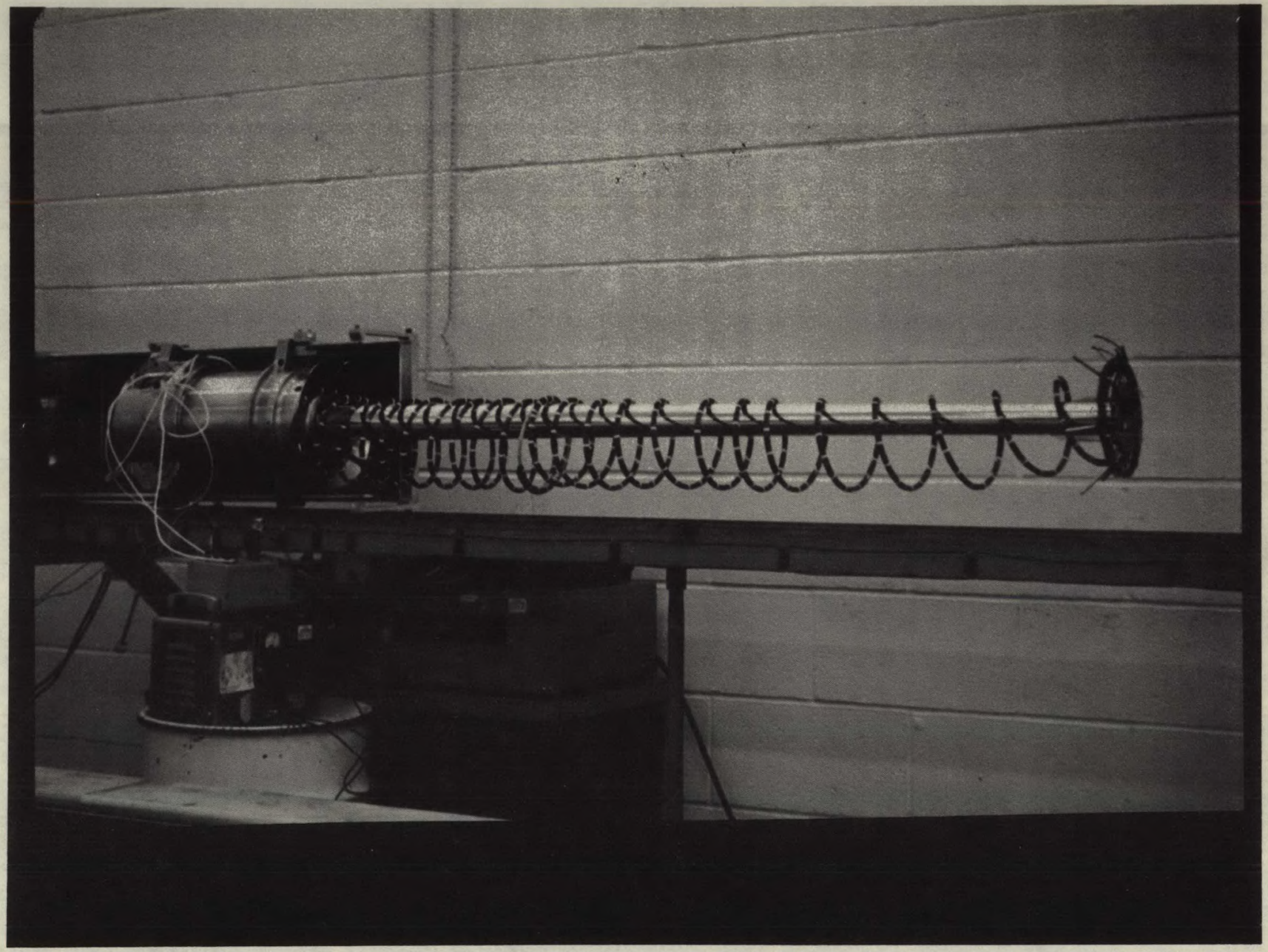
Lockheed Communications Satellite (LCS)

Spar Aerospace is key member of the International Consortium which Lockheed has assembled to finalize a design and fabricate a full scale mock-up for an advanced Communications Satellite which Lockheed plans to propose for the Intelsat V Program. Spar's responsibility includes the complete extendible solar panel design, including the sophisticated rotary power transfer joint, sun tracking system and caging and release mechanism.

Rotary Power Transfer Studies

COMSAT Corp. in Washington has selected Spar to study and breadboard advanced power transfer systems and compare relative merits of slip rings, restart devices and other associated mechanisms.

APOLLO 15, 16 SPECTROMETER BOOM PARTIALLY EXTENDED ON TEST TRACK



Flexible Solar Array Actuators

Over the past year Spar has designed, developed and manufactured a number of Bi-STEM actuators for various international flexible solar array programs. A recent U. S. Air Force space launch which featured an experiment called FRUSA (Flexible Roll Up Solar Array) built by Hughes Aircraft Co., was the first of this advanced system to be flown. Spar supplied the actuation system on FRUSA as well as on German government development programs.

Apollo Missions

The Apollo 15 service module was equipped with two Bi-STEM booms used to extend mass and gamma spectrometer experiments to a 25 ft. radius from the spacecraft. Apollo 16, scheduled for launch in the spring of 1972, will feature similar Spar booms. Spar was recently contracted by North American Rockwell Corp. to design, develop and manufacture an antenna system as part of the Lunar Sounding Experiment for next year's Apollo 17 mission, the last of the Apollo series. The antenna system which consists of a solid yagi array and an 80 ft. tip-to-tip Bi-STEM dipole will enable scientists to analyze lunar subsurface characteristics.

General STEM Programs

A number of 1971 space missions, in addition to those mentioned in the foregoing, featured STEM mechanisms in their payloads. These include Canada's fourth satellite - ISIS II, IMP I (Interplanetary Monitoring Platform), SESP 70-2 (U. S. Airforce), and UK 4 (England). For scheduled launches in 1972, Spar has supplied STEM hardware for use on NASA's Meteoroid Technology Satellite (MTS), a number of U. S. classified satellites, and Nike-Tomahawk and Nike-Apache sounding rockets.

TABLE 1

DETAILS OF ROCKET LAUNCHINGS AND EXPERIMENTS - 1971

VEHICLE	NOSE CONE Kgs	PLACE TIME DATE	Effective Launch Elevation	Apogee Kms	Apogee Time in sec	Roll Rate rps	ROCKET PERFORM-ANCE	REQUIRED LAUNCH CONDITIONS	EXPERIMENTS	EXPERIMENTERS	EXPERIMENT RESULTS
AAD-II-124 Recovery	200.9	CRR 1410 13/1/71	84.0°	146.2	T+185	2.1	Normal	Recovery	0_2/OH Photometer Plasma Probes (2) Micrometeoroid detectors Ozone Concentration Measurements	Vallance Jones/ Llewellyn A.G. McNamara R. Wlochowicz P. Ryder (UK)	Recovery Good Data SRFB 052
AKD-VB-27	190.5	CRR 2032 20/1/71	63.9°	258	T+256	Max 2.9 Stable 0.39	Normal	Reasonably Bright Aurora	Auroral Scanner (2) X-ray flux Measurement Energetic particle Detector Plasma Probes (3) MultiGrid Velocity Analyzer Electric Field Probes	C.D. Anger B.A. Whalen A.G. McNamara G.G. Cloutier/ D. Brooks A. Kavadas	Good Data SRFB 053
ABD-VB-24	161	CRR 2244 22/1/71	82.0°	367.9	T+307	Max 3.7 Stable 0.46	Normal	Type A Aurora	Auroral Photometer (4) Soft Electron Spectrometer (1) Auroral Scanning Photometer (1) Plasma Probe (3) Micrometeoroid Detector (4) Energetic Particle Detector (1) Auroral Photometer (2)	D.J. McEwen D.J. McEwen C.D. Anger A.G. McNamara R. Wlochowicz Judge/ B.A. Whalen A. Vallance Jones	Good Data SRFB 054
AMD-VB-26 Recovery	247.2	CRR 1123 26/1/71	79.5°	282.1	T+270	Max 3.2 Stable 1.63	Normal	Daytime Recovery	Photometer Multi Grid Velocity Analyzer Plasma Probes (4) Spectrometer	G.G. Shepherd G.G. Cloutier D. Brooks A.G. McNamara P.B. Hayes	Good data from experiments except for those affected by non-deployment of clamshells. SRFB 055

TABLE 1

DETAILS OF ROCKET LAUNCHINGS AND EXPERIMENTS - 1971 (Cont'd)

VEHICLE	NOSE CONE Kgs	PLACE TIME DATE	Effective Launch Elevation	Apogee Kms	Apogee Time in sec	Roll Rate rps	ROCKET PERFORM-ANCE	REQUIRED LAUNCH CONDITIONS	EXPERIMENTS	EXPERIMENTERS	EXPERIMENT RESULTS
AKF-IVB-24	75.5	CRR 1646 5/2/71	82.4°	784.4	T+462	Max 4.7 Stable 0.8	Normal	late evening or early morning twilight. Disturbed visual aurora.	Auroral Photometer Antenna Impedance Measurements Micrometeoroid Detector	A.W. Harrison R.E. Barrington R. Wlochowicz	Good data from two of of three experiments
AKF-IVA-18	55.7	CRR 2133 19/2/71	83.0°	785.4	T+462	Max 3.4 Stable 0.4	Normal	Magnetic break-up near midnight	Auroral Photometer Energetic Particle Detector Plasma Probes (2)	C.D. Anger B.A. Whalen A.G. McNamara	Good data SRFB 057
AND-III-41	52.6	CRR 0153 28/2/71	84.5°	151.8	T+185	5.9	Normal	Night time lunar darkness with sun below the horizon at apogee	Cosmic Radiation Measurements	H. Gush	Good data SRFB 058
AAF-VB-32	239	CRR 0053 3/3/71		273.6	T+264	3.1	Normal	Night time during auroral break-up	Energetic Particle Detector Auroral Scanner Multi Grid Velocity Analyzer Spectrometer Electron Beam Fluorescence Probe Electric Field Probes (2) Plasma Probes Micrometeoroid Detection	B.A. Whalen C.D. Anger G.G. Cloutier/ D. Brooks J. Visentin J.H. DeLeeuw A. Kavadas A.G. McNamara R. Wlochowicz	Good Data SRFB 059
AMF-II-115 Recovery	170.1	CRR 2123.48 19/3/71	83.0°	152.3	T+192	0.3	Normal	Recovery	Auroral Photometer Vacuum ultraviolet Measurements Ionization density Measurements thin film tests	R.W. Nicholls D.J. McEwen A.G. McNamara R. Wlochowicz	Good Data SRFB 060

TABLE II

ROCKETS AND EXPERIMENTS PLANNED FOR 1972

Vehicle No.	Pr. Scientist	Engineering	Launch Period	Conditions	Experimenters	Experiments	Remarks
AMF-II-126	Nicholls	BAL	CRR January 1972	Distinct and sustained aurora	Nicholls McEwen McNamara	Spectrum photography and photometer Vacuum ultraviolet Ionization density	Recovery Reflown payload from AMF-II-115
AAF-IIIB-53	Whalen	BAL	January 1972 Gillam	No moon Single aurora substorm	Whalen Harris McNamara	Energetic particle detector A three-channel photometer to make accurate measurements of vertical distributions of emissions in various wavelengths Tip probe and Swing-out probe to measure plasma characterists	To be launched as far south as possible and to be followed by AAF-VB-33 and AAF-IVB-25 from CRR
AAF-VB-33	Whalen	BAL	January 1972 CRR	No moon Single aurora substorm	Whalen Belrose Harris Kavadas/Koehler McNamara Monfils (Belgium)	Energetic particle detector Propagation measurements To make accurate measurements of vertical distributions of emissions in various wavelengths Electric field probes Tip probe, Swing-out probes and ejected package to measure plasma characteristics To measure intensity of OI 6300Å and another reference line in the aurora	To be launched as far south as possible from CRR after launch of AAF-III-53 from Gillam
AAF-IVB-25	Whalen	BAL	January 1972 CRR	No moon Single aurora substorm	Whalen McNamara	Energetic particle detector Tip probe and Swing-out probe to measure plasma characteristics	To be launched as far north as possible after launch of AAF-III-53 and AAF-VB-33
ATT-BA-04	Whalen/ Sheldon	U.S.	January 1972	No moon Single aurora substorm	Whalen/Sheldon	Auroral x-ray	To be launched into same event as AAF-VB-33, IVB-25, IIIB-53
AND-IIIB-63	Gush	SED	Jan/Feb 1972 CRR	Lunar darkness at apogee	Gush	Background cosmic radiation	
ADD-IIIA-54	Llewellyn	SED	Jan/Feb 1972 CRR	Quiet, no auroral forms, moon $< 50°$	Vallance Jones/ Llewellyn McNamara	O_2/OH photometer for the 1.27μ (O_2 band) and 1.75μ (OH sequence), and measurement of 5577Å emissions Swing-out plasma probes to measure ambient electron density and electron temperature	ADD-III-54 is lead shot for eclipse launches at CRR ADD-III-55, 56, 57, 58.

TABLE II

ROCKETS AND EXPERIMENTS PLANNED FOR 1972 (Cont'd)

Vehicle No.	Pr. Scientist	Engineering	Launch Period	Conditions	Experimenters	Experiments	Remarks
AMF-IIIA-52	Schiff	BAL	Jan - Mar 1972 CRR	Quiet undisturbed daytime (Idb)	Schiff/Megill/ Young	Height profile of nitrogen atoms	Possibility of recovery
ADD-II-114	McEwen	SED	1st week of Feb/72 CRR	Visual aurora Intensity II or greater	McEwen Anger Llewellyn McNamara Shepherd Wlochowicz	VUV Spectrometer, Electron Spectrometer Up and Down Looking Photometer and a Forward Looking VUV Photometer Optical measurements at various wavelengths Forward and side looking photometers to measure emissions at various wavelengths Ejected Plasma Probe, Swing-out Plasma probe and a Side Plasma Probe To measure intensities of H 4861, OI 5577Å and the N_2 4278Å emissions looking upward Ejected micrometeoroid probe	Recovery
AED-VB-28	deLeeuw	SED	February 1972 CRR	Night, sun not visible below 200 km and moon intensity of 1/10. or greater	deLeeuw/Haasz McNamara Visentin Young/Shepherd	Electron beam fluorescence probe Ejected plasma probe To measure number densities of atomic oxygen, molecular oxygen, nitrogen and helium, and ambient temp in free molecular region Measurement of atomic oxygen in earth's atmosphere	
APF-IVA-26	Wilson	BAL	April 1972 CRR	Geomagnetic & solar quiet for approx a week prior to T-0	Wilson Venkatesan	Soft x-ray probe X-ray detector	
ADD-IIIA-55, 56, 57, 58	Llewellyn	SED	10 July 1972 CRR	Eclipse	Vallance Jones/ Llewellyn McNamara	O_2/OH photometer for the 1.27μ (O_2 band) and 1.75μ (OH sequence), and measurement of 5577Å emissions. Swing-out plasma probes to measure ambient elcctron density and electron temperature	ADD-III-54 is lead shot for eclipse shots. For eclipse shots, key rocket must be launched to achieve apogee at mid-totality
AAF-IIIA-59/62	McNamara	BAL	10 July 1972 East Quoddy	Eclipse	McNamara Belrose Hall (UK)	Langmuir probes Radio frequency propagation techniques X-ray and Lyman Alpha	

ABBREVIATIONS

AECL	Atomic Energy of Canada Ltd.
AFCRL	Air Force Cambridge Research Laboratories (U. S.)
ANIK	Eskimo name for brother
ARCOM	Arctic Communications Station
AU	Astronomical Unit
APT	Automatic Picture Transmission
ARCAS	Atlantic Research Corporation Altitude Sounding Rocket
ATS	Applications Technology Satellite
BAC	British Aircraft Corporation
BAL	Bristol Aerospace Limited
BASS	Ball Azimuth Stabilization System
CAE	Canadian Aviation Electronics
CARDE	Canadian Armament Research and Development Establishment
CF	Canadian Forces
CHU	A radio station
COMSAT	Communications Satellite
COSPAR	Committee on Space Research
COTC	Canadian Overseas Telecommunications Corporation
CRAM	Centre for Research on Atoms and Molecules
CRC	Communications Research Centre of the Department of Communications
CRESS	Centre for Research in Experimental Space Science
CRR	Churchill Research Range
DCBRE	Defence Chemical & Biological Research Establishment
DND	Department of National Defence
DOC	Department of Communications
DOT	Department of Transport (now MOT - Ministry of Transport)
DRB	Defence Research Board
DREV	Defence Research Establishment Valcartier (ex CARDE)
DRIR	Direct Reading Infrared Readout
DRTE	Defence Research Telecommunications Establishment (now CRC)

Abbreviations (Continued)

EMR	Department of Energy, Mines and Resources
ESRO	European Space Research Organization
ESSA	Environmental Science Services Administration
EW	East West
GMT	Greenwich Mean Time
GSC	Geological Survey of Canada
GSFC	Goddard Space Flight Center
IGY	International Geophysical Year
IMP	Interplanetory Monitoring Platform
INTELSAT	International Communications Satellite Consortium
IQSY	International Years of the Quiet Sun
IR	Infra Red
ISAS	Institute of Space and Atmospheric Studies
ISIS	International Satellites for Ionospheric Studies
ITU	International Telecommunications Union
IUPAP	International Union Pure and Applied Physics
Laser	Light amplification by stimulated emission of radiation
Maser	Microwave amplification by stimulated emission of radiation
Met	Meteorological
NAE	National Aeronautical Establishment
NASA	National Aeronautics and Space Administration
NIMBUS	Cloud Formation (Latin)
NORAD	North American Air Defence
NRC	National Research Council of Canada
NRL	Naval Research Laboratory (U. S.)
NLC	Noctilucent cloud
N. W. T.	Northwest Territories
OGO	Orbiting Geophysical Observatory
OSO	Orbiting Solar Observatory
PCA	Polar Cap Absorption

Abbreviations (Continued)

PCM	Pulse Code Modulated
PSK	Phase Shift Keying
RADINT	Radio Doppler Interferometer
RCA	Radio Corporation of America
REED	Radio and Electrical Engineering Division
SED	Space Engineering Division
SN	Super Nova
SRFB	Space Research Facilities Branch
SSCC	Spin-Scan Cloud Camera
SST	Super Sonic Transport
STADAN	Space Tracking and Data Acquisition Network
STEM	Storable Tubular Extendable Member
TACSATCOM	Tactical Satellite Communication
TELESAT	Telecommunications Satellite
TIROS	Television Infrared Observational Satellite
TOS	TIROS Operations System
URSI	International Union of Radio Science
USA	United States of America
UT	Universal Time
VELA	Nuclear Detection Satellite
WEFAX	Weather Facsimile
WMO	World Meteorological Organization

SYMBOLS

α	alpha
Å	angstrom
AGC	automatic gain control
BeV	billion electronvolt
cm	centimeter
db	decibel
e/cc	electrons per cubic centimeter
eV	electronvolt
FM	frequency modulated/modulation
ft	foot/feet
GeV	giga electronvolts
GHz	gigahertz
G/T	gain of antenna over noise
GV	giga volt
$H\beta$	hydrogen beta
Hz	hertz
i/cc	ions per cubic centimeter
°K	degrees Kelvin
KeV	kiloelectronvolt
kHz	kilohertz
km	kilometer
$L \approx 4$	invarient shell parameter
lb	pound
MeV	megaelectronvolt
MHz	megahertz
mm	millimeter
N_2^+	ionized nitrogen molecule
OH	Hydrozyl
$O_2(^1\Delta)$	term used in spectroscopy
$O_2{}^1\Delta g$	term used in spectroscopy

Symbols (Continued)

$(OI)_{32}$	state of oxygen atom
PCM	pulse code modulated
PSK	phase shift keying
R_E	Earth Radii
RF	radio frequency
SCO	subcarrier oscillator
str	steradian
VLF	very low frequency
w	units of power
μ	micro-micron
λ	wavelength
Δv	the change in vibration quantum number
Λ	Lambda
10^3	thousands
10^6	millions