The Mirrored Spectrum
Volume 2

The Mirrored Spectrum

Volume 2

A collection of reports for the non - scientist and non - engineer about achievements in Canadian Science and Technology

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for
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Price: $3.00 Catalogue No. ST31-2 / 1974-2

Price subject to change without notice

Information Canada
Ottawa, 1974

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Introduction

This is the second book written under the Science and Technology Achievements Program of the Ministry of State for Science and Technology. The articles within are intended to make the general public more aware of what Canadian scientists and engineers are doing today, and what they have accomplished in the past. The articles meet this overall objective in three ways.

First, each story tends to be general. A concept such as plate tectonics, that draws together aspects of geology which had been somewhat independent until a decade ago when plate theory was first proposed, is sketched in only the broadest terms.

Second, the authors and editors have used the simplest language that can still convey the proper descriptions of concepts, instruments and experimental procedures.

For example, the movement and make-up of glaciers is described in the professional literature by many terms which have exact meanings to geologists, glaciologists and topographers. But the authors of this book have favored more general terms — and the use of similes where appropriate — to explain glaciers, electron microscopes, recording instrument packages, etc., without introducing a host of technical phrases.

Third, the book has a slightly promotional tone, for the volume is meant to draw attention to Canadian achievements. Therefore, the authors emphasize various aspects as Canadian — a new process, a more sophisticated piece of equipment, a new application of a familiar process, a brand-new invention, or a set of data more complete than any comparable record in the world.

The articles were chosen from a list of more than 500 achievements nominated by scientists, engineers, professional associations, industries and government departments and agencies. The writers selected those topics which interested them. Therefore, the stories are not ranked in order of importance, nor are the subjects here necessarily the most significant of the achievements available.

However, they are a sample. As such, the articles mirror the spectrum of accomplishments in Canadian science and engineering.

The authors were students or recent graduates from journalism programs across Canada, and came to the Ministry's Information Services for the summer of 1973. They wrote their stories under the supervision of Marvin Schiff, who edited English copy, and Jean Proulx, who examined the French pieces. After approval from these editors, the stories went to the Director of Information Services for his examination and then, for final review, to members of a committee of scientists, engineers and writers.

The Authors

Claude Bonenfant, a masters degree student in French-Canadian literature at the University of Quebec in Trois-Rivières, has written plays, poems and novels in addition to the science stories which appear among the following pages.

Margaret Brasch brought to the program a background in medical science and writing. She obtained her BSc from Sir George Williams University in Montreal, an MSc in endocrinology from Carleton University in Ottawa, and studied journalism at Carleton, too.

Linda Chemelli of Sundre, Alberta, completed a two-year program in journalism administration at the Southern Alberta Institute of Technology in Calgary. Her principal interests include advertising design and layout.

Serge Côté obtained his BA in pre-medicine and his BSc in biology from the University of Ottawa. He is now in third-year law at the same school, and writes on contract for the Ministry of State for Science and Technology.

Randy Denley obtained a BA in journalism from the University of Western Ontario in London. He now writes for the University full-time.

Diane Hill, now a fourth-year student in journalism at Carleton University, hopes to apply her writing experience to specialized reporting.

Martin McCormack took an MSc in geology at the University of Calgary before completing the one-year journalism program at Carleton University. He now works for the Ministry of State for Science and Technology as publications editor, and hopes in the future to concentrate on journalism in the earth sciences.

Anne Sadler graduated with honors from the two-year journalism program at Sheridan College of Applied Arts and Technology in Oakville, Ontario. She hopes to work in television as an interviewer.

Marlene Simmons of Chatham, Ontario, returned to the S/T Achievements Program in 1973 after a stint of practical newspaper experience. This year she continues her studies in journalism at Carleton University.

The Editors

Jean Proulx is director of the philosophy department at CEGEP d'Ahuntsic in Montreal. There he has contributed to a series of philosophical books — on a wide variety of topics, including science — published by a group of the CEGEP's professors. Mr. Proulx also has written for the journal, "Maintenant".

Marvin Schiff, assistant professor of journalism at Carleton University, currently is a freelance contributor to the Toronto Globe and Mail and the Canadian Broadcasting Corporation. Mr. Schiff teaches reporting and is involved in development of a science writing seminar at Carleton. As a former staff member of the Globe and Mail, Mr. Schiff specialized in medical and social welfare reporting.

Serving on the committee of scientists, engineers and writers, which reviewed articles written for this book, were:

Professor D.G. Andrews, professor of nuclear engineering, University of Toronto; Dr. D.M. Baird, director, National Museum of Science and Technology, Ottawa, and staff; Dr. Louis Berlinguet, vice-rector, University of Quebec; Dr. Fraser N. Gurd, associate secretary, Royal College of Physicians and Surgeons of Canada, Ottawa; Dr. Martin Johns, chairman, department of physics, McMaster University; Dr. James Morrison, director, materials research institute, McMaster University; Dr. Louis Siminovitch, professor and chairman, department of medical cell biology, University of Toronto; and David Spurgeon, associate director, scientific publications, International Development Research Centre, Ottawa.

Mr. John E. Bird of the National Research Council gave freely of his time and knowledge on the committee in 1972 and 1973 until his death in the fall of 1973.

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Book Design: Graphics Section MOSST

Type: Alphatext Ltd.

Tracked Carriers

DIANE HILL

Bruce Nodwell

A man trudges through deep snow, sinking up to his knees with each step. Gliding over the snow directly behind him is a 13-ton transport vehicle, its tracks barely denting the snow's crusted surface.

This vehicle that treads more lightly than man has skimmed over snow, swamps and muskeg to open up formerly unconquerable territories, and has created a world market for an all-Canadian manufacturing firm.

Known as the Nodwell tracked carrier, the machine was invented in 1957 by a Calgary equipment designer, Bruce Nodwell, who intended it to move drilling equipment and crews into the hinterlands of Canada's north. Within 15 years, however, Nodwell tracked carriers were being used all over the world for everything from army manoeuvres to swampland reclamation.

It was the oil industry's push to open up Arctic oil reserves that gave Mr. Nodwell his start.

There is a potential of about 60 billion barrels of oil in Canada's north, but access to much of it is hampered by difficult terrains — mainly permafrost, spongy-surfaced soil laced with ice particles, and muskeg, another soil-and-water mixture. Muskeg presents a special problem because its texture changes with the weather.

Until the tracked carrier appeared, northern oil exploration was limited to the winter when muskeg is frozen and can support heavy vehicles and drilling equipment.

In summer, it becomes a bog-like mass that cannot hold up heavy equipment, conventional vehicles, or even roadbeds in some cases. As a result, oil companies were forced to move men and machinery into muskeg areas and out again before spring thaws, whether or not work on drilling sites was complete.

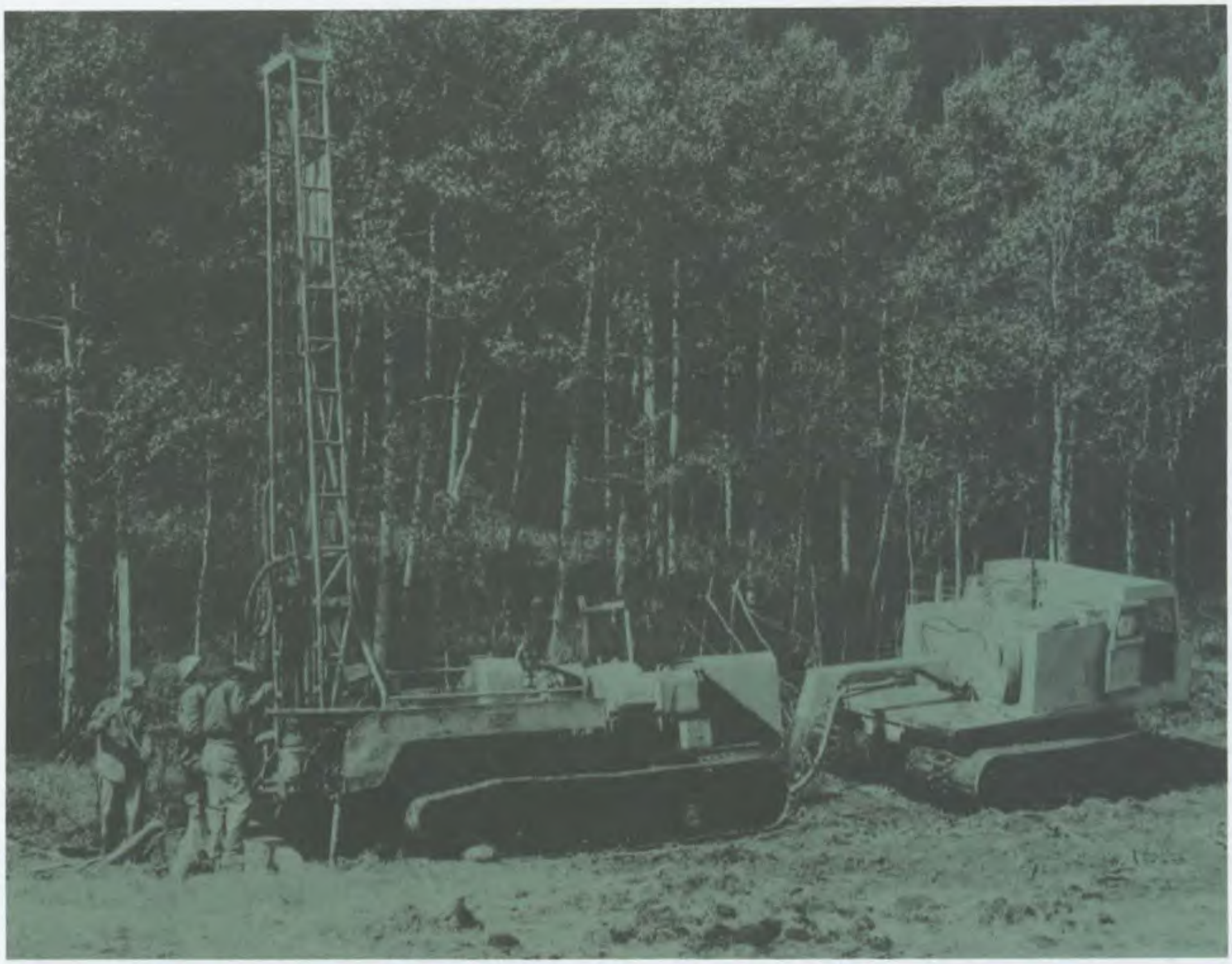
In 1952, Imperial Oil Ltd., looking for a way to extend the northern exploration season, asked Bruce Nodwell Ltd. to design a vehicle that could transport men and equipment over northern terrains, regardless of the season.

For several years before Imperial's request, Mr. Nodwell himself had been working on off-road transport vehicles to give year-round access to muskeg areas. He tried various unsuccessful applications of wheels before deciding that a tracked vehicle must be the solution.

When Imperial Oil and Bruce Nodwell Ltd. started working together, the largest existing tracked carrier was a tank-like vehicle, made in Quebec by Bombardier Ltd. of snowmobile fame. It could carry a 4,000-pound cargo.

The oil companies, however, needed a carrier that could haul at least 12,000 pounds. After five years of trial and error, Bruce Nodwell's firm developed a

The Nodwell 110, loaded with drilling equipment, has no trouble with a wet, muddy road built through an area of muskeg.



This Nodwell tracked carrier hauls a portable drilling rig.

machine that can support 20,000 pounds of cargo.

Although its total weight with cargo would be in the neighborhood of 25 tons, the carrier can skim over virtually any terrain at an average maximum speed of 12 miles an hour with a ground pressure of about two pounds per square inch.

The main problem encountered in designing the lightly-treading carrier was how to give it enough track area to reduce ground pressure without having the vehicle lose all stability on uneven ground.

Two solutions evolved, both in the design of the tracks. Nodwell used four-foot-wide tracks of rubber and steel mounted around a number of rubber-tired wheels. This provided a cushioned track area, wide enough to distribute the vehicle's tonnage. The vehicle, about 40 feet long and 10 feet wide, weighed about 15 tons without cargo and 25 tons with cargo.

But a large machine resting so lightly would be likely to tip on uneven terrain if the tracks were inflexible. To solve the stability problem, each of the wheels inside the huge tracks was joined to an axle, and each axle hooked separately to the drive shaft, the "backbone" of the vehicle. Since each wheel was suspended and could turn independently, the tracks could "walk", wheel by wheel, over uneven terrain, minimizing the possibility of the machine tipping over.

Once the basic track design was adapted to a flat-topped carrier, a variety of vehicles were created. Bunk houses, cook trailers and personnel carriers were rested on Nodwell tracks. An entire camp on tracks could be moved to a muskeg-covered drill site, winter or summer, where it could stay year-round without being bogged down.

Before the first Nodwell tracked carrier was on the market, Imperial Oil Ltd. had joined forces with Shell Oil on the project. Shell Oil conducted the first successful tests of the tracked carrier in 1958 in Alberta's gummy Athabasca Tar Sands, and before the designs for other tracked vehicles were off the drawing board, orders were coming in for them.

The vehicles can move across ice, snow, permafrost, muskeg or sand, and can go through up to 4-1/2 feet of water. They have been shipped to countries in South America, to South Africa, Iran, Indonesia, and to several northern areas such as Siberia, Alaska and parts of northern Canada.

From 1969 to 1973, three sales of tracked vehicles, totalling close to $12 million, were made to the Soviet Union. The People's Republic of China also was considering Nodwell tracked carriers for use in their petroleum industry.

A large tracked carrier with a full load moves along a winter trail.

A major user of Nodwell tracked carriers in Canada's north is Panarctic Petroleum Ltd., a company that is carrying on oil exploration in the Arctic Islands. Although he could not provide figures, one Panarctic official in Calgary said the tracked vehicle, by extending exploration time and by its power to take bigger loads of drilling equipment over rougher terrain, had been saving money for his company since the early 1960s.

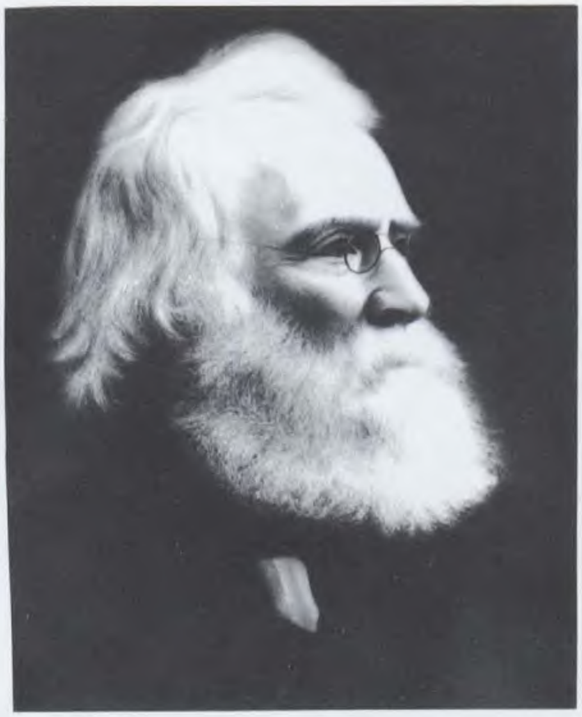
Tracked vehicles by Mr. Nodwell's firm range in price from about $13,000 for a personnel carrier with a 1-1/2-ton capacity, to about $130,000 for the largest, which carries just over 40 tons of cargo.

The machines are built in Calgary, where Bruce Nodwell worked on the first carrier for Imperial Oil. Mr. Nodwell is now a vice-president of Foremost International Industries Ltd., which specializes in off-road transport vehicles. They put out five lines of tracked carriers based on the design of the first Nodwell carrier, and three sizes of vehicles with flotation-rubber tires.

In recognition of his work, Mr. Nodwell received the Governor-General's Medal of Service of the Order of Canada in 1970.

Sir William Logan

MARTIN McCORMACK



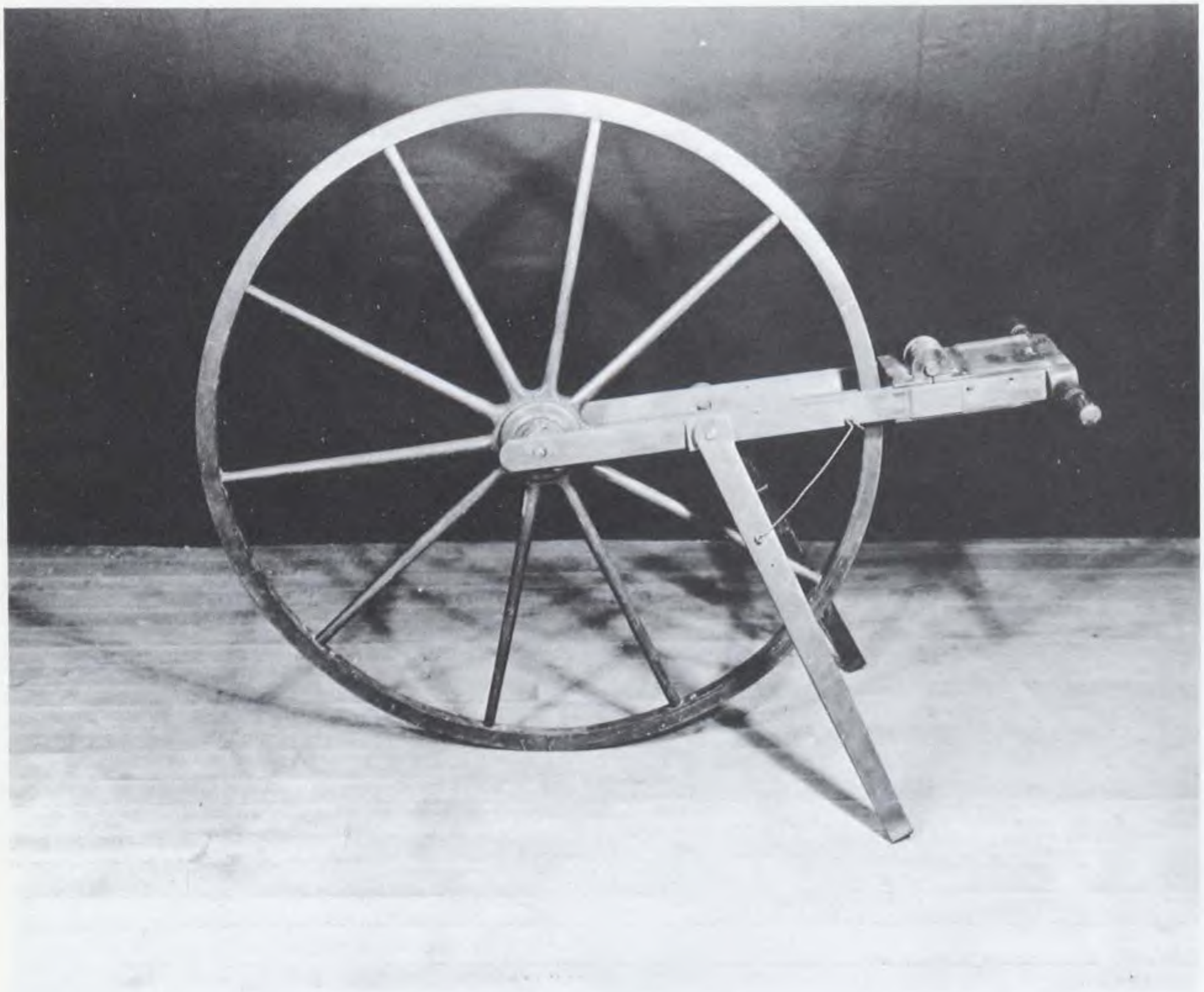
Sir William Logan founded the Geological Survey of Canada and led a long career as a geologist.

A short middle-aged man with a bushy red beard and tattered trousers walked along the Gaspé shore, dragging behind him what looked like a spinning wheel and jotting notes on a scrappy pad as he hovered around some huge grey rocks.

Three clam-diggers who watched him that summer day in 1843 thought the man was definitely mad and they told him so. But to Canadian geologists more than 130 years later, the work done by Sir William Edmond Logan, the man with the notebook and primitive odometer, ranks as a major cornerstone of contemporary Canadian geology. And to Canadian mining interests, it is the foundation upon which much of their multi-million-dollar industry is built.

In fact, the Geological Association of Canada, the Department of Energy, Mines and Resources, and the Geological Survey of Canada jointly proposed in 1973 that a postage stamp in Sir William's honor be issued in 1975, a century after his death.

It certainly was not to be the first tribute to the man who, in 1842, founded the Geological Survey of Canada, the oldest existing Canadian scientific organization. Canada has two Mt. Logans, one in



Sir William pulled this early odometer behind him to measure distances along the routes he walked in the field.

the Gaspé region of Quebec and the other a 19,850-foot peak in southwestern Yukon Territory, the highest mountain in the country.

Geologists — scientists whose specialty is the formation of the Earth's crust — still get together at meetings of the Logan Club, founded in 1888, which convenes every few weeks at the Geological Survey building in Ottawa. And the Geological Association of Canada awards the Logan Medal every year to a geologist for exceptional work in the science.

Such diverse recognition of Sir William Logan stems from his numerous achievements, many regarded today as the foundation of North American geology. During more than 30 years of painstaking work, he examined an unusually wide variety of phenomena which included coal, rivers, ice, rocks, fossils, metals and mountains.

Logan's dedication, it seems, bordered at times on fanaticism. He once spent a stormy night, without food or a sleeping bag, under the overhang of a huge boulder near the north shore of Lake

Superior.

"A little after day had fairly broken, he was perceived emerging from the bush, hammer in hand, occasionally pounding a rock as he advanced, and seemingly quite unconcerned, though his trousers were torn to rags, and his boots completely minus the soles," wrote Alexander Murray, Logan's first assistant in the Geological Survey.

Prior to becoming the first director of the Survey, Logan made three important observations sufficient to establish his reputation as a competent geologist:

> —In the late 1830s he noticed upright tree stumps at the bottom of most coal beds, and concluded that the soft black rock was formed from dead plants which grew where the coal is found today, rather than from ancient leaves, roots and stems washed in from some distant location. This interpretation resolved a controversy about the origin of coal;
>
> —In 1841 Logan found footprints of one of the earliest known reptiles in rocks now thought to be 260 million years old, proving that reptiles evolved much earlier than was thought before his observations;
>
> —And during the winter of 1840-41 he described the packing and periodic breaking up of ice in the St. Lawrence River at Montreal in such detail that the city of 50,000 built retaining walls at critical points along the river, preventing floods of the kind that had struck in previous years.

But Logan's most historically significant work was yet to come.

In 1841 the first Parliament of the United Canadas — Upper Canada and Lower Canada — voted £1,500, worth over $15,000 today, to set up a two-year geological survey to determine the nature and extent of Canada's mineral resources.

The Governor General of Canada, Sir Charles Bagot, responded to the recommendations of several top geologists in Great Britain and chose William Logan as director. Logan, born in 1798 in Montreal, had spent the period from 1814 to 1840 in Scotland, Wales and England. There he had made such an accurate map of coal seams in a Welsh mining area that his potential was recognized by no less an authority than Sir Henry de la Beche, director of the British Ordnance Survey.

Logan even contributed £800 of his own money, the equivalent of over $8,000 today, to keep the Geological Survey of Canada going after the initial £1,500 ran out in 1844. Parliament voted the following March to support the Survey on a continuing basis, due to Sir William's efforts, and Logan served for 25 more years as director with his headquarters in Montreal.

He mapped the rocks, hills, valleys, rivers and lakes of the Maritimes, the Gaspé Peninsula, the Ottawa Valley, the Lake Temiscaming area of Ontario and the north shores of Lake Huron and Lake Superior. In keeping with the main purpose of the Geological Survey, Logan paid particular attention to areas which yielded or might yield commercially valuable minerals — especially copper, silver and coal.

From that start, the Geological Survey of Canada grew from a staff of two — Logan and his assistant, Mr. Murray — in 1842 to 650 full-time employees in 1973. Annual budgets increased from $30,000 in 1869 to about $19 million in 1973-74. And by 1973 the Geological Survey had mapped over 90 per cent of Canada, issued about 3,900 reports and published over 12,000 maps.

The total budget of the Survey from 1842 to 1869 was $414,000 in currency of the day and, largely because of the Survey's work in those 27 years, Ontario and Quebec produced about $1.3 million worth of minerals and building stone in 1869 alone, a handsome return on so small an investment.

But Logan's work continued to pay dividends long after his death. The copper-producing area he discovered near Sherbrooke, Quebec, earned about $165 million between 1855 and 1966. Silver Islet near Thunder Bay, Ontario, produced $3,260,000 worth of silver between 1860 and 1920. And Sir William's descriptions of rocks bearing uranium minerals near Elliott Lake, Ontario, led to mining 80 years later when uranium had become vital to nuclear power and weapons production.

Logan also found rocks containing asbestos in Quebec's Eastern Townships; asbestos production began there about 10 years after Sir William's death. The area ultimately became the world's largest producer of asbestos, a position it held until outranked by Soviet production in the early 1960s.

The field work necessary to locate mineral deposits suited Logan, but even the best of geologists could have a bad day outdoors. Consider this account by Sir William himself about August 18, 1843: "It is twelve o'clock at night, and I am fagged...I have had a blow on the head from a great stone weighing half a hundredweight, which fell upon me, fortunately from no great height. I have had a tumble, too, on a slippery stone, striking my elbow; and I put my foot between two stones and pinched my instep; so that I am all bruises, and my limbs are as stiff as sticks. I'll go to bed."

In spite of such days, Sir William achieved during his leadership of the Survey a number of firsts in addition to finding certain key ore deposits:

—He organized outstanding collections of valuable minerals and displayed them at London and Paris exhibitions to advertise Canada as a nation rich in natural resources;

—He described in detail numerous trace fossils, the preserved grooves, swirls, blotches or humps which animals left behind when they tunnelled through or crawled along ancient mud or sand;

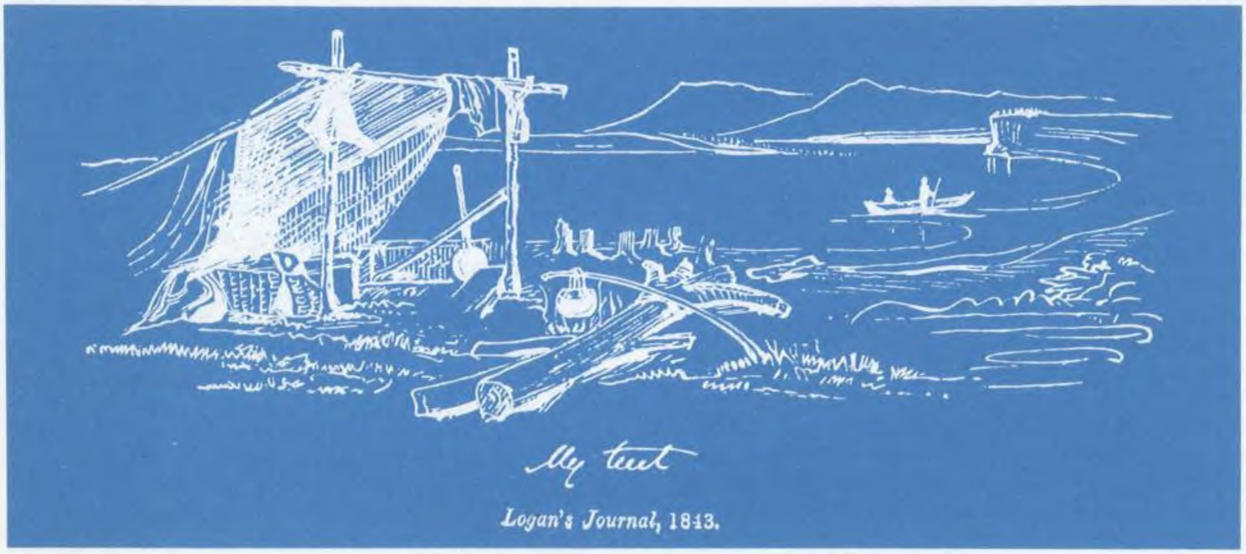
—He identified a major thrust fault zone extending from an area near Quebec City to Lake Champlain. (A thrust fault is a rupture in rock where the rock above the break overrides and may jut over the underlying rock.) Never before had a North American geologist recognized a thrust fault hundreds of miles long;

—Near Lake Temiscaming, 250 miles north of Toronto, he found slate and granite that extended off and on to near Ottawa — then called Bytown — and he concluded that the slate was older since it was overlain by the granite. Before Logan's observations, geologists had simply called both of these kinds of rock "Primary", referring to the time when the Earth formed;

—Logan compiled his findings and the studies of his Survey associates in Geology of Canada, published in 1863, and the geological map of Canada, printed in 1869, the first comprehensive publications on Canadian geology.

Sir William received numerous awards for his work, including knighthood from Queen Victoria in 1856, the Cross of the Legion of Honour from the Emperor of France in 1855, and the Wollaston Medal, the highest honour of the Royal Society of England. He won 19 other awards, and established two of his own at McGill University in Montreal — the Logan Chair of Geology, a professorship, and the Logan Medal.

Modern geologists still praise Logan. Y.O. Fortier, one of Logan's successors as director of the Geological Survey from 1964 to 1973, said, "Logan was a real scientific thinker — a superior man in three ways. First, he recognized fundamental problems in geology; people are still debating various interpretations of what Logan saw out in the field. Second, he was very conscious of Canada's mineral wealth; he saw the value of geological exploration in Canada as a way of developing the country. Third, Logan had much foresight; he felt the Geological Survey was a precious instrument for scientific thinking and economic strength."



Sir William's tent, as he drew it, was headquarters for much of the year.

L-dopa

MARGARET BRASCH

A senior citizen, confined to the loneliness and boredom of her apartment for four years, could go out and visit with friends. Another could get in and out of bed without assistance for the first time in three years. A 45-year-old pianist resumed playing after a year of incapacity, while a middle-aged accountant got the promotion he had been denied for five years.

Although different in many ways, these people have two things in common — they are among an estimated 200,000 Canadians suffering from a shaking palsy known as Parkinson's disease; and a drug known as Levodopa or L-dopa has given them what a Montreal neurologist, who pioneered the treatment, calls a "vacation" from their illness.

Fifteen or 20 years ago, Parkinson's patients were not as lucky. Though the drug, chemically identified as L-3-4-dihydroxyphenylalanine, has been known since 1960 to relieve the symptoms of Parkinson's, it was not until 1968 that a group of Canadian doctors introduced it into routine therapy.

In 1970, that same team, headed by Dr. André Barbeau of Montreal's Institute for Clinical Research, contributed to the refinement of L-dopa treatment when they combined it with the compound R4-4602 to offset most L-dopa side effects.

Until 1968, a delicate and comparatively hazardous form of surgery had been the favoured method for easing the shaking, muscle stiffness and mask-like expression which characterized Parkinson's. By 1973, L-dopa treatment had by far exceeded surgery as the preferred form of therapy.

Dr. Barbeau estimated that only five per cent of treatable Parkinson's patients still underwent surgery to ease their symptoms. Moreover, 90 per cent of those taking L-dopa found their symptoms relieved to some degree, compared to 66 per cent who were treated surgically.

Chemical therapy, while still no panacea, essentially amounts to swallowing about 33 cents worth of pills each day and seeing a neurologist for regular check-ups.

The disease owes its name to a British surgeon, James Parkinson, who first described it in 1817.

Dr. Barbeau, who has been treating Parkinson's sufferers since the early 1960s, has noted that one person in 200 over the age of 40 suffers from the disease. Patients are generally from 45 to 65 years old and the disease hits most victims when they are about 55 years old. Men's chances of getting Parkinson's are a bit higher than women's — 51 per cent compared to 49 per cent — but researchers have not discovered why.

The disease is now defined as a non-hereditary, chronic, progressive disorder of those areas of the brain known collectively as the extrapyramidal motor centre which contributes to the control of muscular activity.

Two factors, healthy cells and chemical balance, are essential to the normal functioning of this centre. In 1960, Austrian researchers headed by Dr. Oleh Hornykiewicz, then assistant professor of pharmacology at the University of Vienna, and Dr. Barbeau's team in Montreal discovered independently of each other that the brains and urine of Parkinson's patients consistently were deficient in a compound known as dopamine.

This compound, 80 per cent of which is found in the extrapyramidal system, transmits chemical messages from the brain to the muscles along neurons or nerve cells. Without it, the message is either not received by the muscles or, if received, is distorted. The end result is the same — muscular rigidity or a lack of coordination.

In 1961, Dr. Barbeau discovered that oral doses of L-dopa, the chemical from which dopamine is derived, greatly reduced the tremor and rigidity associated with Parkinson's.

That same year, Dr. Hornykiewicz, who later became head of psychopharmacology at Toronto's Clarke Institute of Psychiatry, led his Austrian group in establishing that the intravenous injection of L-dopa relieved the akinesia — lack of muscular activity — of Parkinson's patients.

Since dopamine is the compound known to be deficient in Parkinson's patients, why not inject it instead of L-dopa? To answer that question it is important to understand this: substances travelling to the brain by the circulatory system must cross a series of membranes before reaching the brain cells. These membranes constitute what is known as the blood-brain barrier.

Dopamine belongs to the class of compounds known as amines which do not easily cross this barrier. L-dopa, on the other hand, because of its molecular configuration, crosses the blood-brain barrier to reach nerve cells; once in the brain, a chemical process converts it to dopamine. L-dopa therapy, therefore, is dopamine replacement therapy.

There are, however, some harsh realities to L-dopa treatment.

For instance, patients with previous histories of kidney, liver, endocrine, cardiovascular or pulmonary disorders cannot take L-dopa. In addition, there are well-documented cases of side effects which occur to some degree in all patients after 14 to 18 months of continuous L-dopa therapy. Gastrointestinal disorders such as vomiting and nausea afflict 40 per cent of all patients, partly due to the effect of the drug on the vomiting centre of the brain. This can be reduced by taking L-dopa at meal times.

The second most frequent side effect, appearing in 40 to 60 per cent of all cases, is dyskinesia — involuntary muscle movements — especially those affecting facial expression. These abnormal movements could be caused by excessive concentration of dopamine in the basal ganglia, part of the extrapyramidal system, caused by the administration of L-dopa, according to one researcher.

Occasionally, patients also suffer from hallucinations, depression or a rapid drop in blood pressure. In about 11 per cent of all treated cases, side effects are serious enough to warrant stopping the treatment altogether.

As L-dopa therapy gained popularity, it became apparent that the side effects were somehow related to the relatively high concentrations of L-dopa that had to be administered to combat Parkinson's symptoms.

Clinicians could reduce the amounts of L-dopa prescribed but that allowed symptoms to re-emerge. Instead, they sought a way to reduce the dosages of L-dopa they were administering without sacrificing its effectiveness.

Mounting information about what happened to L-dopa in the body provided a clue as to how this might be done. Researchers found evidence that an enzyme — L-dopa decarboxylase — was converting much of the drug into dopamine before it could cross the blood-brain barrier to the affected brain cells.

It was generally agreed that if L-dopa could be administered in conjunction with a drug that inhibited this enzyme's action, dosages could be reduced with no loss of effectiveness and fewer side effects.

Meanwhile, in 1964, a Viennese physician had already experimented with such a substance — a peripheral "decarboxylase inhibitor", called R4-4602 — combining it with L-dopa in the treatment of Parkinson's patients.

Dr. Barbeau, who treated 462 Parkinson's patients between 1968 and 1973, introduced the treatment to Canada in 1969. He emphasized that the daily dose of L-dopa should be carefully adjusted to individual needs. It varies between three and five grams per day at the beginning of the treatment when L-dopa is used alone. Combined with R4-4602, it can be given in doses of .5 to .8 grams per day.

"At first...the improvement is mainly subjective. The patient attempts to perform tasks that may have been beyond him for many years," wrote Dr.

Barbeau in a scientific journal. He added that "rigidity and hypokinesia (sluggishness) are often completely reversed.

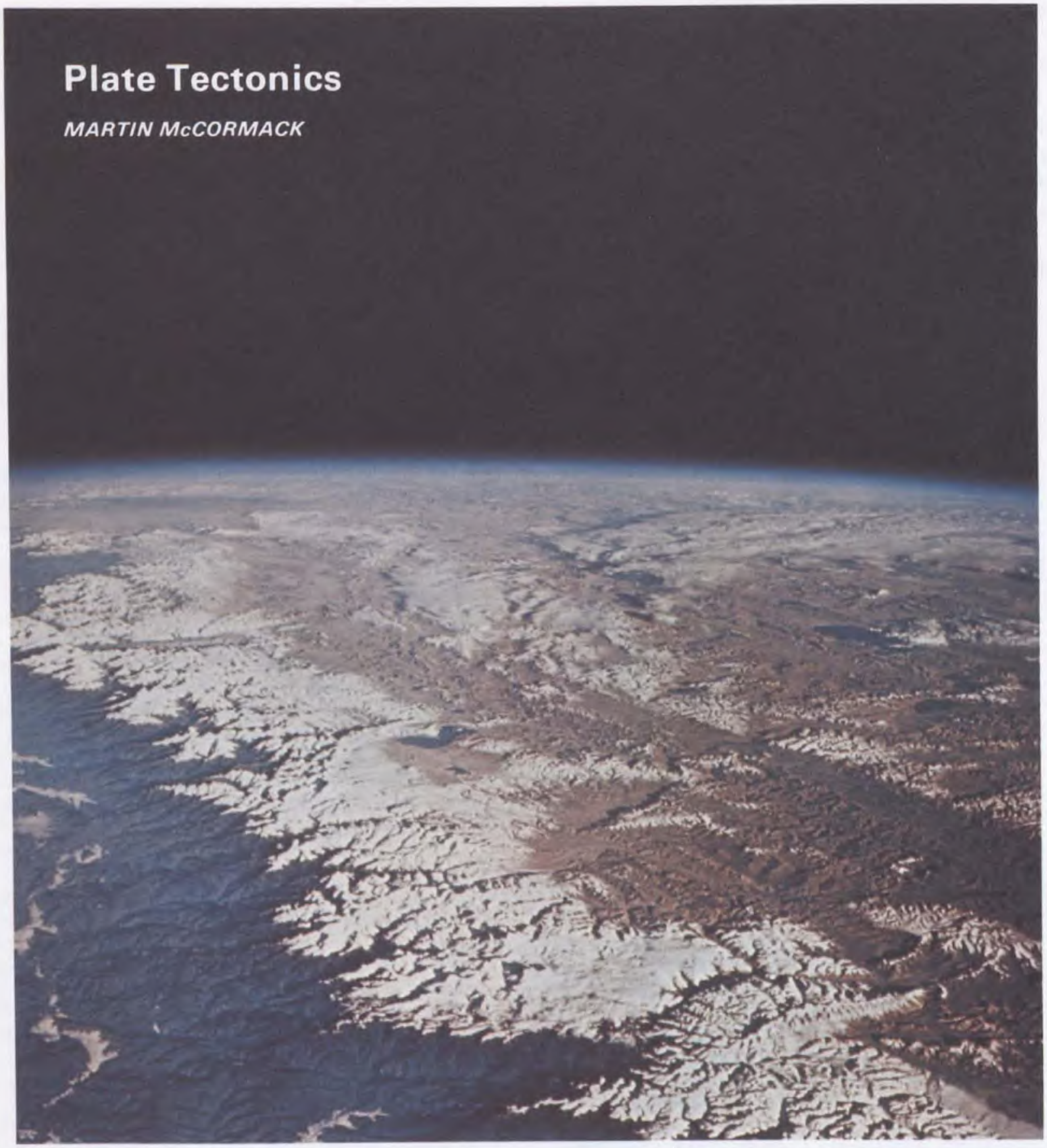
Meanwhile, we should re-emphasize our deep conviction that, despite all the problems, there is at present no better treatment for akinetic Parkinson's disease than Levodopa, alone or in combination with a peripheral decarboxylase inhibitor."

As of 1973, research was concentrating on two main questions about the disease: How can the side effects be completely eliminated? What is the basic cause of Parkinson's?

Both Dr. Barbeau and Dr. Hornykiewicz had written more than 100 articles dealing with Parkinson's — the former being more concerned with the clinical aspects, the latter with the biochemistry of the disease. Dr. Hornykiewicz's research program, in 1973, was being jointly subsidized by the Ontario Mental Health Foundation and the U.S. National Institute of Health. From 1971 to 1973, Dr. Barbeau's Montreal team received grants from the Medical Research Council of Canada.

Plate Tectonics

MARTIN McCORMACK



The world's highest mountains, the Himalayas, formed when a plate carrying India collided with the plate carrying Asia. According to earth scientists D.P. McKenzie and J.G. Sclater, the "India Plate" broke away about 75 million years ago from a position near Madagascar, off the southeast coast of Africa. The "India Plate" then travelled northwest in a somewhat irregular fashion until it ran into the Eurasian Plate. One result of the collision was the Himalayan mountain ranges, which are still growing today.

Dr. J. Tuzo Wilson

Enormous plumes of rock rise centimeter by centimeter from near the core of the Earth to its surface. Continents drift thousands of miles. Oceans open and close. Now, as in the primeval past, the Earth is in motion.

Seven hundred million years ago, for example, an Atlantic Ocean was born — not the Atlantic of today, but a narrower, ancestral ocean that closed 350 million years later. And when dinosaurs roamed the Earth 200 million years ago, North America and Europe began to split apart again to form the present-day Atlantic.

Today the same monumental forces that caused that ancient rupture still are at work, imperceptibly altering the seemingly changeless face of the Earth. That, at least, is the guiding assumption of a contemporary field of geological study called plate tectonics, a field in which Canadian scientists have played a major role since the early 1960s.

According to plate tectonics, the outer layer of the Earth consists of six large and about a dozen small, rigid plates which may move horizontally several centimeters in a year, bearing land masses as large as continents.

Although Francis Bacon wrote in 1620 that South America and Africa look like they once had been joined, for hundreds of years most scientists refused to believe that blocks as huge as continents could move at all. But almost 3-1/2 centuries later in 1963, Dr. J. Tuzo Wilson, a Canadian geologist who is now principal of Erindale College in Toronto, expounded a theory in the British publication Nature to explain how "plates" of rock — 30 to 60 miles thick and thousands of miles long and wide — could split apart, collide, or simply slide past each other. That concept gave rise to plate tectonics.

Nearly all geological activity — such as volcanic eruptions, earthquakes, creation of new ocean floor, mountain building, or the formation of many ore deposits — occurs at the edges of plates. This means all these phenomena and many others should occur in roughly curved or linear belts. Geological evidence collected over the past 130 years shows that they do.

Plate tectonics not only explains how oceans might open and close, it also describes continents as passengers on larger, thicker plates. When a plate made of ocean-floor rock collides with a plate carrying a continent, the less dense rocks in the oceanic plate rise and adhere to the continent. Continents can also split apart as one plate divides in two.

Canada has proved to be an excellent place to study plate motion. Rock exposures in Newfoundland, which are believed to bear evidence of the

Before the Atlantic Ocean began to open 200 million years ago, the continents may have been part of a much larger land mass, as suggested below by the close fit of four present-day continents. The ocean above the shelf areas is 3,000 feet deep, or shallower. The 3,000-foot contour, in most cases, marks the boundary between oceanic and continental crust. The drawing is after Patrick Hurley (1968).

ancestral Atlantic Ocean, are the most complete in the world, according to E.R.W. Neale of the geology department at Memorial University in St. John's. And the widespread, extremely old rocks of northern Ontario, Quebec, Manitoba, Saskatchewan and the central Arctic have been less distorted, twisted and melted than most rocks of comparable age in other countries.

Canadian oceanographers, geologists and geophysicists are participating with scientists from 48 other countries in the International Geodynamics Project, begun in 1970 by the International Council of Scientific Unions to promote world-wide understanding of plate tectonics.

The earliest Canadian work in this field concerned the modern-day movement of plates. In 1963 Andrew Larochelle and L.W. Morley of the Geological Survey of Canada suggested that magnetic properties of ocean-bottom rock could verify that modern sea floors were spreading slowly in opposite directions from mid-oceanic ridges, one or two miles high and thousands of miles long.

The concept of sea-floor spreading, well established by 1965, led earth scientists at Dalhousie University in Halifax and the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, to study the North Atlantic. As in other ocean basins, the new Atlantic sea floor wells up at the centre of the mid-oceanic ridge, solidifies within hours, and shoves the older rock — usually two or three miles thick — away from the ridge toward the continental coasts.

The older rock, continually pushed from behind, slides down trenches near continents and moves hundreds of miles deep into the Earth until it melts.

The work at the Institute and at Dalhousie has shown that new oceanic rock has three distinct layers, each seldom more than a mile thick, which extend across the width of the Atlantic Ocean floor. And various segments of the mid-Atlantic ridge are now pushing rock away at two to five centimeters per year, the average rate for all ocean-floor spreading.

The slow eruption of rock from the mid-oceanic ridge has caused North and South America, which together ride piggyback on the large Americas Plate, to separate from Europe and Africa, each of which rides on a different plate.

According to Charlotte Keen, a marine geophysicist at the Bedford Institute, the North Atlantic began to open up 200 million years ago; the South Atlantic began to spread 135 million years ago. The Labrador Sea and Baffin Bay did not open until 80 million years ago, but the Labrador Sea stopped spreading 40 million years after it started while Baffin Bay has continued to open.

Although Bedford Institute scientists have done most of their studies on the sea floor around northeastern Canada, they were scheduled to join Dalhousie researchers in 1974 to drill about two miles through the rock near the centre of the mid-Atlantic ridge in an attempt to reach the lower layer of the sea floor rock. Fabrizio Aumento of Dalhousie's geology department explained: "In cooperation with the United States and France, Canada will take a continuous sample of the sea floor, from top to bottom — the first such sample ever obtained."

The Canadian studies since 1965, along with U.S. and European work, have given a more complete picture of how the various plates around North America are moving today. The interpretations as of mid-1973 suggested the African Plate sits still. The Americas Plate moves due west and overrides that part of the Pacific Plate which lies between Vancouver Island and western Alaska. This northern part of the Pacific Plate moves roughly north, but near the Aleutian Islands the plate sinks into a trench, in much the way the bottom steps of a moving escalator disappear.

In the early 1960s Dr. Wilson developed a theory to explain these movements. Far down in the Earth's interior — perhaps 1,750 miles deep, at the boundary between the liquid core and the mantle, or solid middle layer of the Earth — the rock in a particular area heats up, Dr. Wilson said.

The hot rock, which is less dense than the surrounding cooler material, rises upward a few centimeters a year in a roughly cylinder-shaped "plume". After millions of years the upward-moving rock comes close enough to the rigid surface plates to cause a swelling first and later a rupture.

Plates are now thought to break in a particular pattern. "It's like a pie which someone intended to cut into three equal parts," explained A.M. Goodwin of the University of Toronto geology department. The upward swelling of a plate above a plume causes part of the plate to crack from a central point along three lines — hundreds of miles long — which divide the plate into 120-degree wedges.

The plate actually breaks open along only two of the cracks. In time, ridges form where new rock wells up to the surface through these open cracks, pushing older rock away.

A modern example of the results of such a breakup is the Red Sea, the Gulf of Aden — between Ethiopia and Arabia — and the Rift Valley, which extends southward from Ethiopia almost the full length of Africa. The Arabian Peninsula represents the third of the "pie" that actually came loose; the Red Sea and the Gulf of Aden opened about 20 million years ago, and the Rift Valley is the line along which no active spreading occurred.

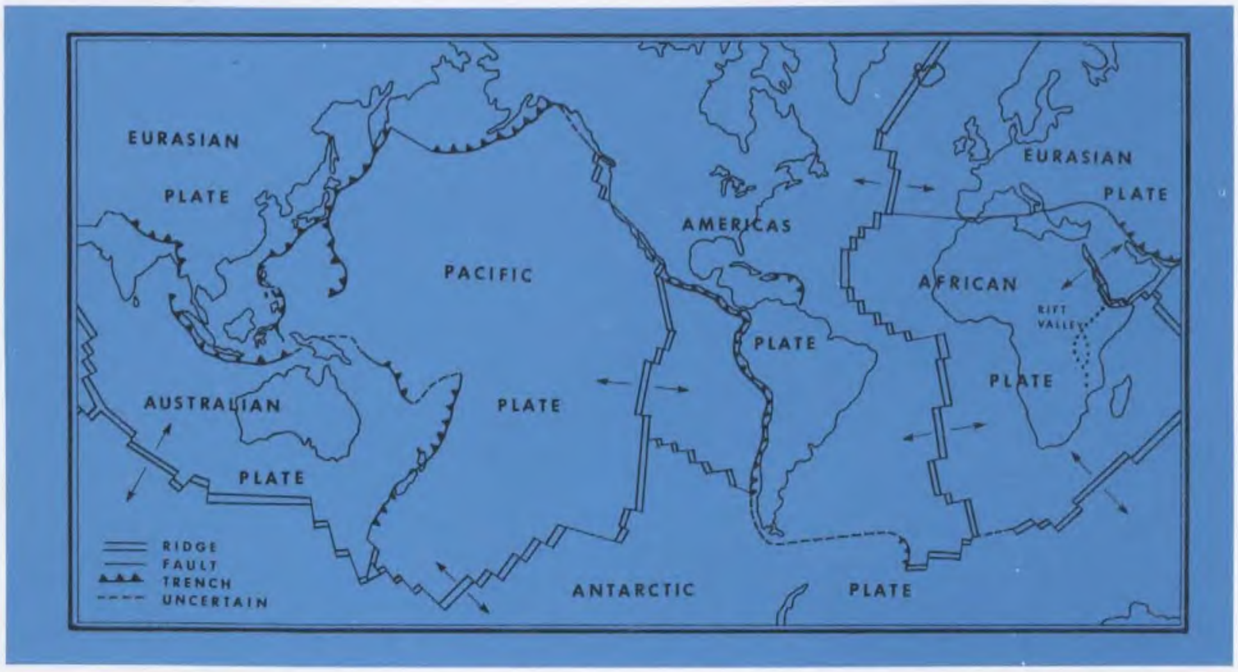
Dr. Wilson explained that many of these "triple-breaks" link together to form lines along which plates separate. One of the two active ridges of a given triple-break extends until it joins with an active ridge of another triple-break, and so on to form a zig-zag ridge thousands of miles long. The world-wide network of mid-oceanic ridges was formed in this manner.

Dr. Wilson went on to conclude that if one triple-break is caused by one plume rising near the Earth's surface, a series of triple-breaks implies a series of rising plumes. And so, it is thought that a ridge as long as the mid-Atlantic represents the activity of numerous plumes.

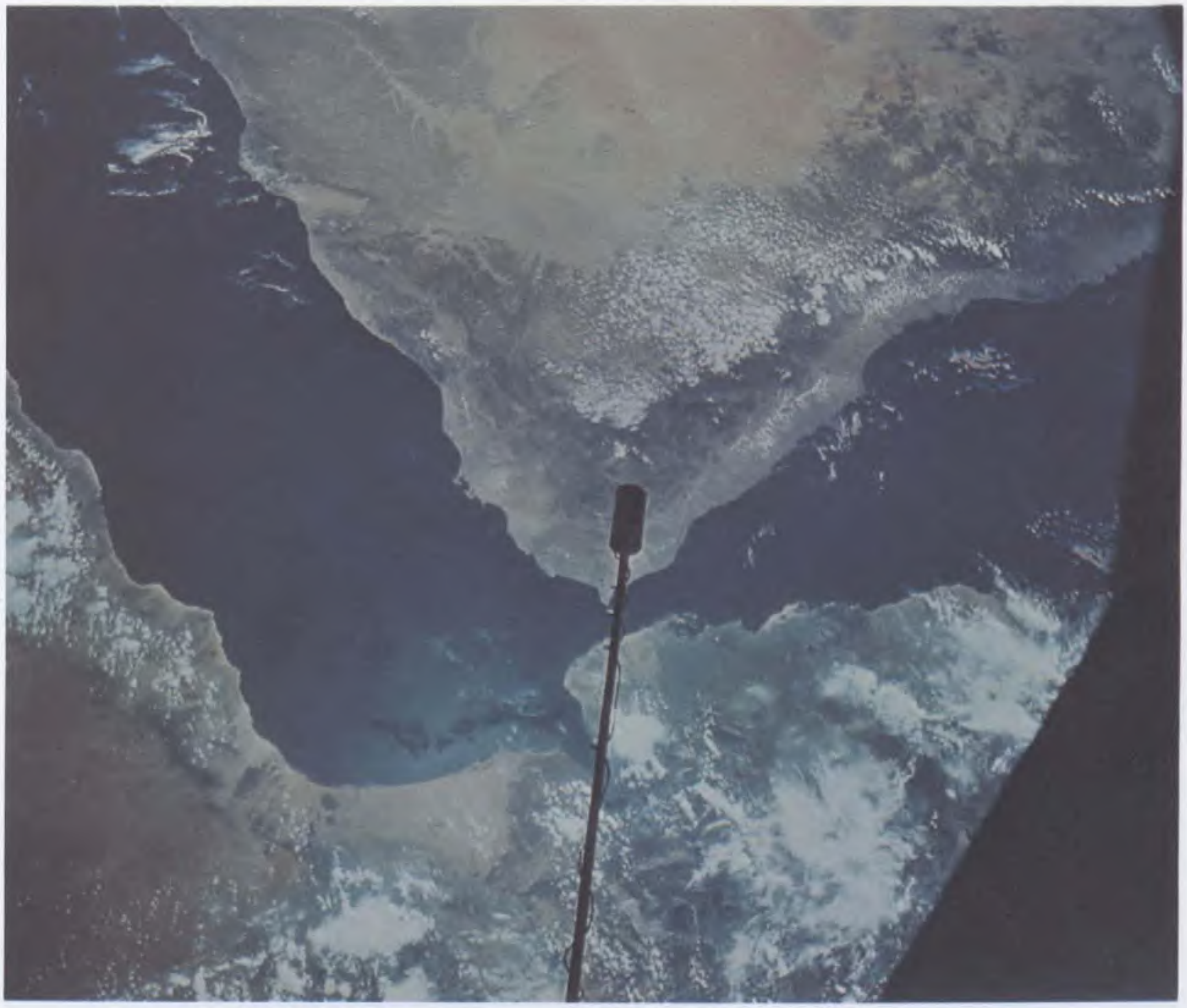
Once the breaks occur, gravity makes the disconnected part of the plate slide down the swelling caused by the plume, said Dr. Wilson. The fact that the plate slides suggests that the huge plates themselves float on a cushion of partially molten rock, now thought to form a continuous, 200-mile-thick layer within the Earth. The top of this putty-like zone is 30 to 60 miles deep and the bottom runs to an average depth of 250 miles.

This cushion layer remains partially molten and occurs under so extensive an area because it continually absorbs heat and much of the new rock carried up from below by plumes, according to Giorgio Ranalli, a geophysicist at Carleton University in Ottawa. When the rising plume rock reaches this zone, the surrounding rock is no longer denser than the rising rock, so the plume not only forms a bulge but also disperses some of its contents into the partially molten layer.

According to R.I. Walcott of the Geological Survey of Canada, the continental plates are about 60 miles thick. He based this calculation on the rate at which the Canadian portion of the Americas Plate is recovering from the sag caused by the weight of glaciers during the last Ice Age. Until 10,000 years ago nearly all of Canada bore the tremendous weight of ice — often 200 to several thousand feet thick — and the northern part of the Americas Plate sagged downward against the partially molten cushion.



The six principal plates are shown above. Arrows show the direction of sea-floor spreading on either side of active ridges. Pips on the trenches indicate the direction in which plates are moving down into the Earth's mantle. This drawing is modified from John Dewey (1972) and Peter Rona (1973).



This photograph shows the Red Sea to the left and the Gulf of Aden to the right. About 20 million years ago a plate carrying the Arabian Peninsula split from the African Plate, making this event one of the youngest major plate breakups. New oceanic crust is being produced along a central ridge in the Red Sea.

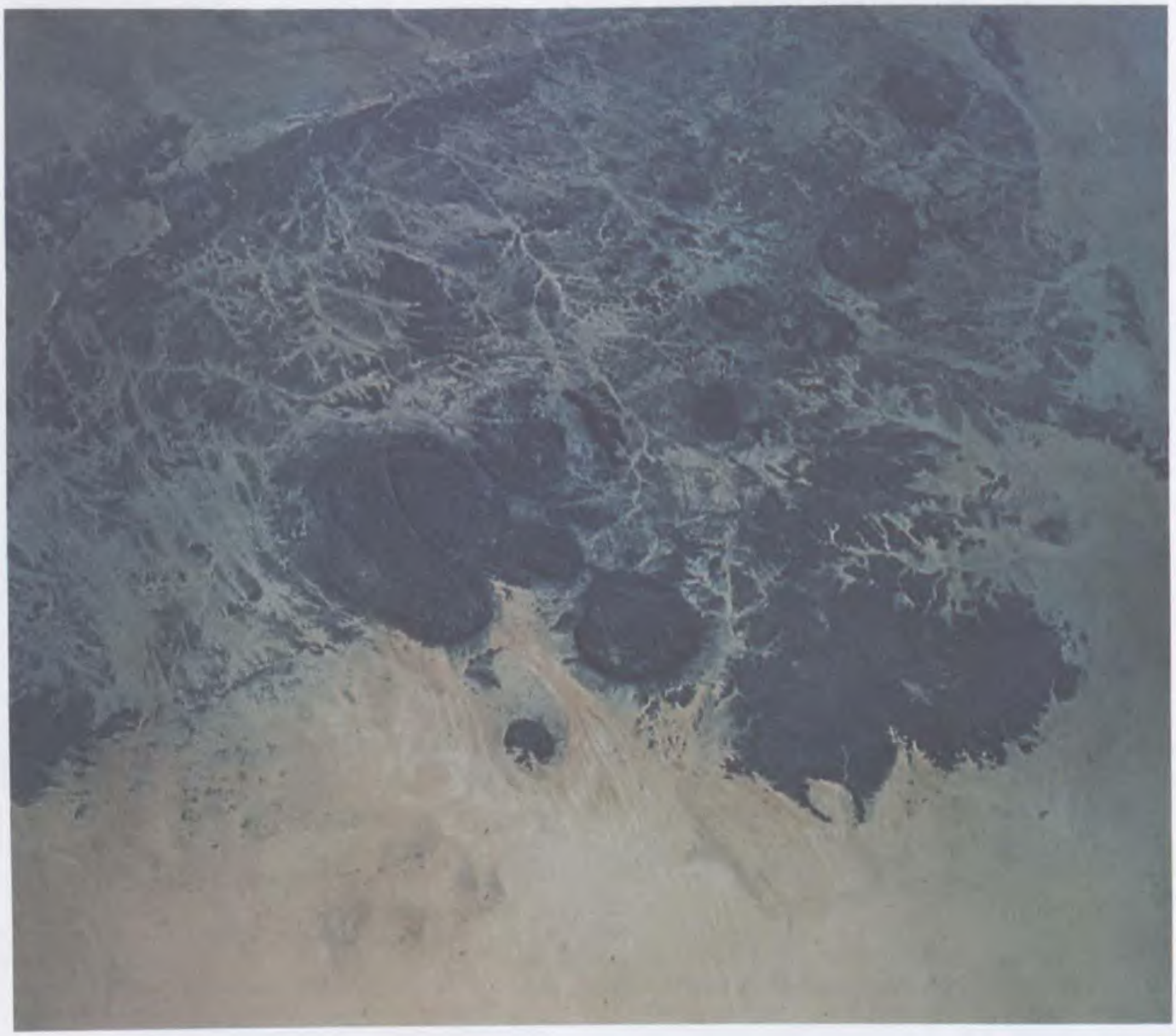
Several pools of hot brine, lying in depressions and cracks in the ridge, contain very high concentrations of economically valuable elements such as lead, zinc, copper and iron. Many geologists believe there is a direct link between formation of ore deposits and plate collisions and breakups.

Using very sensitive instruments which measure slight changes in altitude and the gravitational field beneath a given area, Dr. Walcott determined that parts of Canada were rising several centimeters per year. From the rates measured in many locations, and from the estimated weight of the ice in any given area, Dr. Walcott calculated that the plate under Canada is about 60 miles thick. He assumed other continental plates are about as thick.

Meanwhile, a group of five geophysicists at the University of Alberta in Edmonton and the University of British Columbia in Vancouver have reported evidence of a plume beneath Hawaii and have studied and described their find more thoroughly than has been done with any of several other suspected plumes. Their analysis is based on earthquake waves generated in the South Pacific and recorded at networks of seismic stations in south-central Alberta and northeastern British Columbia after passing through the plume.

These stations measure the speed at which the seismic waves leave earthquakes in the Tonga Trench, 500 miles east of the Fiji Islands, curve down to the core-mantle boundary below Hawaii, and then curve upward to western Canada. If the rocks below Hawaii were the same as the average rock of the mantle, the earthquake waves would reach each of many monitoring stations in Alberta and British Columbia at approximately the same time.

At some stations, however, they arrive several tenths of a second later. Ernest Kanasewich, leader



These dark volcanic domes in Africa's Sahara Desert are thought to indicate that a mantle plume is rising from below. According to many earth scientists, the plumes which rise beneath a stationary plate create high plateaus, particularly those with evidence of volcanic activity similar to the domes shown above.

of the group which began work in 1970, attributes the discrepancies to a cylindrical zone of rock that differs in density from the surrounding rock. Most likely a plume, the zone is about 300 miles wide down at the core-mantle boundary, and 600 miles wide just below Hawaii.

The central cylinder of the supposed plume seems to contain dense rock, thought to be similar to the calcium-, aluminum-, and titanium-rich rocks of the moon. The outer cylinder apparently consists of lighter rock which slows down earthquake waves and thus causes delays.

However, while the Kanasewich group has described plumes, the origin of these phenomena remain in doubt. Variations in the amount of heat-producing radioactive elements at points along the core-mantle boundary may cause some areas to be hotter than others, said Dr. Kanasewich. These hot areas might give rise to plumes.

But Dr. Ranalli suggested that in the Earth's molten core there are very slow-moving convection currents — a bit like the circular bubbling up and settling motion of boiling porridge — which rise from within the core to heat the rock at certain points on the border between the core and the mantle.

Whatever the cause of plumes, Dr. Wilson suggested in 1973 that perhaps as many as a dozen plumes were rising below Africa, because that continent has many high plateaus such as the Tibesti Massif, which rises over 8,000 feet above the floor of the Sahara Desert. He also theorized that high plateaus — especially those topped by volcanoes — indicate that a plate has remained stationary over a plume for some time, whereas long chains of volcanoes, such as those on the Hawaiian Islands, indicate that a plate has moved over a plume.

Dr. Wilson said the African Plate, which includes the continent and a large area of the Atlantic, Antarctic and Indian Ocean floor around Africa, has not moved at all in the past 25 to 30 million years.

While Canadian geophysicists tried to explain why plates move and oceanographers studied modern-day plate motion, geologists right across Canada were discovering traces of plate movement in the distant past.

Studies on the west coast indicated that Vancouver Island may have moved thousands of miles north in the past 40 to 60 million years.

The evidence comes from examination of tiny magnetic crystals, such as those of iron-bearing minerals, which line up according to the Earth's magnetic field when molten rocks solidify. Although the charge of the north and south magnetic poles has reversed many times in geologic history, the locations of magnetic poles — and thus orientation of magnetic lines of force — have remained stationary throughout time. Therefore, rocks of any age which formed in the same place relative to the north and south magnetic poles should have the same alignment of magnetic crystals.

However, geologists discovered wide variations in the orientation of magnetic crystals in rock units of different ages, found overlying each other on Vancouver Island. These variations suggest that the plate on which a given rock unit formed later moved to a new location where the next unit welled up and solidified.

From such evidence J.O. Wheeler of the Geological Survey of Canada estimated Vancouver Island once may have been near Peru.

Other Canadian geological teams found that:

> —Five large episodes of plate movement may have occurred during the period from 2.5 billion to 600 million years ago. Ted Irving and J.K. Park of the Earth Physics Branch of the Department of Energy, Mines and Resources used the same kind of magnetic evidence used in the study of Vancouver Island to reveal five major shifts in the orientations of magnetic crystals;
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> —One billion years ago, the territory from North Bay to Niagara and northeastward along the Saint Lawrence River up to Labrador may have been off the coast of Nigeria, where the Gulf of Guinea is today, said Dr. Irving and Dr. Park;
>
> —There is evidence of a triple-break two billion years old in the Great Bear Lake area of the Northwest Territories. In the early 1970s P.F. Hoffman of the Geological Survey of Canada discovered, among other clues, Rift-Valley-type rocks around the east arm of the Great Bear Lake and in the present valley which extends about 100 miles further eastward.
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> —The 2.5 billion-year-old sulfide ore deposits of northern Ontario, Quebec, Manitoba and Saskatchewan resemble in many ways the metal deposits found today where plates split up or collide, said Dr. Goodwin. Therefore, the general areas where sulfides occur — usually 50 to 100 miles wide and 100 to 250 miles long — may indicate the edges of smaller plates far back in geologic time.

Imax

MARLENE SIMMONS

Eight hundred people in Toronto were trapped in a raging forest fire, surrounded by the crackling and crashing of burning trees. Several hundred in San Diego, California, experienced travel through the universe. In Orlando, Florida, hundreds more put their heads into a lion's mouth.

All enjoyed the appropriate emotional or esthetic experiences, but the Toronto crowd escaped unsinged, the people in San Diego didn't suffer a moment of weightlessness, and not one member of the crowd in Orlando was hurt by the lion.

All of them had undergone their various experiences in a motion picture theatre, courtesy of Imax, a new 70-millimeter motion picture system developed by a Galt, Ontario firm.

Using a screen six storeys high and 80 feet wide, Imax — "eye-max", as in "maximum" the "eye" can see — makes it possible to involve an audience almost totally in a film because the picture fills all of the viewer's visual field, even his peripheral vision.

Up to 90 speakers with as many as 24 tracks of sound on each can be used with a single film, completely surrounding the audience and further heightening the illusion of action all around them.

By the summer of 1973 six Imax films had been produced, including a remake of Labyrinth, originally a multi-image film produced for Expo 67. The budgets for these movies, each of which was a series of unrelated short sequences, ranged from $100,000 to $1,200,000.

Multiscreen Corporation, the developer of Imax, has provided Imax movies and projectors to the Reuben H. Fleet Space Theatre & Science Centre in San Diego, California; the Cinesphere at Ontario Place in Toronto; the Ringling Brothers Barnum & Bailey Circus World project at Orlando, Florida, and the Fuji industrial group's pavillion for Expo 70 in Osaka, Japan.

The camera used to shoot Imax films is a surprisingly compact nine inches high, 13 inches wide and 17 inches long and weighs about 40 pounds unloaded. With a lens and three minutes' worth of the 1.9-by-2.7-inch Imax film, it weighs about 70 pounds.

Initially Imax, like previous three-dimensional or wide-screen processes, was received as something of a gimmick or novelty. Some film authorities seemed convinced it would remain just that. Others saw it as a major development in legitimate film making.

Norm Kingston, a film editor for Film House in Toronto, feels Imax "has a lot going for it". He acknowledges that Imax's weakness lies in close-ups, but feels it is highly effective in portraying action.

"People get put off by seeing giant eight-foot heads, but this system really gives you the feeling of being part of any action going on. I think Imax could be added very effectively to 35-millimeter movies for striking special effects," he said.

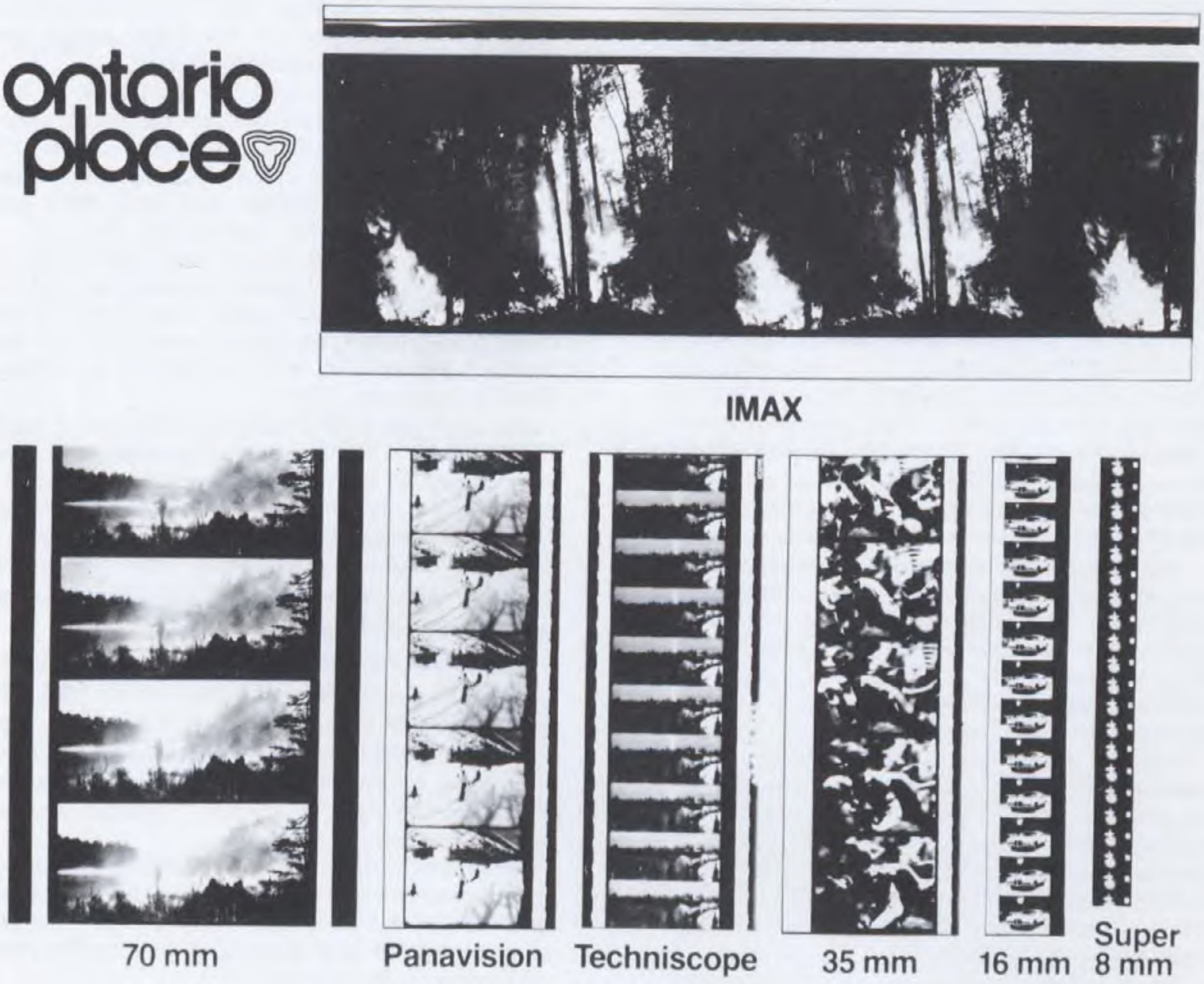
Multiscreen Corporation began working on the Imax system in 1967. Robert Kerr, a businessman, was joined by director-producers Graeme Ferguson and Roman Kroitor, as well as engineer William Shaw, to form the company to exploit the market for multi-image films like the original Labyrinth, which had been very popular during Expo 67.

The problem with multi-image, Expo-type films was that they used a lot of costly equipment geared to show just one specific movie. "Expo-type films don't have to make money, but we wanted to be able to produce similar films that would make money with a simpler, more flexible system that was less expensive," Mr. Kerr said.

To produce all the images seen in a film such as Labyrinth with just one projector instead of several, it was necessary to use larger film. That, in turn, meant a specially-designed projector and camera.

The Imax film — three times larger than Cin-

ontario place



Two and one-half frames of Imax film are compared to other standard motion picture films.

erama, the second largest form of motion picture — posed no problem in itself. The first difficulties arose in developing a projector through which the film would move with minimal damage.

Since the frames on an Imax film were so much larger than normal, the film had to be moved through a projector considerably faster than usual. In conventional cameras, the film is pulled through on sprockets, the teeth of which catch perforations at the side of the film strip. Moving at the required speed over these sprockets, large film tended to tear on the teeth. The result was an unsteady, poorly-focused picture and a severely reduced lifetime for a film print.

In 1968, Multiscreen tested and purchased patent rights to the "Jones rolling loop", a new way to move film that was invented by an Australian engineer. It became the basis for the Imax projection system. This loop sent the film through the projector with a wave action similar to the action by which a caterpillar moves — that is, pulling up its end by arching its back and thrusting its head forward. The loop practically eliminated sprocket damage.

To maintain good focus, a vacuum control system was installed at the film gate to hold the film flat for projection. The best source of vacuum available was Mrs. Shaw's vacuum cleaner, which was almost built into the projector that went to Expo 70. It actually did go to Japan as a spare part, along with nearly five tons of equipment for the Imax debut at that Expo.

Meanwhile, Multiscreen was commissioned by the Fuji group — 36 industries headed by the Fuji Bank, Japan's largest bank — to do a film for Fuji's Expo 70 pavillion.

"We were lucky they came to us at that time because we had only a little private money in our corporation. We were also able to get a PAIT (Program for the Advancement of Industrial Technology) grant of $206,025 from the Department of Industry, Trade and Commerce to help in the development of the projector," Mr. Kerr explained.

Realizing in the spring of 1969 that time was running short, Multiscreen farmed out the development of the Imax camera to a Danish engineer. "Because the film only had to go through the filming camera once, the sprocket damage would be negligible, and so all that really had to be done was scale up a conventional camera to hold the larger Imax film," said Mr. Kerr.

The only problem remaining, then, was to find a light source strong enough to project the huge Imax picture. Multiscreen's solution was a xenon lamp and a solar simulator used by the U.S. aerospace industry to test solar energy panels for satellites.

This system gave the 25,000 watts of light the projector needed — equal to the light emitted by 65 street lights — but it also produced enough heat to keep a house comfortably warm all winter. To cool the projector a series of heat sinks and fans were built into it. A series of special mirrors, which remove 90 per cent of the infrared heat but preserve 90 per cent of light, also were incorporated into the projector.

The Expo 70 showing was a gruelling test for any projection system because it had to run almost 12 hours a day for 180 days, with two showings each hour. It was estimated that 35 million feet of film went through it without a single break.

"The Russians at Expo 70 produced a 70-millimeter film with 10 perforations per frame, about two-thirds the size of Imax, but their best film life was 250 showings. A similar Japanese film lasted only 150 to 200 showings, and both films had pretty unsteady pictures," claimed Mr. Kerr.

Mr. Kerr estimated that it cost $600,000 to develop the basic Imax system and another $150,000 for design improvements. After Expo 70 the Ontario government bought the projector and it was installed in the 800-seat Cinesphere at Ontario Place in December, 1970.

Mr. Kerr said Imax movies were not that much more expensive than ordinary movies because costs of shooting on location, transportation, living expenses and director's salary were pretty well fixed. He said the larger size of Imax film would make it more expensive and would mean higher developing costs but these represented only a small percentage of a total movie budget.

Working in conjunction with Paramount Pictures, Multiscreen was scheduled to produce a $650,000 Imax picture for the U.S. Pavillion at the 1976 Expo in Spokane, Washington. Negotiations have been completed for an Imax theatre and movie for the Thorpe Water Park in London, England, another amusement centre.

Multiscreen rents out Imax cameras for about $1,500 a week and will sell the projector and control panel for about $235,000. A percentage of the box office receipts of each showing of an Imax film must also be paid to Multiscreen.

Wind Tunnel

RANDY DENLEY

As buildings in Canadian urban centres began soaring to unprecedented heights in the 1960s, the risk of severe wind damage to the new skyscrapers climbed with them. Building technology had simply advanced faster than man's knowledge of the effects of wind on tall structures.

By the middle of the decade, however, an engineer at the University of Western Ontario had developed a wind tunnel technique for testing the effects of wind on projected skyscrapers before a spadeful of sod was turned to start their construction.

Ultimately, the work of Dr. A.G. Davenport was to result in the establishment of new governmental construction standards and save thousands of dollars for developers and building owners by preventing unnecessary construction and maintenance costs.

Wind can cause extensive damage if a structure is not designed to cope with it. In 1941, "Galloping Gerty", the Tacoma Narrows Bridge in Washington State, completely broke apart as the deck of the bridge jumped five feet in the air in only 40-mile-per-hour winds.

In 1958, gusting winds blew down the inadequately-braced frame of the Union Carbide Building in Toronto, causing $600,000 damage.

Perhaps the most dramatic recent example of wind damage is the case of the John Hancock Mutual Life Building in Boston. During 1972 and 1973 over 350 panes of glass in the 60-storey building were cracked or broken by wind.

Wind can also cause cracks in plaster and exterior building surfaces or even make a building sway enough to make its occupants uncomfortable.

In 1970, in keeping with Dr. Davenport's findings after 13 years of research, the National Building Code of Canada was amended to require that buildings over 400 feet and very slender buildings be tested for wind response. Guidelines for determining safe limits for wind response also were written into the Code.

Dr. Davenport's wind tunnel tests also allowed architects to be less conservative in design by indicating where they could remove excess material. Because alterations are made in the design before any actual building is done, it is not possible to accurately relate the savings in terms of dollars.

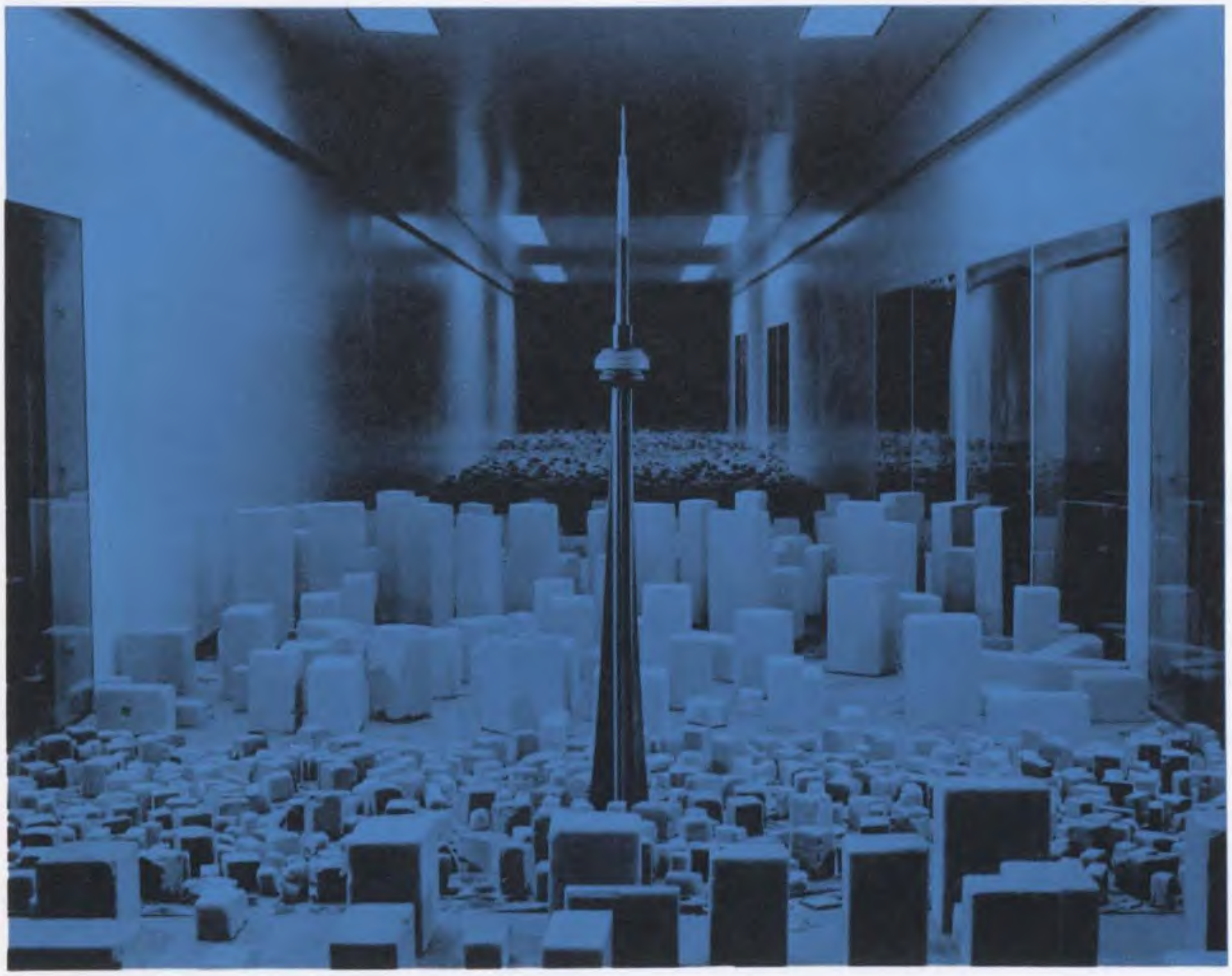
Before Dr. Davenport's research, whenever architects or engineers took wind pressure into account, they assumed that winds blowing at a given velocity would exert a static or unvarying pressure on buildings. This static theory of wind flow and its effects failed to account for two important factors — turbulence caused by surrounding buildings or landforms and the cumulative effects of this turbulence.

The inadequacy of this approach was not so significant a problem when buildings were shorter and thicker and used more concrete, a dense material which responds relatively little to wind pressures. But it assumed increasing significance with the proliferation of modern skyscrapers, built largely of more flexible steel and glass.

When Dr. Davenport began studying the National Building Code in 1957, while with the National Research Council in Ottawa, he agreed with earlier theorists that the static theory was inadequate. He consequently set out to examine the real effect of wind on buildings, ultimately using a natural flow wind tunnel of his own design. He became the first to demonstrate the importance of the dynamic response.

According to the dynamic response principle, buildings and landforms surrounding a structure cause gusts and turbulence which exert variable pressures on the structure and make it react in ways not accounted for by the old static concept.

A building is always vibrating, but gusts can increase or decrease that vibration, depending on their strength, direction and the moment at which they hit the building.



A test of the 1,805-foot CN tower, now under construction in Toronto, was performed at the Boundary Layer Wind Tunnel Laboratory.

If a building happens to be moving in the same direction as a gust when the gust hits it, the vibration will increase; if the building and the gust are moving in opposite directions, vibrations may decrease.

To determine the real wind pressure that a building in a given location might have to withstand, the pressure of the maximum gusts is added to the maximum static wind pressure.

In 1965, Dr. Davenport developed the Boundary Layer Wind Tunnel at the University of Western Ontario, which he had joined after having left the NRC and having done post-graduate work in England. The wind tunnel was designed to simulate the natural flow of wind around a given set of buildings and enable technicians to measure the dynamic response of a proposed structure.

The "boundary layer" refers to the first 1,500 feet above the ground. Within this space occur the effects on winds of buildings and land surfaces.

The methods of measuring pressure in the tunnel were unique when it was constructed. Since then, similar tunnels have been built elsewhere in Canada, the United States, France and Holland.

The wind tunnel is a rectangular pipe, 100 feet long, eight feet wide and seven feet high. A model of the building and as much of the surrounding surface area as it is possible to get into the space are set up on the floor of the tunnel.

The models, scaled to one four-hundredth the size of existing and proposed buildings, are made of various metals, plastics and woods. The materials are not necessarily the same as those that will go into the final building but they have many of the same properties such as stiffness, mass and strength.

Fans, as wide and high as the tunnel, generate winds, the speeds and directions of which are based on meteorological data gathered at the building site. The fans are fixed at one end of the tunnel. The models of the building under study and the immediately surrounding structures are on a turntable, enabling technicians to simulate winds from different directions.

Some natural conditions, such as pressures caused by rotation of the earth, cannot be simulated in the tunnel, but it can reproduce most wind forces significant to building designers.

Sensors implanted in the models are attached to transducers, electronic devices that translate wind pressures into electrical current. Computers analyze test results to determine how much sway or vibration there would be in the real building under maximum winds.

Since 1963, Dr. Davenport has put his research into practical effect as a wind consultant on such major buildings as the 41-storey Royal Bank, the 58-storey Commerce Court and the 72-storey Bank of Montreal, all in Toronto, and the World Trade Centre in New York. The buildings have performed as predicted.

"Judging by the number of times the telephone rings, we must be doing something right," Dr. Davenport said.

C.D. Carruthers and Wallace Consultants Ltd., of Toronto, agreed.

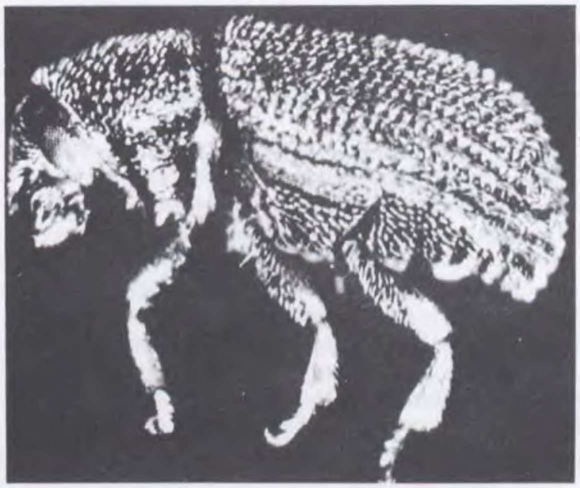
"We have used wind tunnel tests and will use them again because they provide an accurate description of how a building will behave in a given wind situation," a spokesman said.

Dr. Davenport, born in South Africa, has done most of his research in Canada and now is a Canadian citizen. He won two awards from the Engineering Institute of Canada and two from American engineering societies for his work on tall buildings and other structures such as bridges and cylindrical chimneys. He also won an award from the Canadian Meteorological Society for his use of meteorological data in the testing of tall buildings.

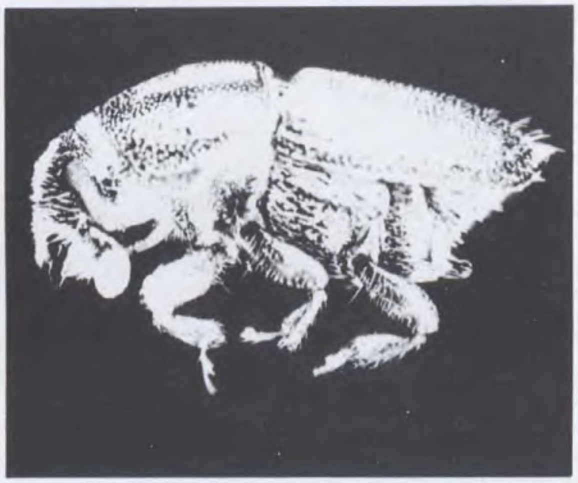
In 1973, Dr. Davenport was branching out from his work on tall buildings to study the effects of wind on smoke and ways to reduce wind in city streets.

Dutch Elm Fungicide

MARLENE SIMMONS



The native bark beetle above and the European elm bark beetle below, both about one-eighth of an inch long, are responsible for Dutch Elm disease.



For over 40 years, forests from Florida to the Laurentians and from the east coast to the Prairies had been decimated by a disease-bearing bug no larger than a fruit fly.

Perth County, Ontario, one of the hardest hit areas in Canada, lost over 100,000 trees between 1967 and 1973. Ottawa alone lost 1,000 to 1,500 trees a year after the late 1950s.

The bug, scolytus multistriotus, better known as the European elm bark beetle, carries the fungus that causes Dutch Elm disease. More than half a century of research in Europe and North America had failed to turn up a cure for the disease.

Dutch Elm disease has injured the trees on the left more than the elms at the right.

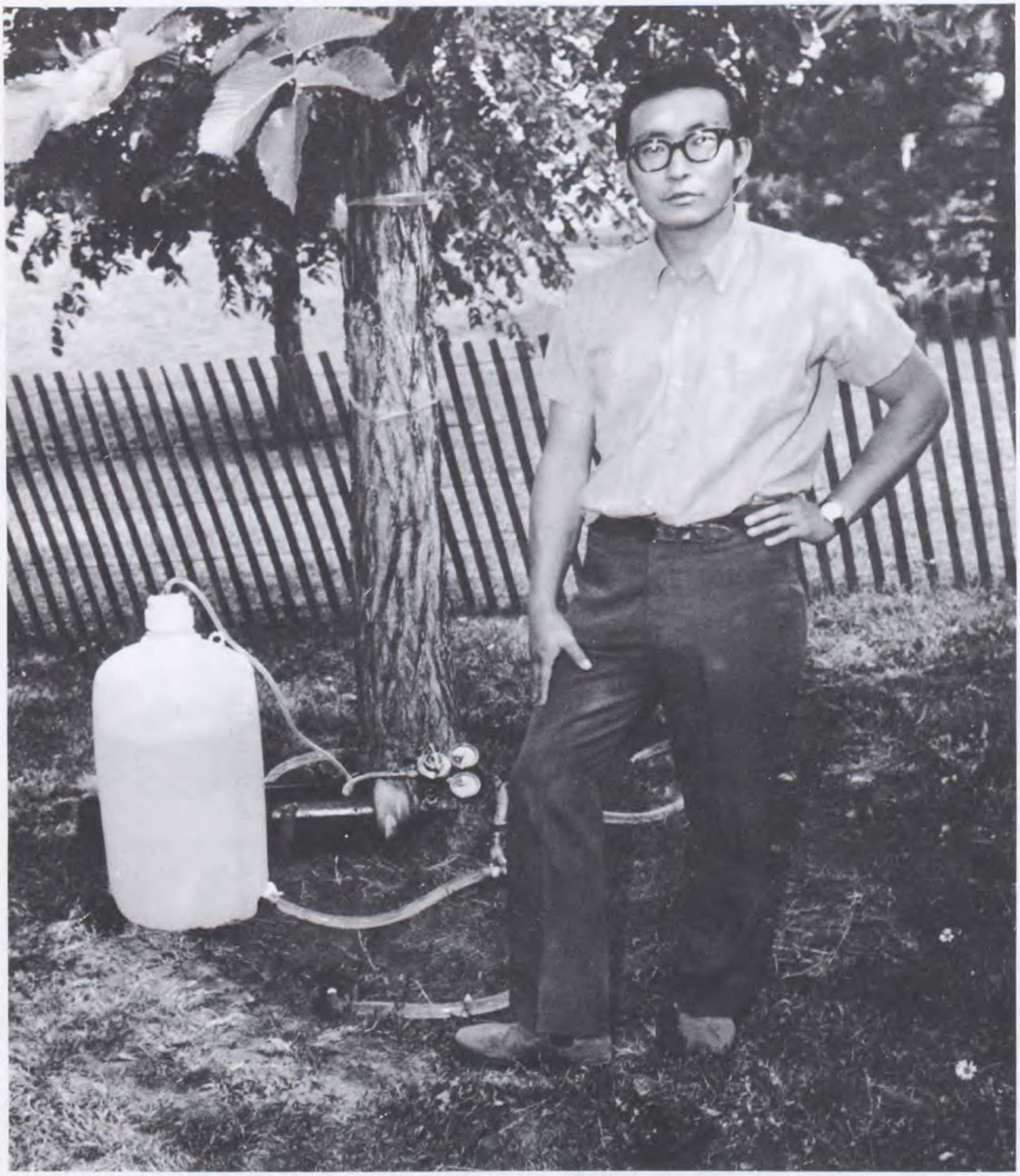
But, in the fall of 1970 a team of scientists from the University of Toronto and the federal government's Great Lakes Forestry Research Station at Sault Ste. Marie found what three years of subsequent testing indicated was a cure.

They developed a light grey powder which is mixed with water and injected through the roots of the elm tree. Because their fungicide was not yet patented by mid-1973, they would not reveal its composition but they did describe how it works. The tree's circulatory system distributes the fungicide evenly to all its limbs. Like a vaccination, this fungicide immunizes a tree against further infection while it kills any fungus already present.

"It literally chokes the fungus to death," explained Dr. D.N. Roy, a chemist at the U. of T. Faculty of Forestry who helped develop the fungicide. "It encircles the fungus colony and cuts it off from the food and water that it usually takes from the tree. The tree grows a new annual ring, and the dead fungus is locked away."

The scientists who developed the fungicide estimated that once it was into commercial production, it likely would cost about $50 to immunize an 80- to 90-foot tree for five years.

Before the discovery of this cure, infected branches were usually pruned or a diseased tree was sprayed with a chemical that would kill the



Dr. Ed Kondo stands by the root injection equipment used to curb Dutch Elm disease.

beetle. Though these methods slowed down the disease, they did not stop it since they attacked the disease carrier and not the disease itself. The new fungicide goes to the root of the problem and kills the fungus.

Meanwhile, another fungicide that depended for its effectiveness on a tree's own circulatory system already had been marketed. But it was applied by soaking the ground around the roots with a fungicide solution and, according to one user, had been only about 30 per cent effective when tested on 11 infected trees.

The new fungicide, which is injected into the tree instead of sprayed from the air, causes no ecological damage. Nor does it harm the tree itself. In fact, it fertilizes the tree and, one year after the first injection, the tree has larger and greener leaves. In addition, the tree stores the substance, which means it does not need yearly attention.

Dr. Erik Jorgensen, a plant pathologist at the Faculty of Forestry who also worked on the fungicide's development, said experiments showed the fungicide remains potent at least three years and possibly as long as five. These experiments, using trees on National Capital Commission property in Ottawa, began in 1971.

"We have cut samples from 14 trees which had been treated two years earlier with our fungicide and found it was still 100 per cent effective," said Dr. Jorgensen. Wood taken from treated trees was bathed in a solution containing the disease and resisted it. Untreated wood put in the same solution quickly became infected.

A second experiment was carried out on 80 diseased NCC trees in the spring of 1972. They were treated with fungicide while 10 other trees in the same area were left untreated. Only one treated tree died, but all 10 untreated trees died between mid-June and mid-July, the period when the disease is most virulent.

European scientists had been looking for a cure for Dutch Elm disease since 1919 and North Americans joined the search in 1928. They knew that when the small European elm bark beetles emerged from winter breeding sites in dead or dying elms, they began to feed on healthy ones. As they did, they transmitted the spores of a fungus that deposits a gummy substance in a tree's circulatory system and kills it by choking off the passage of its nutrients and water.

Dr. Jorgensen began his fungicide research at the Shade Tree Research Laboratory at the University of Toronto in 1961. He was primarily interested in the relationship between the tree and the fungus itself and he enlisted Dr. Roy to select possible chemicals that would kill the Dutch Elm fungus without hurting the tree. Thirty chemicals were identified; then the field was narrowed by trial and error.

To inject the fungicide into a tree, the scientists used a system developed by Dr. Ed Kondo, a research scientist at the Great Lakes Forestry Research Laboratory of the Canadian Forestry Services. They dug outward from the trunk of the tree until they found a root three-quarters to 1-1/2 inches thick. They severed the root and hooked a hose to it by means of an adapter ring. A series of these hoses was attached to a 45-gallon reservoir in which the fungicide was kept under a pressure of 10 pounds per square inch.

The reservoir had to be refilled every 12 to 18 hours and trees would absorb anywhere from two to 175 gallons of the fungicide, depending on their size. It took from 24 to 48 hours to saturate the xylem tissue on the outer annual ring of the tree, the ring that is susceptible to the Dutch Elm fungus.

Dr. Kondo said in 1972 it had cost an average of $92 to treat a tree, but NCC officials, whose trees had been the subject of developmental experiments, considered the money well spent.

"I'm really quite pleased with the results of our work with the fungicide," said Neil McLaren, deputy director of Parks and Grounds for the National Capital Commission. "At first glance it seems to be expensive, but when you realize it cost us anywhere from $100 to $750 to remove a dead elm tree, then it is relatively cheap."

In the summer of 1973 the injection system was being tested to see if it was practical enough to be used by a non-scientist. Dr. Kondo arranged to have 600 trees in Ottawa injected with the fungicide by nurserymen.

Dr. Kondo said other researchers were experimenting with the system which could have other uses besides treating Dutch Elm disease. In the United States researchers were adapting it to pump nutrients into fruit trees that had been defoliated by caterpillars and could not manufacture their own sap.

Scientists in Canada were working on adapting the system to protect fruit trees from pests, but it was too early to assess either project.

Waste Water and Peat

CLAUDE BONENFANT

A new process for eliminating heavy metals from industrial waste water has been developed this year by two University of Sherbrooke professors, Bernard Coupal and Jean-Marc Lalancette. This method will be used mainly to remove mercury from the effluent of industries using this metal in their manufacturing process.

The chief characteristic of this new method of purification is the use of a bed of peat. This method seems quite simple, but nonetheless it has demonstrated its effectiveness.

An indication of the importance of this new pollution-fighting technique is the fact that 90 percent of all water consumed in Quebec is used for industrial purposes. Thus the possibility of water pollution by industry is quite strong, and an effective new process for purifying industrial effluent is certainly welcome.

Furthermore, a study by the Quebec Water Board estimates the cost of fighting water pollution in the province over the next 15 years at $600 million; thus a process which is as inexpensive as the peat method should be pleasing to the industries concerned.

Mercury is a particularly harmful pollutant which can have disastrous effects on public health and the environment. The aquatic ecosystem is necessarily the most affected. A study of aquatic organisms and their predators revealed that there was a serious mercury pollution problem in the St. Lawrence and its entire drainage basin. Large quantities of mercury (and its compounds) are dumped into the water by the highly industrialized communities ringing the Great Lakes.

Furthermore, Quebec and Ontario alone account for two-thirds of the total Canadian consumption of mercury. Without wishing to be alarmists, we anticipate a great danger of mercury pollution in eastern Canada.

Because of the dangers posed by mercury, governments often regulate strictly the use of this metal (the Scandinavian countries, in particular, established safety measures over 10 years ago). In Canada some industries have already instituted radical changes in their manufacturing methods. For example, the pulp and paper industry is using less and less mercury. Others, due to a lack of technology or the prohibitive cost of purification, have to discontinue the use of mercury; this sometimes poses a threat to their survival. Some companies spend considerable amounts of money for only mediocre purification.

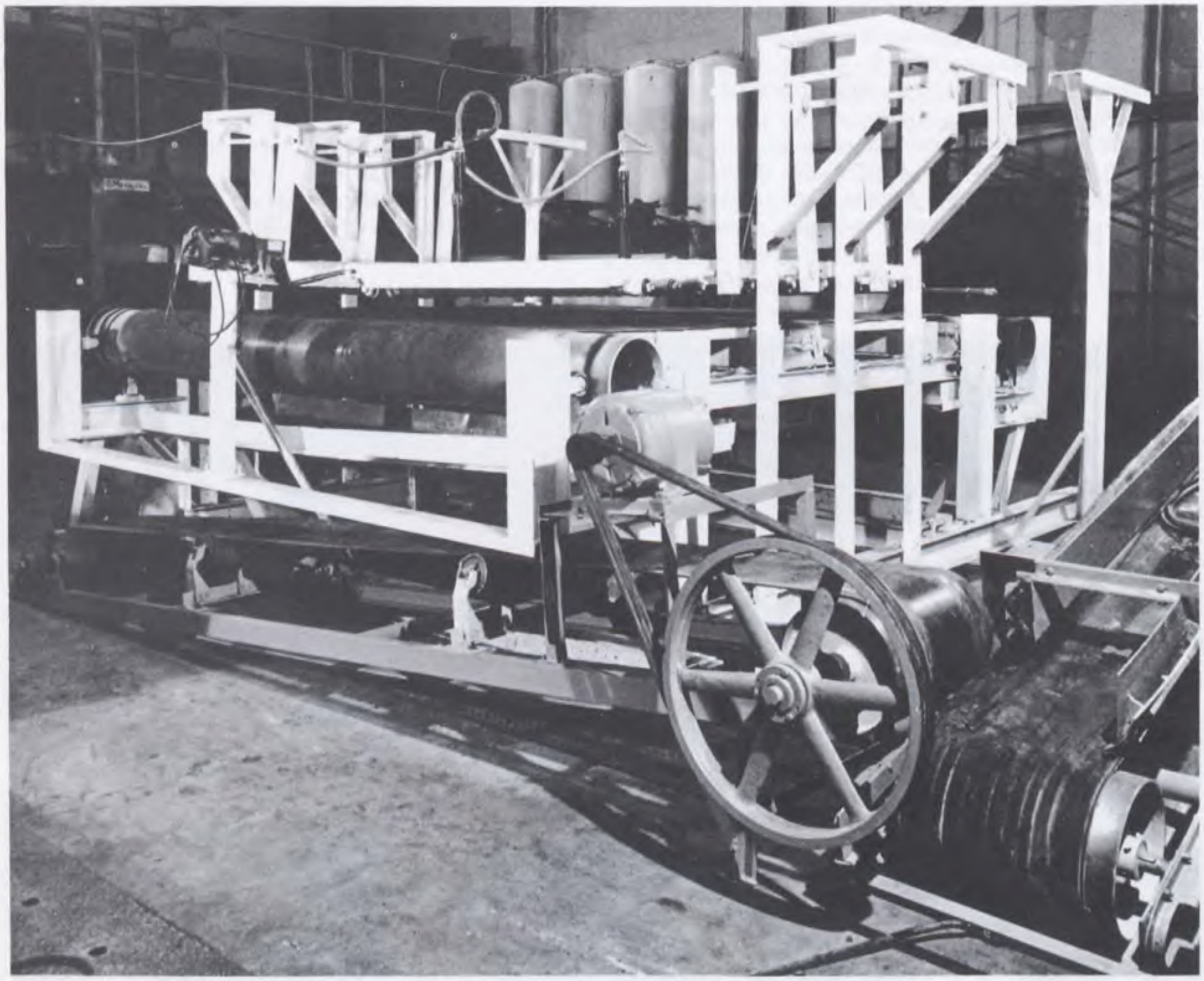
The peat purification process has proved to be inexpensive and effective. Peat treatment of water polluted by mercury or by other heavy metals such as cadmium, copper, zinc, nickel and lead is an extremely desirable method from the economic standpoint. It often requires no major modification in the techniques in use in these industries; moreover, the necessary material is easily obtainable.

As for effectiveness, laboratory experiments have proved that 99.998 per cent of the mercury is eliminated by the peat process. Thus water so treated is no longer a source of pollution, at least by mercury.

Here is a summary of the main stages of this discovery. In 1969 Bernard Coupal, of the Chemical Engineering Department of the University of Sherbrooke, began research on possible uses of peat. One of his tests involved measuring the absorption of petroleum by this organic substance, when the tanker Arrow broke up off the coast of Nova Scotia in February 1970.

Jean-Marc Lalancette of the University's Chemistry Department, who had also begun experiments on the absorption of mercury and other metallic

Professor Bernard Coupal, left, is director of the Department of Chemical Engineering at the University of Sherbrooke. Professor Jean-Marc Lalancette is assistant dean of research at the same university.



This is one part of the machine built by Mr. Lalancette and Mr. Coupal. After being used to filter the polluted water, the peat is wrung dry before being burnt. The burning permits the peat to recover the heavy metals.

pollutants by peat, joined Mr. Coupal in the summer of 1971 to form a research team to seek industrial applications for this process.

It should be pointed out that peat is not merely sod - it is a combustible, spongy, light substance, resulting from the slow decomposition of vegetable matter. Because of its surface, which can be described as dense, and because of its special molecular structure, it has interesting absorption properties.

However, Mr. Lalancette said that their experiments had revealed that the extended, spongy surface of the peat could not alone effectively retain mercury, since several parts per million (ppm) of the metal remained in equilibrium in the solution in the presence of peat. This can be removed by adding an agent which can precipitate mercury - sodium sulfide, for example - causing the formation of a fairly insoluble salt. Peat easily absorbs the new compound, mercuric sulfide, especially if ions have first been attracted to the already polarized surface of the peat. Since the sulfur is effectively retained, the quantity of mercury remaining in solution is therefore quite small.

Industrial effluent containing 500 ppm of mercury was given the peat and sodium sulfide treatment, and the concentration was thus reduced to 10 parts per billion. This represents, as we have mentioned, an elimination of 99.998 per cent.

Before treatment, there are preliminary operations which simplify the process. In order to avoid needlessly treating too great a volume of water, the effluent containing mercury is collected separately from other waste water, and then channelled at slow speed to a settling tank where the metallic mercury and other residual matter in the water is collected.

The actual treatment can then begin. In the first stage, water containing mercury (in the colloidal or combined state) is passed through a bed of peat impregnated with a 2-per-cent solution of sodium sulfide. The mercury sticks to the mass of peat while the contaminated water filters through the bed. There is another equally effective method of treatment: it consists of stirring the polluted water, peat and sodium sulfide in a tank. The water thus treated is then passed through a bed of peat.

In the second stage, the metallic mercury is recovered and the purification of the water is completed.

The recovery of the mercury requires several precautions so that the peat, once impregnated with mercury, does not become a new source of pollution. It is drained and dried in the open air, and once its moisture content has decreased by half, it is burned at 500 degrees centigrade; a controlled draught of air keeps smoke at a minimum.

Before leaving the burner, the effluent gas is heated to between 500 and 700 degrees centigrade so that no tar or condensable gas is produced. By passing it through a wash tower containing limestone and sulfur, the mercury vapours and sulfurous gases are eliminated. After settling, the mercury is recovered in its elemental state. This recovery can be a significant saving for a large industry. These condensates constitute less than 1 per cent of the water treated.

These various operations do not produce pollution. The effluent gases, after passing through the wash tower, are free of mercury and sulfur dioxide. The sediment in the tank can be burned with the peat. As for the excess sodium sulfide which might remain in the water after treatment, simple methods can be used to eliminate it, such as oxidation, ozonization or the bacteria bed process.

Besides reducing the danger of mercury pollution of water, at least by industry, this discovery should have a beneficial effect on the economy. As well as lowering the cost of water purification for the industries concerned, this process could eventually create a market for the peat in the vast tundras of northern Quebec and Ontario. Who knows? Once mercury pollution has been eliminated, we may witness the reopening of the fishing grounds of the estuary and gulf of the St. Lawrence.

The Sherbrooke team has received several research grants since 1968. These have come principally from the Quebec Department of Education and the National Research Council; the latter provided an important grant of $ 155,000 in 1970.

This discovery seems a suitable solution to the world-wide problem of mercury pollution caused by industrial waste water. Five patents have already been taken out on it. And sales permits have been issued for Canada, the United States, Japan and several European countries (France, Belgium, and others).

The process may prove very useful to the pulp and paper industry and the chemical processing industry. At the present time, the electroplating industry as well as the mining and textile industries of several countries are particularly interested in this new method of purifying industrial waste water.

Tar Sands

RANDY DENLEY

For over 40 years, Dr. Karl Clark of Edmonton tried unsuccessfully to promote commercial adaptation of the technology he had created to develop Canada's richest crude oil reserve, the Athabasca Tar Sands.

But not until a year after his death in 1966 was the technology Dr. Clark first developed in an Edmonton powerhouse basement in 1923 finally employed on a large scale to synthesize crude oil from the tar sands. Considered too costly until the late 1960s, the Alberta metallurgist's process became more and more economically feasible as North America awoke to an impending energy crisis and oil prices began to rise dramatically.

The Athabasca Tar Sands, which cover a 30,000-square-mile area the size of Lake Michigan 300 miles north of Edmonton, could yield about 300 billion barrels of synthetic crude oil, commercially recoverable as prices stood at the outset of the 1970s. A further 300 billion barrels could be extracted from hard-to-mine or poor quality deposits. Known North American reserves in 1973 totalled only 56 billion barrels.

In 1973, the Alberta government officially confirmed 26.5 billion barrels of Athabasca oil as part of Canada's known reserves. Even this small percentage of the total deposit increased the life of Canada's oil reserves from 15 years to 62 years, at 1973 rates of consumption.

Although the huge oil-producing capability of the Athabasca Tar Sands was first discovered in 1897, no successful commercial development was undertaken for 70 years. A small commercial plant built during the Second World War failed because of high mining costs in the face of competition from abundant supplies elsewhere.

By the late 1960s, though, the oil outlook had begun to undergo a drastic change. World energy consumption was expected to double between 1970 and 1980. Canadian oil reserves seemed likely to run out by 1990. Canadian domestic crude oil prices rose from $3.16 to $3.76 a barrel from 1971 to early 1973. The Canadian government clamped restrictions on heating oil and gasoline exports to the oil-hungry United States in an effort to moderate spiralling oil prices.

Dr. Clark's previously-uneconomical technology had come into its own. When he began his research with the Alberta Research Council in 1920, there was no way to separate the oil-rich bitumen from the black, sticky tar sand.

The Alberta Research Council enlisted Dr. Clark to develop a technology in the hope that the tar-like bitumen might be used as a road-paving substance. But Dr. Clark was able to see the future significance of the tar sands as an oil-producing area.

Although he worked with other men while with the Alberta Research Council and later when he was a professor of mining and metallurgy at the University of Alberta, Dr. Clark was the driving force behind tar sands research for more than 40 years.

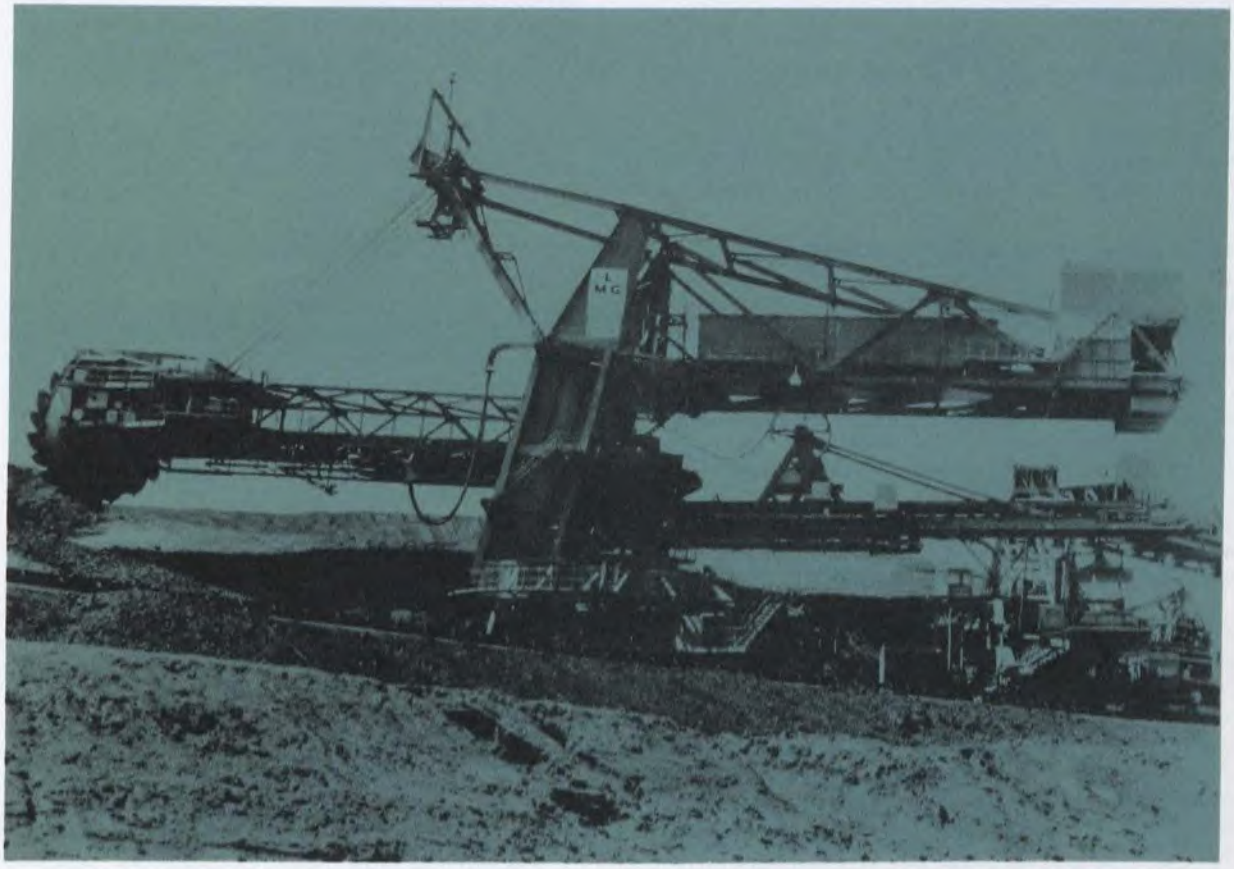
The separation process Dr. Clark developed is quite simple in theory. Water wets quartz sand surfaces more readily than oil, so when the tar sands are treated with boiling water, the water displaces the oil which floats to the surface. Boiling water is used because it causes air bubbles which break up densely packed sand and liberate pockets of oil.

In 1923, Dr. Clark and an Alberta Research Council chemical engineer, S.M. Blair, built their first hot water separation plant in the basement of the University of Alberta powerhouse at Edmonton. While the process itself was not complicated, the challenge lay in reproducing the technology on a large commercial scale.

In 1929, the small experimental plant in Edmonton was disassembled and moved to Waterways, Alberta, on the Athabasca Tar Sands. There Dr. Clark addressed himself to the technical problems which prevented large-scale production.

In the earlier experimental plants sand had been removed after processing by an inefficient bucket conveyor and there had been no way of cleaning the plant water or removing large lumps and impurities which clogged the system.

Technical modifications in the Waterways plant solved these problems. After the trees and muskeg which usually overlay the tar sands were removed



Giant bucketwheel excavators are used to mine tar sand near Fort McMurray, Alberta. Each of the crawler-mounted excavators can theoretically dig more than 100,000 tons of tar sand daily.

from a small area, the sands themselves were scooped up by steamshovels and stockpiled outside the plant.

A bucket conveyor carried the sands into the plant and emptied into a mixing tank. There the sand was stirred and mixed with boiling water and a silicate solution that neutralized the acidity of the water to make it better for separation.

The sand and water mixture then passed through a rotating screen which eliminated the lumps and impurities that had caused problems in the earlier plant. The hot, wet sand then passed into a separation tank, filled with hot water, where the oil-producing bitumen floated to the surface as a froth while the sand sank to the bottom.

The bitumen was scooped off the surface by a large steel bucket-wheel and stored. Sand was removed from the bottom of the separation box by a screw conveyor. In earlier plants, the sand had been carried up through the separation tank by a bucket conveyor, which scooped up and wasted some of the bitumen floating on the surface of the tank.

The used water was diverted to two cone-shaped tanks where the silt settled and was removed so the water could be recycled through the plant. This eliminated the necessity of frequently changing plant water to avoid silt accumulation.

The Waterways system proved to be an efficient way to remove 90 percent of the bitumen from the sand. When fully operational the plant could produce 1,000 barrels of bitumen a day to pave roads in Edmonton.

With the basic technological problems resolved, the tar sands development faced a bleak future. The Waterways plant was closed, a victim of the Depression. No significant effort to revive and build on Dr. Clark's work was undertaken until 1967 when the Great Canadian Oil Sands processing plant opened at Fort McMurray using the Clark system.

Dr. Clark's road-paving substance was far removed from the synthetic crude oil now produced from bitumen at the GCOS installation. Synthetic crude is a clear amber liquid that looks like flat beer. It is equal in quality to natural crude and can be refined to make gasoline, fuel oils and kerosene.

The $235-million GCOS plant was the first commercial synthetic oil plant in the world as well as the first successful commercial plant on the tar sands. It uses six coking furnaces to break the bitumen down into its components — gas oil, kerosene, naphtha, butanes, pentanes and coke. The gas oil, kerosene and naphtha then are reunited to form synthetic crude.

The plant produces 45,000 barrels of synthetic crude a day which is shipped to Edmonton by pipeline. From there it is shipped to the Sun Oil Co. Ltd. refinery at Sarnia, Ontario.

Other companies were planning much larger operations in the tar sands in the 1970s. Syncrude Canada Ltd. was planning to move into the tar sands in August, 1973, to start the largest mine in Canada with a capital investment of $700 to $800 million. The Murphy Oil Co. Ltd. of Calgary, and Shell Canada Ltd. of Edmonton were also planning to tap the huge potential of the tar sands in the 1970s. Again, the technology Dr. Clark never saw employed on the commercial scale he envisaged would be the basis of these operations.

Recording Instrument Package

ANNE SADLER

Canadian engineers have been eavesdropping on icebergs and rainfall in the northern Pacific and Arctic oceans — all in the name of defence research.

Since 1967 the Defence Research Establishment at Victoria, B.C., has been planting complex listening devices known as Recording Instrument Packages — or RIPs — at ocean depths of up to 2,000 feet. Their ultimate purpose is submarine detection.

Automatic monitoring systems such as the RIP — systems that can be deposited, left and recovered much later — are particularly attractive for use in Arctic waters. Surface ships can operate freely there for only two months of the year and cables from the water to the shore are both expensive and subject to damage by trawlers and ice masses near the shore. Long-term manned stations, either on shore or on the ice, are also expensive but, perhaps more significant, they are unattractive to most scientific personnel.

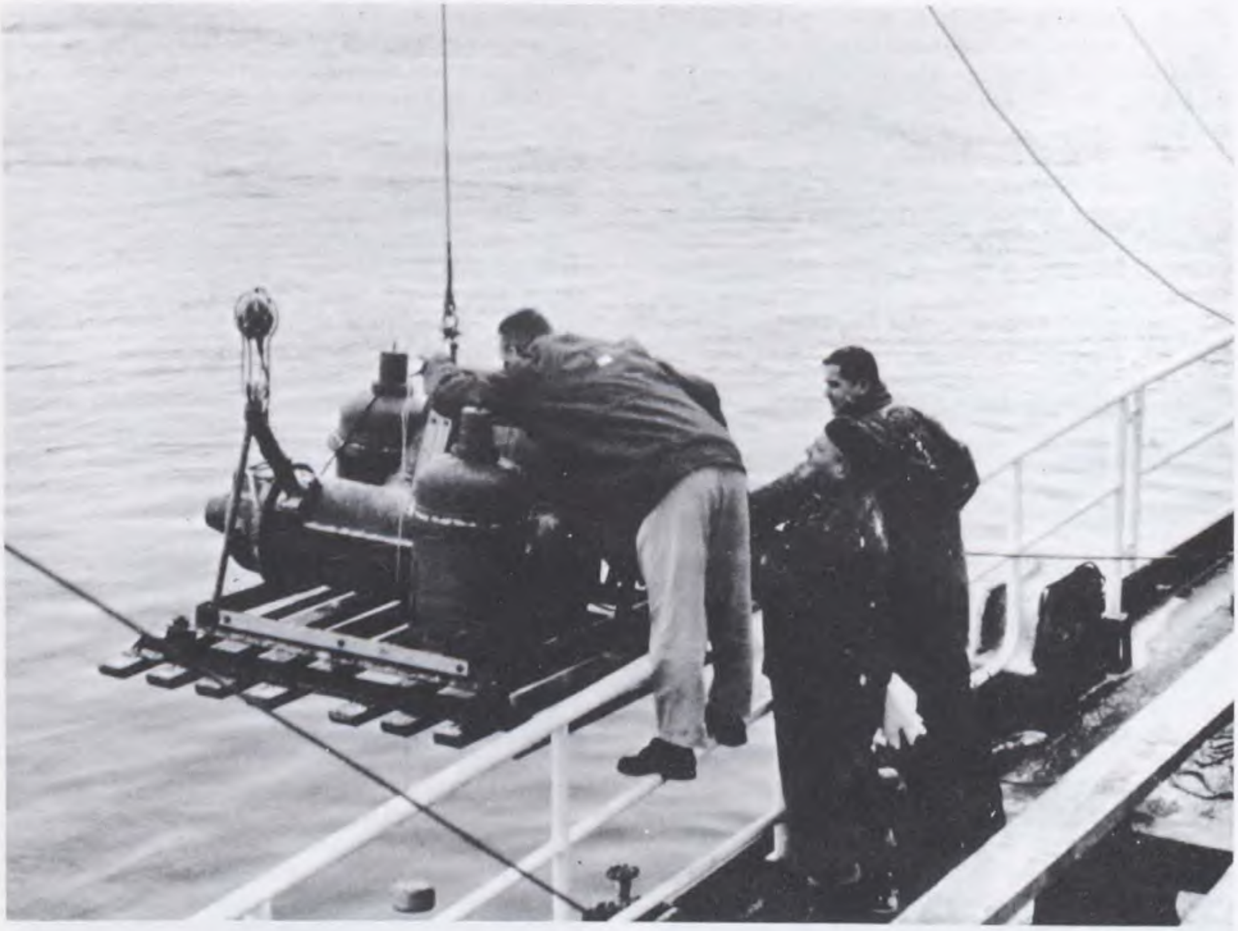
The RIP equipment developed at Victoria — the housing installation and recovery systems — could be used in systems designed for the underwater measurement of a wide range of ocean or sea characteristics such as salinity, temperature and turbulence.

But the original purpose of the RIP was to record the average loudness and persistence of noise common in the northern ocean depths as a backdrop against which unusual noises, like those of a submarine, would stand out. This information was later to be used in the design of a submarine detector; details of how were classified information.

There are conflicting opinions as to whether there is a real danger from submarine attack in the north. Still, the possibility remains that submarines can navigate in northern waters and either threaten Canada directly or go through our "back yard" to get to other countries. But even if a military threat is unlikely, there is the possibility of commercial submarine traffic through the north and Canadian maritime authorities want to keep an eye — or an ear — on underwater movements.

The first five RIP units were submerged in the summer of 1967 in channels between islands in the vicinity of the Queen Elizabeth Islands west of Greenland and north of Baffin Island.

The general RIP concept was not uniquely Canadian; U.S. engineers had been doing much the same thing in other oceans. But the equipment developed at the Victoria defence research station was original. Electrical engineers J.H. Ganton and W.H.M. Burroughs, working with mechanical engineer G.H. Dennison, produced a largely automatic system for laying and recovering RIPs as well as the recording instrument itself.



Crewmen examine a recording instrument package about to be lowered to the ocean floor.

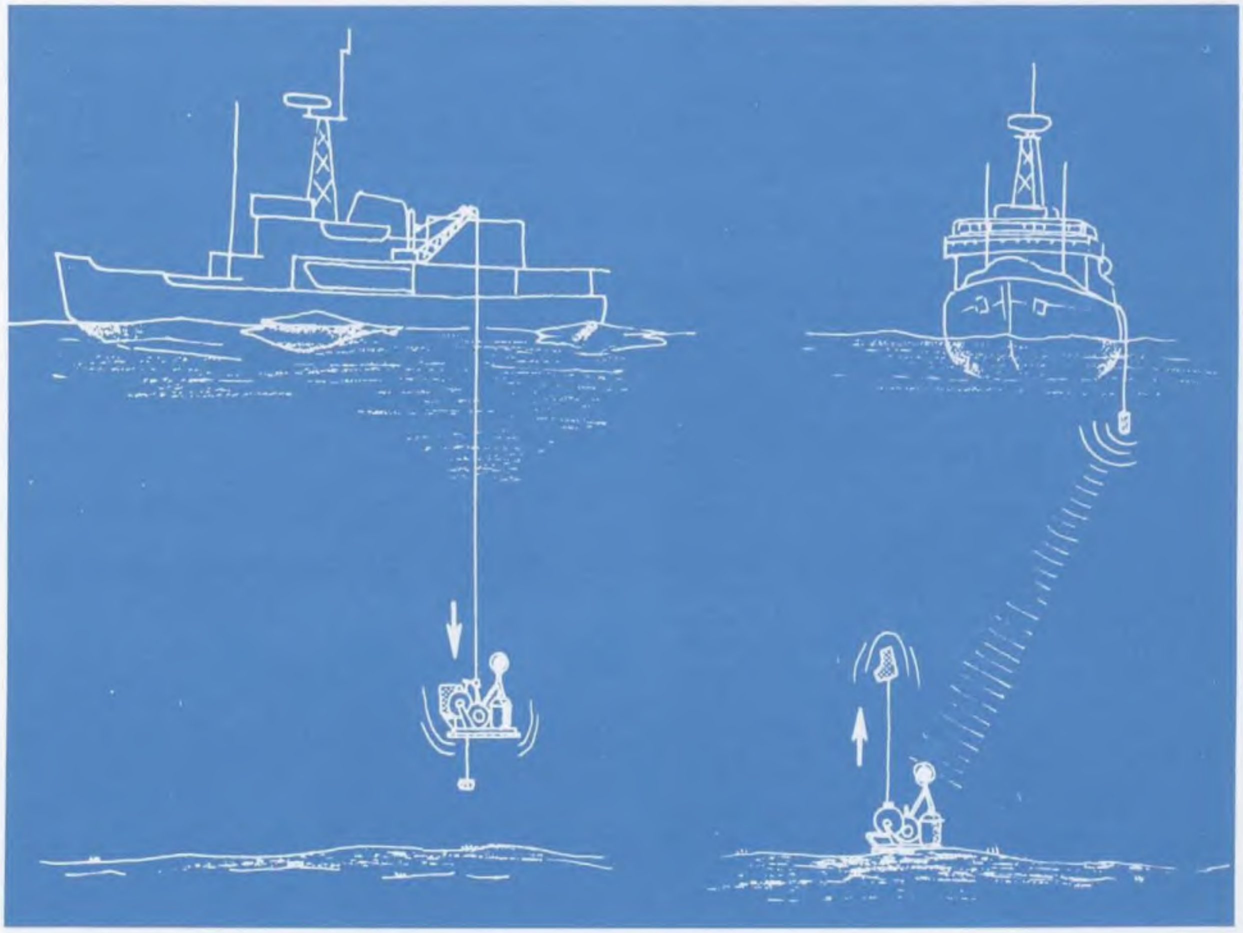
One of the basic components of the RIP is, of course, its recording instrument, in this case a tape recorder which, unlike the garden-variety acoustic or sound recorder, records what it hears in code on computer tape.

The RIP's recorder is a complex device that analyzes sound in four-minute segments. Stated in greatly simplified terms, the recorder "listens" to underwater sounds in a particular frequency range for a period of four minutes. After each four-minute segment it stops listening momentarily and the average loudness of sounds heard is encoded on the tape. Then it changes to another frequency and the whole process is repeated.

As something of a double-check, the recording package also includes a print-out device that indicates the average loudness of sounds in the 150-to-300 Hertz frequency range on paper in graph form. The data indicated on the graph can be checked for accuracy against that indicated on the computer tape or, in the case of a recorder breakdown, provide at least some data where otherwise there would be none.

When the RIP is recovered, the coded tape is run through a computer and the result is printed out again as graphs which are subject to a broad range of statistical analyses.

It would be possible to employ a regular acoustic tape recorder in an underwater listening device, but it would not be practical. An acoustic tape recorder would have to record right through every four-minute segment, so enormous quantities of tape would be required in view of the long periods of submersion to which the RIP is subjected.



This Defense Research Establishment sketch shows the recording instrument package descending to the ocean bottom. Once in place the instruments beam back information on command.

A RIP unit, complete with housing and delivery-recovery apparatus, weighs 2,100 pounds in air and 1,100 pounds submerged. It is approximately five feet square and 3 1/2 feet high.

Two independent battery packs, sealed in seamless steel pipe pressure cases 14 inches in diameter, are set in vertically opposite corners. The recovery winch and the hydrophone, a microphone designed to function under water, are in the other corners. The electronics case, also made of 14-inch steel pipe, is set horizontally in the middle. The system is designed to remain at depths of up to 2,000 feet for as long as two full years.

The RIP is lowered to the ocean bottom by a cable with a specially designed release. When the unit has been submerged for its scheduled time, normally a year, a recovery vessel navigates to its location and sends down through the water a coded acoustic signal. The signal activates an electronic switch, which, in turn, activates an explosive bolt and releases a bright orange float.

Upon release, the float turns 180 degrees. This turns on a mercury switch, starting broadcasts from a radio beacon in the float for the ship to ''home'' in on. The float, towing a pilot line, moves toward the surface and ejects a brilliant green dye when it is 60 to 50 feet from the surface.

Opening of the dye case trips a lever which raises the radio beacon's antenna. The recovery vessel manoeuvres to the float and pulls up its pilot line, the attached retrieve line and finally the unit itself.

One of the basic principles that governed RIP design was that the system be kept simple enough for rapid fabrication and cheap enough that sufficient units could be produced in case of damage caused by the kind of abrasion likely in Arctic operations. The design, from original concept to completed prototype, took five months using standard techniques as much as possible.

Corrosion protection was another serious concern for RIP designers. Results from many tests showed that ordinary vaseline gave the best protection, mainly because it adheres well to metal surfaces. Consequently, all bolts, studs and exposed machined surfaces were coated with vaseline.

The steel parts of the whole assembly were given the standard protective processing used on ship hulls. They were sandblasted to the bare metal, given one coat of wash primer and aluminum vinyl, then two coats of vinyl paint containing a copper-base poison to prevent marine growths.

The RIP design was basically successful but there were many initial problems and deficiencies which have since been eliminated. The main problems were caused by the purchased components.

For example, a number of faults were discovered in the tape deck but because choosing a replacement recorder would have meant a year's postponement of RIP installation, the various flaws were repaired or accommodated. A new type of tape deck was used on later units. The underwater cables also failed after periods of three to 11 months because moisture penetrated the protective coverings. A new protective compound is being used now.

Similar problems were encountered in 1969 with three RIP units off the coast of British Columbia and Washington State.

Two units, reworked to eliminate previous flaws, were submerged in 1972 — one in Lancaster Sound and one in Wellington Channel — just north of Baffin Island. Another unit was installed in the north late in the summer of 1973.

Meanwhile, the instrumentation for submarine detection was in "the planning stages" in Victoria.

The Vacuum Tapping System

CLAUDE BONENFANT

«En caravane, allons à la cabane...» To sugaring-off party-goers, this is a familiar refrain. However, opportunities to take part in these enjoyable outings to celebrate ''sugar-time'' are becoming fewer and fewer. Yet, who doesn't love the sought-after maple sugar, syrups and other maple products? And if you cannot get to the sugar bush, these products can be bought at the supermarket and eaten at home — if they can be found!

While the Quebec maple products industry has the monopoly on the market, producing 80 per cent of the world's maple syrup and maple products, its production nevertheless declined around the end of the 1960s. From 1968 to 1971, production could not keep up with market demand. Large numbers of sugar-bush operators — as maple products manufacturers are called — are leaving their sugar bushes untapped. The methods of tapping and processing the sap are simply too antiquated. In some regions, 70 per cent of the maple sugar bushes have been abandoned.

In order to give the maple products industry a boost, Denis Désilets of Laval University's Rural Engineering Department developed a new sap tapping method. The research was conducted in close co-operation with the Maple Industry Division of the Quebec Agriculture Department.

Research on the vacuum tapping system was begun in 1969 at the St. Norbert d'Arthabaska experimental sugar bush. Not only was this new technique designed to mechanically transport the sap from the tree to the evaporator, but it was also intended to augment productivity by helping the tree to yield more sap.

The main characteristics of the vacuum tapping system may be outlined as follows. Instead of the traditional pails to collect the sap, flexible plastic tubes are connected to the spout. All these tubes are joined to a gathering conduit which carries the sap to the cabin. The sap is drawn by vacuum pump which exerts a negative pressure in the entire tubing, thereby creating suction and consequently forcing the flow through the pipes.

Between the conduit and the pump is a vacuum container to catch the sap. When the container is full, a float mechanism causes it to drain — while maintaining constant vacuum — into the storage tank which feeds the sap into the evaporator.

The first part of this system — the tubing system — had been developed about 10 years ago by the University of Vermont and installed at the experimental farm and at the farms of some avant-garde sugar bush operators. This system was only used for transport of the sap, making use of the force of gravity.

The Department of Agriculture experimental sugar bush uses the vacuum system to increase production. With the sap transported by gravity, accurate assessments can be made of the value of the suction system in order to establish standards for the quality or effectiveness of vacuum pumps, tubing and other equipment.

The results of various studies show that tubing of quite a large diameter — about one and a half inches — is preferable. Also, a high vacuum on the order of 20 inches or more of mercury below atmospheric pressure is recommended. The air flow is approximately 7.8 cubic feet per minute for a total of 1,000 taps, and it increases in proportion to the number of taps.

The pumps and vacuum containers used at the experimental sugar orchard and in 40 private sugar bushes which were fitted out with this new system in 1973 (this number will triple in 1974), are the same as those currently used in milking machines. Therefore, their availability and servicing is guaranteed throughout the province of Quebec. In places where there is no electricity, the vacuum tapping technique can be practised by using a gas pump.

According to Mr. Désilets and Jean Guilbault of the Department of Agriculture, the vacuum tapping system considerably increases the quantity of the sap crop — especially when the output is already low — without any apparent damage to the maple trees. In 1971 the experimental farm harvested some 3.72 pounds of syrup per tap, whereas the average production for the entire province had been 1.20 pounds per tap.

The report of the 1972 tests shows the same rate of increase; that is 154.4 per cent more than the province as a whole. A survey of "pioneer" sugar bush operators in several counties, conducted by agronomist Moïse Cossette, shows a similar increase. His conclusions, based on the sugar bush operators' remarks, were that with the vacuum tapping system the season starts earlier, the sap flow day is longer, and the sap still flows in overcast weather when there is not a drop in the "traditional" sugar bushes.

But, what about quality? The conclusion of the reports on the experimental sugar bush and the large store of evidence indicate that the use of the vacuum pump system in no way reduced the percentage of sugar in the sap. Better still, the quality of the product is improved; this makes the producers happy because they are paid on the basis of the grading of their products. The vacuum tapping system has brought about new standards of cleanliness. The sap does not have to be handled and is free from exposure to bad weather and foreign bodies which could fall into the pail when the traditional method is used. Since the sap is transported quickly to the cabin, there are no longer any losses caused by the sap aging or turning yellow.

From the experience of the St. Norbert sugar bush and several other bushes, it appears that whereas three or four men were needed for gathering sap by the traditional system, one man is sufficient for a sugar bush of 3,000 or even 4,000 taps linked to the vacuum tapping system. His main job is supervision, in addition to manufacturing syrup.

This considerable reduction in labour, and the increase in the production of the sugar bush compensate for the high investment of installing the system. It is the tubing, of course, that costs the most, because of the quantity required to connect a large number of trees. A capital of $1.00 to $1.25 per tap must be put up for the installation. This is not so high if we recall that the traditional equipment (spout, pail, and cover) only costs about 10 cents less. The cost of the pump and the vacuum container is comparable to what it would cost to buy a good horse.

The system can be installed at any time of the year. However, it is preferable to install it in summer or fall because of easier access to the sugar bush. It is also easier to prepare the land, place the pipes and trim the trees, if necessary.

The piping stays in the forest all year round. Any leakage in a tube is easily pinpointed by the noise it makes when the system is operating. When the tapping is over, the taps have only to be removed and caps put on the tubes, after they have been carefully washed. To clean the tubes, a cleaning solution is forced under pressure in the reverse direction of the flow. When well-cleaned, the tubes do not attract squirrels or other rodents.

This procedure opens a new era for the 10,000 sugar bushes in the province of Quebec. The maple products industry, which in 1973 had a turnover of some $15 million, will no doubt be able to turn this new sap tapping technique to good account. Government action, such as that taken to promote aluminum evaporators in the same sector, would certainly have a beneficial effect on the use of this new procedure, and, consequently, on the entire maple products industry production. However, it is hoped, as Mr. Désilets points out, that the sugar bush will retain its folkloric character, if only for the sake of the tourists or for those who still love a good sugaring-off party.

Electron Microscope

MARGARET BRASCH

A sub-microscopic world — much of it previously unknown, some of it known but never before seen — became visible to scientists in the late 1930s when Canadian and German physicists, independently but almost simultaneously, developed practical electron microscopes.

Geneticists can see the structure of chromosomes and the DNA molecule that determine heredity. Geologists can observe the effects of stress on rock stratification. Biologists can see the structure of viruses and cells, the smallest units of living matter.

In virtually every field of science, the electron microscope has become a valued research tool. Its development was spectacular, even by modern standards. Stimulated by a long-felt need, it became a reality in an exceedingly short time after it was accepted as a theoretical and technical possibility. And within 15 years, it reached a degree of refinement attained in the conventional light microscope only after nearly 300 years.

Three Canadians — Cecil Hall, James Hillier and Albert Prebus — were responsible for the development of the first electron microscope in North America. And although virtually the same developmental work was being carried out in Germany at the same time, it can at least be said that the three Canadians share laurels with the Germans for having developed the first known operational models in the world.

The earliest Canadian interest in the field can be dated back to about 1935. Dr. E.F. Burton, head of the physics department of the University of Toronto, had just returned from a conference of biologists and physicists in Germany. It was there that two electrical engineers, Max Knoll and Ernst Rushka, who had been working on ways of employing electron energy for practical purposes, claimed that the electron — the smallest unit of negative electricity — could be harnessed to form images of biological specimens.

The two Germans already had build a prototype of an electron microscope which, though very crude, was to form the basis of the work to be carried out at the U of T. Dr. Burton returned to Canada anxious to apply this theory to the design and construction of a practical electron microscope.

He invited Cecil Hall, who had come to Toronto from the University of Alberta on a National Research Council Fellowship, to do his master's thesis on this problem. Mr. Hall graduated in 1936, and, by that time, had produced a crude model resembling a four-foot-tall piece of plumbing — the first model of an electron microscope in North America.

Cecil Hall was immediately hired by Eastman

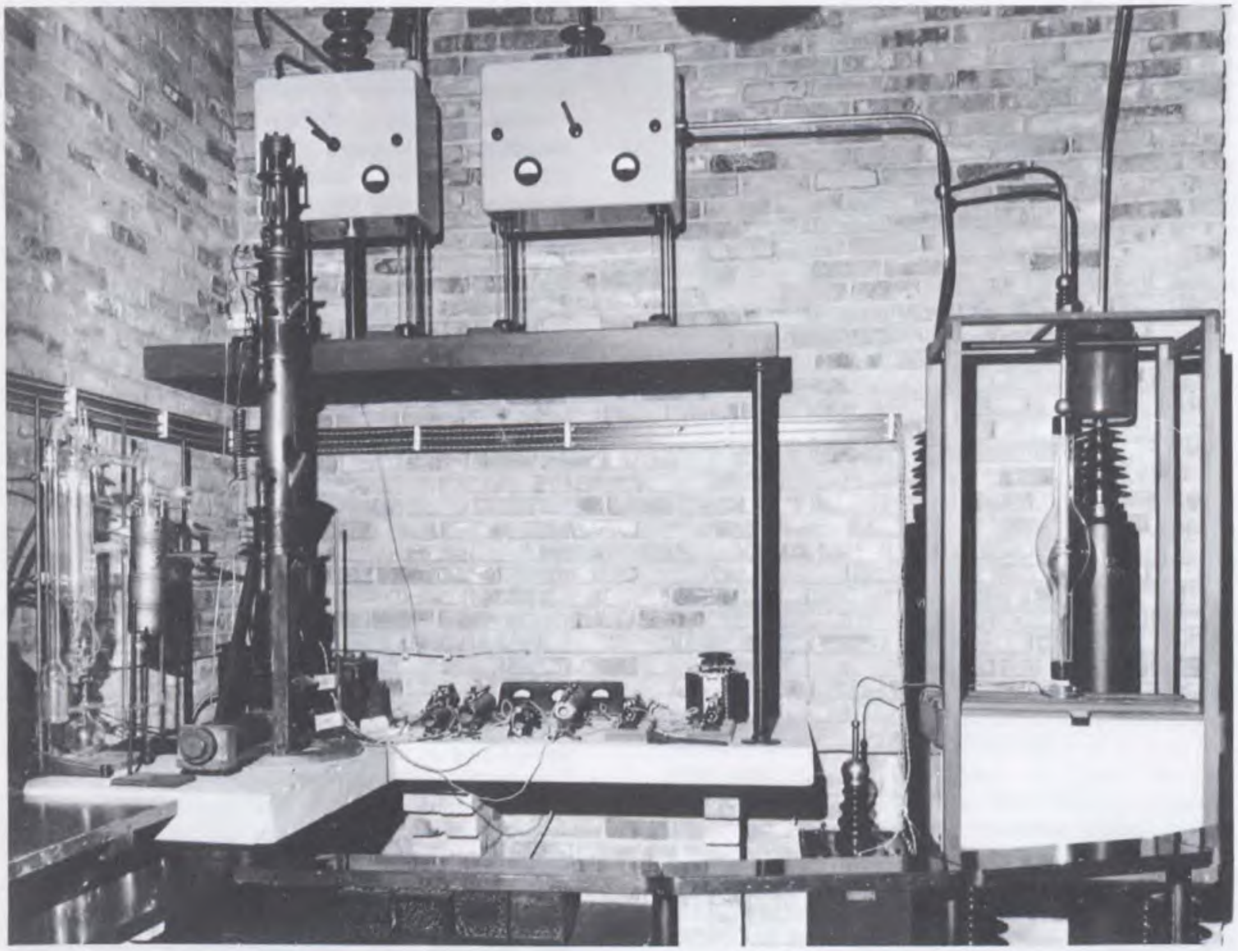
Kodak in Rochester to develop electron microscopes in the United States. However, prominent electron microscopists said that he left Kodak to join the staff of the Massachussetts Institute of Technology without having further developed the electron microscope.

Despite Mr. Hall's departure, Dr. Burton was anxious not to let the project die. He hired James Hillier — then a U of T lecturer — and Albert Prebus, another Albertan NRC physics fellow, to work on perfecting Mr. Hall's original model.

By April 1938, the Toronto team had built two models capable of producing recognizable photographs of biological and non-biological specimens. Both designs were improvements on Mr. Hall's original model, which had suffered from image instability, the result of inadequate control over the amount of electrical current passing through the lenses. Mr. Hillier and Mr. Prebus were able to correct this fault with a more sophisticated transformer system.

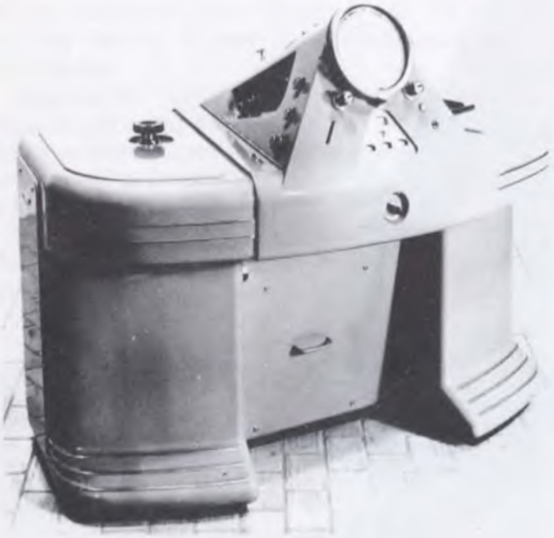
In addition, the magnification and resolving power of Mr. Hall's model did not greatly surpass that of existing light microscopes. By correcting the symmetry of the lens systems, his successors also improved 10 times on the magnification and the resolving power.

Both Mr. Hillier and Mr. Prebus received their



Assembled about March, 1938, this is the first version of a high-voltage transmission electron microscope at the University of Toronto.

James Hillier (right) and A.F. Prebus work by the electron microscope.



One of the first commercially available electron microscopes, shown at left, appeared in 1950.

PhDs in 1940 from the University of Toronto. Their theses were on the construction of the electron microscope.

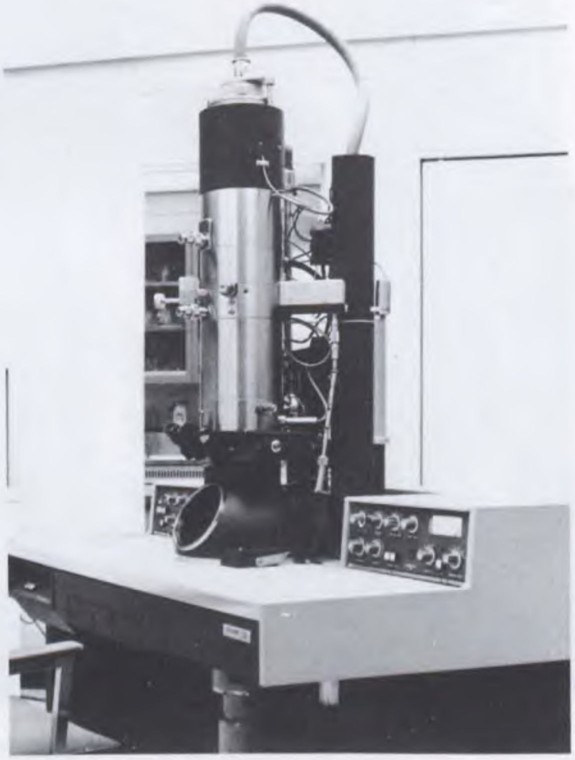
Compared to contemporary electron microscopes — or EMs, as most scientists call them — the Hall and the Hillier-Prebus models were primitive indeed. While the first models sat precariously on top of lab benches looking like a plumber's nightmare, the modern EM is a streamlined instrument constructed of gleaming stainless steel.

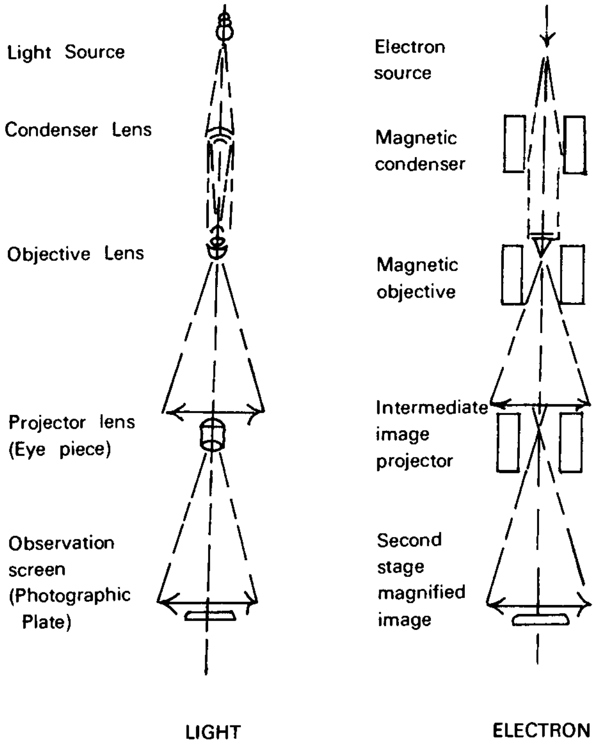
The price has also changed over the years. The first model sold by RCA in the United States was priced at $15,000 in 1940; 30 years later, the average price of EMs sold by some 20 corporations around the world was $75,000.

Today, as in those early days of EM development, the word "microscope" is likely to conjure up, in most people's minds, the image of the familiar desk-top light microscope used as a teaching aid in most high schools. And, basically, both the EM and the light microscope serve the same purpose — to produce greatly enlarged images of minute objects. The resemblance, however, in terms of appearance, operating principles and capability ends there.

As its name implies, the light microscope produces an image of a specimen by manipulating light rays which are generated by a lamp at the base of the instrument. A series of glass lenses, known collectively as the condenser, gather the rays into a cone and focus them on the specimen. The different

This modern electron microscope enables the viewer to see about 300 times more detail than possible with a very powerful optical microscope.





This drawing schematically shows how a ray of light travels through an optical microscope, and how a beam of electrons passes through an electron microscope.

areas of the specimen absorb varying amounts of the incoming light and the rest passes through the specimen to register an image. That image is magnified for viewing.

In the EM, on the other hand, the image results from the activity of streams of electrons rather than rays of light. And the focusing of electrons, which cannot be done with glass lenses, is accomplished with electromagnets.

The electrons are emitted from a fine, tungsten wire filament — the electron gun. They then come under the influence of an elaborate series of electromagnets which accelerate, deflect and finally focus them on the specimen.

When electrons pass through the specimen, they are scattered in a pattern, the nature of which depends on the specimen's thickness and molecular structure. The scattering pattern, invisible to the naked eye, can be made visible if projected on a fluorescent screen. The EM produces such large magnifications in such minute detail that a single image of a whole specimen would be impossible. Instead, selected areas of a specimen are recorded for examination on photographic plates. These photographs are called electron micrographs.

During observations, the microscopist can vary both the sharpness and magnification of the image by adjusting the amount of electrical current flowing through the system. Generally, the higher the voltage, the sharper the image.

The Hillier-Prebus models, when first put into operation in 1940, could produce images up to 1,500 times the size of the specimen. This was a slight improvement over the existing light microscopes.

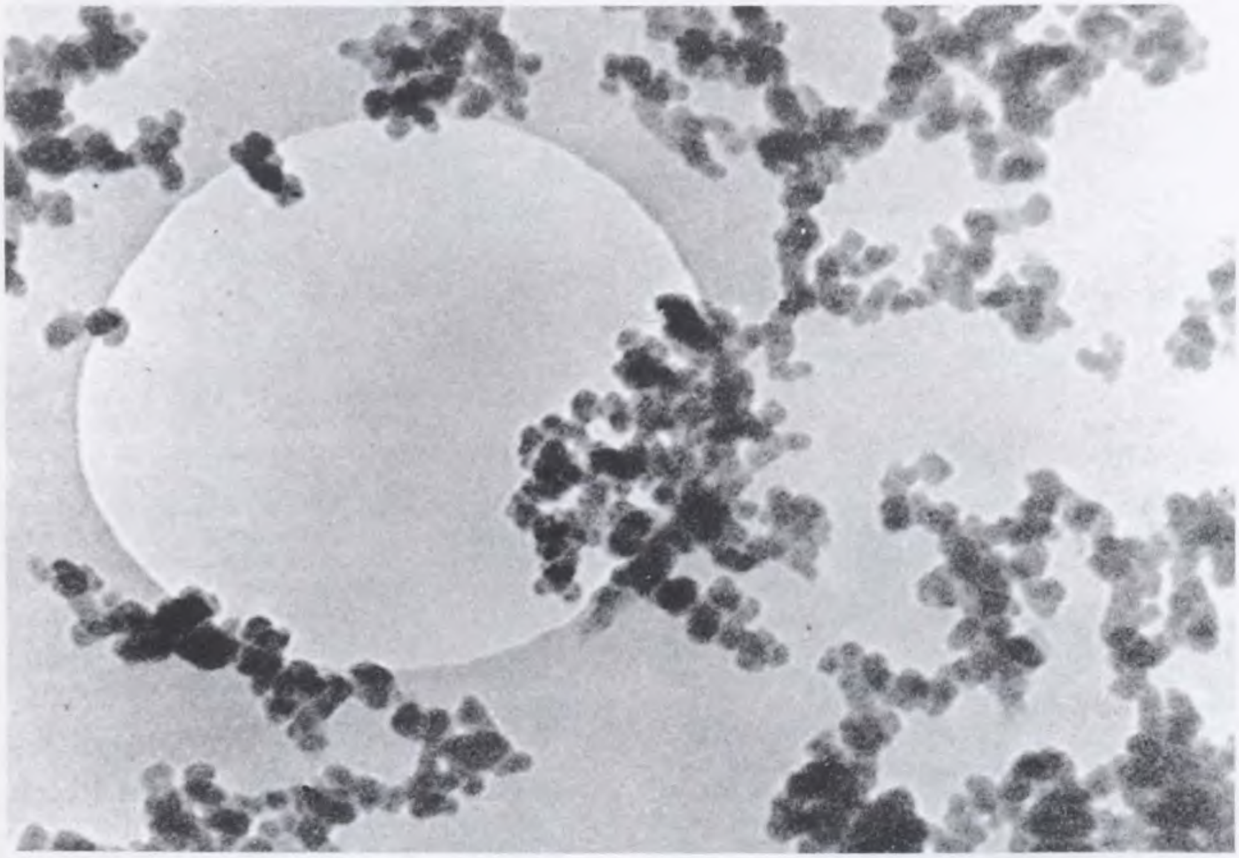
By 1973 light microscopes could magnify up to 2,000 times, but a modern EM theoretically could magnify up to 1 million times. In practice, however, the useful magnifications fall within the 50,000 to 200,000 range. Magnified to this extent, an ant would look like a dinosaur.

The most important quality of any microscope, though, is its resolving power or its power of resolution. Resolution is measured in terms of the shortest distance between two points or lines at which they can still be perceived as separate. The human eye, for example, has a resolving power of a hundredth of a centimeter — that is, it can distinguish between two points separated by as little as that.

But before examining a specimen of biological material, the microscopist must have the patience to go through about a week's preparation which involves killing the tissue chemically to preserve it, embedding it in a wax or plastic medium and cutting it into less than tissue-thin slices on a specialized instrument called a microtome to make it visible under the microscope. To further increase his perception of detail, the microscopist may stain the tissue with specific dyes.

In electron microscopy, slices are so thin they are measured in fractions of a micron, one of which is equal to one ten-thousandth of a centimeter. Specimens usually are sliced to a thickness of only five-hundredths of a micron.

Meanwhile, electron microscopes are capable of resolving such minute detail that details are measured in Angstroms, one of which is equal to one ten-thousandth of a micron. With a specimen of average thickness, an EM would have the resolving power of five Angstroms.



This electron micrograph, taken in late 1939, shows specks of carbon black deposited on a collodion membrane.The magnification is 100,000 X and the resolving power is about four one-billionths of an inch.

In simple terms, this means the modern electron microscope enables its user to see 300 times more detail than would be possible with a light microscope.

It takes two den-sized rooms to house an EM and support equipment such as a vacuum pump and a cooling system. The EM has two major components. The first is a five-foot-tall metallic column encasing the electromagnets, the electron gun, specimen holder and photographic plates. The column rests on a second component, a flat console with a series of dials and knobs with which the microscopist can change the position of the specimen and increase both the sharpness and the magnification of the image.

Because of the EM's complex nature, a half-hour preparatory ritual must be observed before a scientist can actually examine specimens. First, the system must be evacuated — that is, all air is pumped out to avoid excessive scattering of electrons by ambient gas molecules. Then the specimen and photographic plates are inserted into the column and the whole system is re-evacuated.

Contemporary electron microscopes are getting more and more sophisticated though the basic technology, evolved in the 1930s, is still the same. For example, EMs can now be hooked up to television cameras for group observations.

Though the EM has proven a financial success, Canada had never produced it until 1974. At the time of the EM's development, the country was at war and it seemed a low priority in comparison with other demands on industry. Moreover, Canadian scientifically-oriented industries were virtually in their infancy.

"Neither of us," recalled Dr. Prebus, now professor of solid state physics at Ohio State University, "was initially approached by a Canadian company capable of financially undertaking this project, nor did we seek one out. The U.S. seems to have always been in a favoured economic position whereby they can easily afford such ventures."

Dr. Hillier, who now is RCA's vice-president in charge of research and development, added: "It would have required a basic $200,000 investment to get the thing going. Prebus and I thought of going into business for ourselves, but as new graduates, we could hardly afford this sum of money."

Ozonization

SERGE CÔTÉ

Do you remember the last time you were in a swimming pool? Are your eyes still smarting and is your throat still irritated? Mark Spitz did not have this problem when he won seven gold medals at the Munich Olympic Games. The water in that pool was not chlorinated; it was ozonized.

According to Karel Stopka, the president of Ozonair — Canatraco Ltd., and Professor Marcel Gagnon, director of CRESALA (Centre for Research on Food-related Sciences) at the University of Quebec in Montreal, ozonization is the modern method of purifying water for consumption and of treating waste water.

The Film Layer Purifying Chamber (FLPC) system is the new water purification and treatment process advanced by Mr. Stopka. His optimism about it is based on three main factors: The advantages of ozonization over chlorination, the effectiveness of the electric coagulator, and the superiority of the FLPC system compared to the European method.

Ozone is a gas composed of three oxygen atoms. A considerable amount of electricity is required to form a molecule of ozone. There are two natural energy sources which produce this gas: the ultraviolet rays given off by the sun, and lightning. After a particularly violent electrical storm, it is possible to smell the acrid odour of ozone in the air.

This gas plays a crucial role in our lives. There is a layer of ozone surrounding the earth, approximately 13 to 16 miles above its surface. If this layer were not there to absorb the sun's ultraviolet rays, we would all be doomed to extinction.

Ozone concentrations greater than 0.1 ppm (parts per million) over a period of eight hours constitute a health hazard because the gas attacks the respiratory system. In large cities the ozone concentration in smog is sometimes as high as 0.5 ppm, at which level there is a serious danger for man.

A useful property of ozone is that it attacks the external membrane of bacteria and viruses, leaving the interior of the cell with no protection against the environment. The phenomenon is lethal for one-celled organisms. Since ozone is a better oxidizer than chlorine, it can destroy undesirable organisms more quickly and more effectively.

In tests carried out by CRESALA, the number of bacteria present in a specimen taken from the sewers of Beaconsfield, Quebec, dropped from 90 million per 100 millilitres to zero in 36 seconds. These results were confirmed by the National Canners' Association in the United States. Whereas chlorine produces chloramines, which are toxic to fish and probably to humans, the ozone left over in water is not harmful because it changes into oxygen.

According to the supporters of chlorination, ozone does not linger in high enough concentrations in pipes and tanks to deal with unexpected contamination. Chlorine, on the other hand, tends to remain in appreciable concentration. The backers of chlorination conclude that if a source of contamination were to appear somewhere between a pumping station and the place where the water was being used, there would not be enough residual ozone left to cope with the pollution. But Dr. Gagnon argues if a leak in the sewer system were to infect drinking water, residual chlorine would be just as incapable as ozone of killing the bacteria.

The electric coagulator used in the ozonization process surpasses the chemical coagulator both in terms of effectiveness and handling. There is no need to continually watch the temperature and acidity (pH) as is necessary with the chemical coagulator.

In the FLPC process the electric coagulator receives waste water from the sewer system. The hydrogen produced at the cathode creates a turbulence in the system and attracts solid matter and fatty substances to the surface. A skimmer is used to remove this material from the surface of the water and it is then directed to a reservoir. At the present time, CRESALA is studying the possibilities of using this residue as fertilizer.

After this initial coagulation, the water is sprayed under pressure into an ozonization chamber. The tiny water droplets come into contact with ozone in the chamber's oxygen-saturated atmosphere and the bacteria and viruses are attacked by the best oxidizing agent known: ozone. This part of the process takes 12 seconds. The treatment is repeated in a second, then a third chamber. The exposure time varies according to the degree of pollution of the water.

Mr. Stopka's ozonization system differs from the one which has been used in Europe for 75 years. The traditional method involves passing gas bubbles through the polluted water. The impurities in the water are oxidized on contact with the ozone. The system is not, however, as effective as it might be. Everyone is familiar with the way carbon dioxide bubbles rush to the surface of a glass containing a carbonated beverage. This is what happens in the case of traditional ozonization.

Now let us suppose that we were to reverse the procedure. Instead of passing the ozone through the water, let us pass the water through the ozone: this is the FLPC process. Waste water is sprayed into a sealed container filled with a mixture of oxygen and ozone. In this way, the water droplets come into contact with the ozone much more easily. The length of time the water is in contact with the ozone varies from one half hour to four hours for the traditional method, but it is less than one minute for the FLPC process.

In addition to its use in treatment of industrial waste water, ozone can be used to purify water for human consumption. At present, several studies are underway on the applications of ozonization. One of CRESALA's research projects is cold sterilization of containers. Pre-sterilization of contents has also been suggested. Such a process would eliminate all danger of poisoning caused by spoiled food.

Another advantage of ozonization is the treatment allows water to be recycled cheaply. The Simonds company in Granby, Quebec, will re-use its water at a cost of seven cents per 1,000 gallons, thanks to the FLPC system. By comparison, the company paid the municipality 18 cents per 1,000 gallons in 1972. Under the new system, the company will save 11 cents on every 1,000 gallons of water it uses.

According to Ozonair — Canatraco's projections, the initial cost of an FLPC unit capable of treating 10 million gallons of water a day would be $1,300,000. The net cost for the second and third treatments of waste water would be about five and a half cents per 1,000 gallons.

Canada still has a long way to go in the field of environmental protection. In several towns and villages the water filtration process leaves much to be desired; often, it is in fact nonexistent. An adequate treatment of waste water would greatly reduce the burden nature must now assume to protect herself.

Weather Echoes

MARTIN McCORMACK

The McGill Radar Weather Observatory, shown in a later stage of construction, was completed in 1968. At the top of an 86-foot-high tower, the radar "dish" is capable of detecting a rainfall or snowfall of .004 inches per hour 100 miles away.

During the Second World War, when radar was solely a military device, operators anxiously watched their screens for the tiny, bright blips caused by ships and airplanes. The larger, fuzzier patches known as "weather echoes" were simply a nuisance.

But after 30 years of work by an organization of Canadian weather scientists called the Stormy Weather Group, these bright, irregularly-shaped patches are now the substance of much of Canada's storm research.

Today, when a thunderstorm or a snowstorm hits the Montreal-Ottawa-Quebec City area, chances are it is under the group's radar surveillance. And there is a strong possibility that the life history of the storm — its development and progress within a 120-mile radius of Montreal — is on film or computer tape for future reference.

The Stormy Weather Group, which in 1973 consisted of nine principal scientists, is the oldest radar-based weather study organization in Canada. Since 1956, it has conducted some of the world's most precise hail investigations in its Alberta Hail Studies Program. And since 1943, in its eastern Canadian studies, the group has developed a radar-oriented system so sophisticated that every five minutes it can wire an updated precipitation map to the Montreal Weather Office at Dorval Airport.

A valuable aid in weather forecasting, these maps are the final step in a technical process which sweeps the sky with a revolving radar beam and analyses rain-, snow- or hailstorms. The process is based on the fact that accumulations of precipitation in the sky reflect radar waves.

Reflected waves, or echoes, come back to the radar unit's dish-like antenna and are converted to electrical impulses. These impulses create bright, fuzzy patches on phosphorescent screens which indicate the intensity of the echo and show its point of origin in the sky.

In 1943, two Canadian scientists — J. Tuzo Wilson, then Director of Operational Research for the Canadian Army, and D.C. Rose, then head of the Army's Operational Research Group — decided that radar might be used to study the structure of storms and trace their movement. The two organized Project Stormy Weather, with physicist John Stewart Marshall as head.

The Stormy Weather Group, still led by Dr. Marshall in 1973, has developed radar as a weather instrument far more fully than anyone envisaged in 1943, at a total cost of about $3.5 million. Today, radar can distinguish rain from snow from hail. It can act as a giant rain gauge and measure how much rain falls over an area as large as 40,000 square miles.

Radar can dissect a storm and analyze it as a series of vertical or horizontal cross-sections. It may reveal the formation of a new low-pressure area. And radar can consistently distinguish small, weak showers from small, intense thunderstorms.

The Stormy Weather Group's most recent facility, the McGill Radar Weather Observatory completed in 1968, can detect rainfall or snowfall as light as .004 inches per hour within 120 miles of Montreal. According to Dr. Marshall, there is some precipitation in this area one day out of three.

When an area of precipitation is detected, the radar observatory begins examining it closely and sending the maps to the Montreal Weather Office. Each map is in four shades of grey to show relative amounts of rain in the clouds at low altitude. The shapes and heights of clouds are shown by contour lines — curves and rough loops and circles similar to the lines which depict mountains, valleys and plateaus on topographic maps.

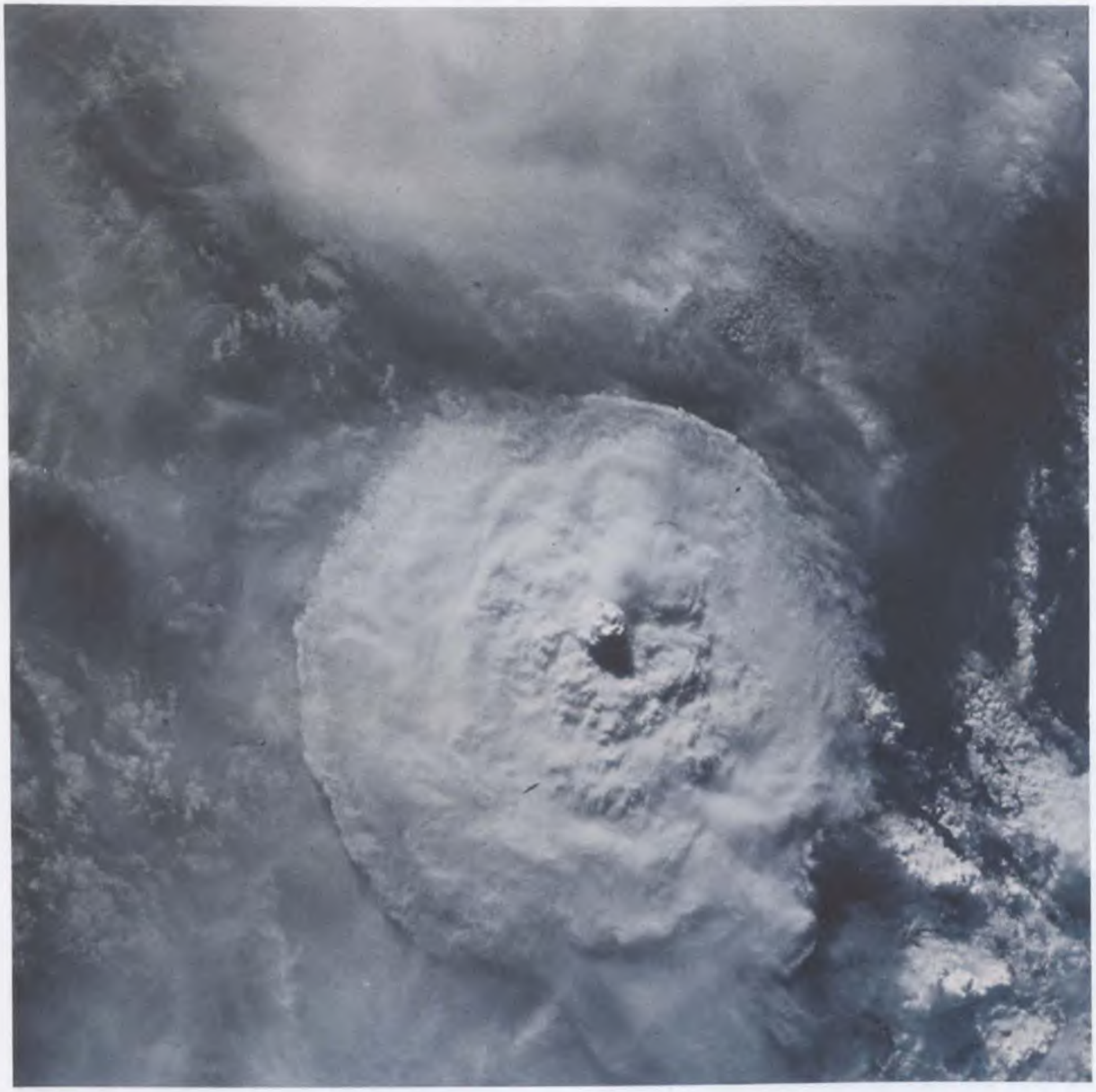
Once the precipitation moves away from the Montreal-Ottawa-Quebec City area, map production stops automatically. It does not begin again until the next storm comes within range.

While these maps help short-range forecasting a great deal, most of the emphasis has been on using radar to improve daily weather forecasts. In this work it is important to spot trends developing over a large area, such as disorganized showers which may consolidate into fairly broad regions of steady rain or distinct bands of thunderstorms.

Another application of these precipitation maps is in forecasting weather conditions for pilots so they can avoid showers and storms wherever possible. Here, radar has been particularly useful.

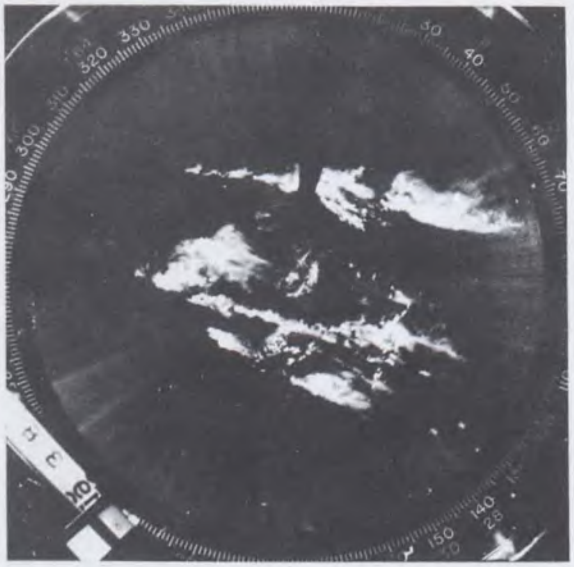
Dr. Marshall felt radar-derived forecasts should be used more fully by the media — particularly television — to forewarn their audiences of sudden showers and storms. But today, weather advisories based on radar observations are broadcast only when "hail and damaging winds" are expected.

And nowhere in Canada is hail more of a problem than in central Alberta, where every summer severe hailstorms cause a great deal of damage to crops. Consequently, in 1956 the Alberta Hail Studies Project began, under joint provincial and federal sponsorship, and with scientific guidance from the Stormy Weather Group. Since 1956 the project has used a National Research Council radar unit at Penhold, 75 miles north of Calgary, to study hailstorms with the hope of one day being able to prevent hail. The 24-member Alberta Hail Studies



This large South American thunderstorm is about 60 miles across. Within the circular mass of cloud lie smaller cells. The most intense activity in a thunderstorm — high winds, hail and cloudbursts — is usually confined to these cells.

In the foreground, scattered clouds lie above Florida, while further north there is a line of thunderstorms. Such lines of storms are often associated with a cold front moving into warm, humid air. Most of the storms above have an anvil-like structure. This flat top usually occurs at altitudes of 25,000 to 40,000 feet.



East-west lines of thunderstorms appear on this plan-position indicator display at the McGill Radar Weather Observatory near Montreal. The picture, showing precipitation echoes on a map of 125-mile radius centred on the radar, was taken at 7:38 PM on August 8, 1968. The lines of precipitation are roughly 150 miles long.

In the central part of the picture are bright pinpoint "ground echoes" from the Montreal urban area. The Adirondack Mountains show as relatively firm blobs 40 miles to the south, the Green Mountains similarly, 80 miles to the southeast.

Group examines the size, concentration and echo-producing ability of hail, and the patterns on the ground over which hail falls.

Their most recent undertaking has been to track silver iodide crystals that have been dropped into storm clouds from airplanes to cause precipitation to fall as rain before it turns to hail. The path of the crystals shows the direction and speed of winds within a severe storm. This information, in turn, helps reveal the structure of a hailstorm.

Although the Alberta Hail Studies Program has monitored the radar reflections from hail and traced silver iodide dispersal more carefully than has any other study in the world, the efforts have not stopped hail from falling, said Walter Hitschfeld, a founding member of the hail studies group. The whole program is now under pressure from the Alberta farmers, who want less research and more outright efforts to prevent hail.

Nonetheless, in the late 1960s hail detection had become highly sophisticated. "There were some instances when we phoned residents of our area, 40 to 50 miles from Penhold, and discussed with them the hail that was falling outside their windows. Painful as it often was for them, it was not ungratifying for us to learn that our estimates from the radar — say of golf-ball-sized hail — were correct," said Dr. Hitschfeld.

This degree of accuracy results from a long series of Stormy Weather Group achievements in radar technology which have enabled them to:

- — Distinguish among rain, snow and hail in approaching weather systems;
- — Locate these kinds of precipitation accurately and at great distances in a sky full of clouds;
- — Relate the intensity of precipitation echoes to the amount of rain, snow or hail that likely would strike the ground;
- — Record all of this information so it can be used in later research.

For example, the group noticed in the early 1940s that snow produces a grainy, dull echo on radar screens. On the average, rain is five times brighter than snow. In 1944, members of the Stormy Weather Group noticed that snow melting to rain is brighter still.

Therefore, the brightness of the echo is a key to distinguishing the three types of precipitation. But to be sure the intensity they saw on the screen was "true", the scientists had to refine their equipment to meet two fundamental conditions.

First of all, the strength of the echo had to accurately reflect the kind and amount of precipitation that caused it. After five years of research, the Stormy Weather Group found that short radar waves — particularly those one to four centimeters long — reported in great detail about the near side of a storm, but were themselves absorbed by the rain, and so gave a weakened and distorted picture of the storm's intense core. After 20 years of experiments, Stormy Weather scientists decided to use eight- to 10-centimeter waves, which gave the most accurate echo intensities.

The second condition was that the phosphorescent screen had to faithfully reproduce echoes of various strengths. In 1947, the Stormy Weather Group built a screen that represented echo intensity in five shades of grey, the lightest grey representing the strongest echo. Today, computer tape can register 15 levels of intensity.

Even with these conditions met, radar weather scientists could not consistently distinguish hail from rain until Glen McCormick of the National Research Council used polarized radar waves in 1966. Unlike the usual radar waves which vibrate in many planes, polarized waves undulate only from side to side in one plane. When two separate beams of polarized radar waves strike an area of hailstones in the sky, the echoes from the hail are brighter than those caused by any rain.

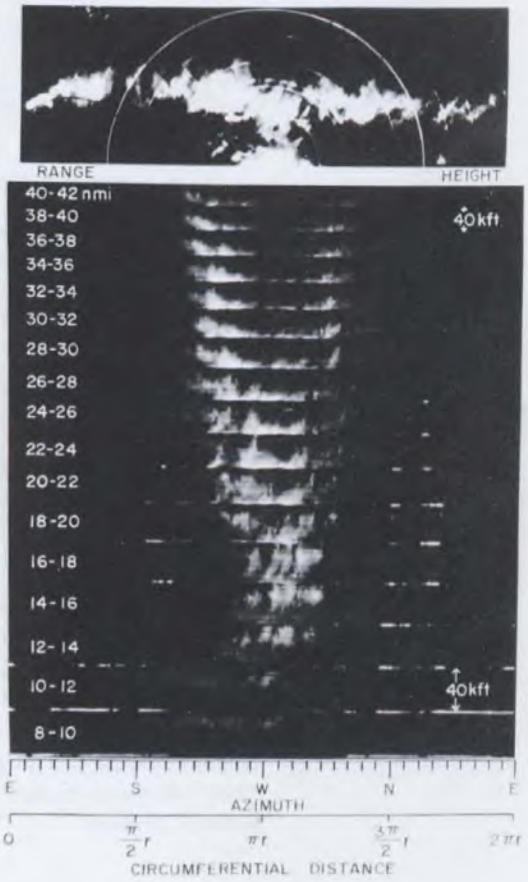
In order to precisely locate an area of precipitation, scientists must have radar screens which, in effect, dissect a storm into vertical and horizontal slices. But in 1943, radar operators had only two types of phosphorescent screens, the plan-position indicator and the range-height indicator.

A plan-position indicator is basically a circular map with the radar unit in the centre. The edge of the circle represents the maximum reach of the radar beam, and the field of view is divided latitudinally and longitudinally into wedge-like sectors. Precipitation shows up on a plan-position indicator as one or more bright patches with a definite geographic position, as though the storm were seen from a point high above the radar unit.

One major drawback of the early plan-position indicator was that it squashed everything flat; all the echoes seemed to come from the same altitude, which is by no means true.

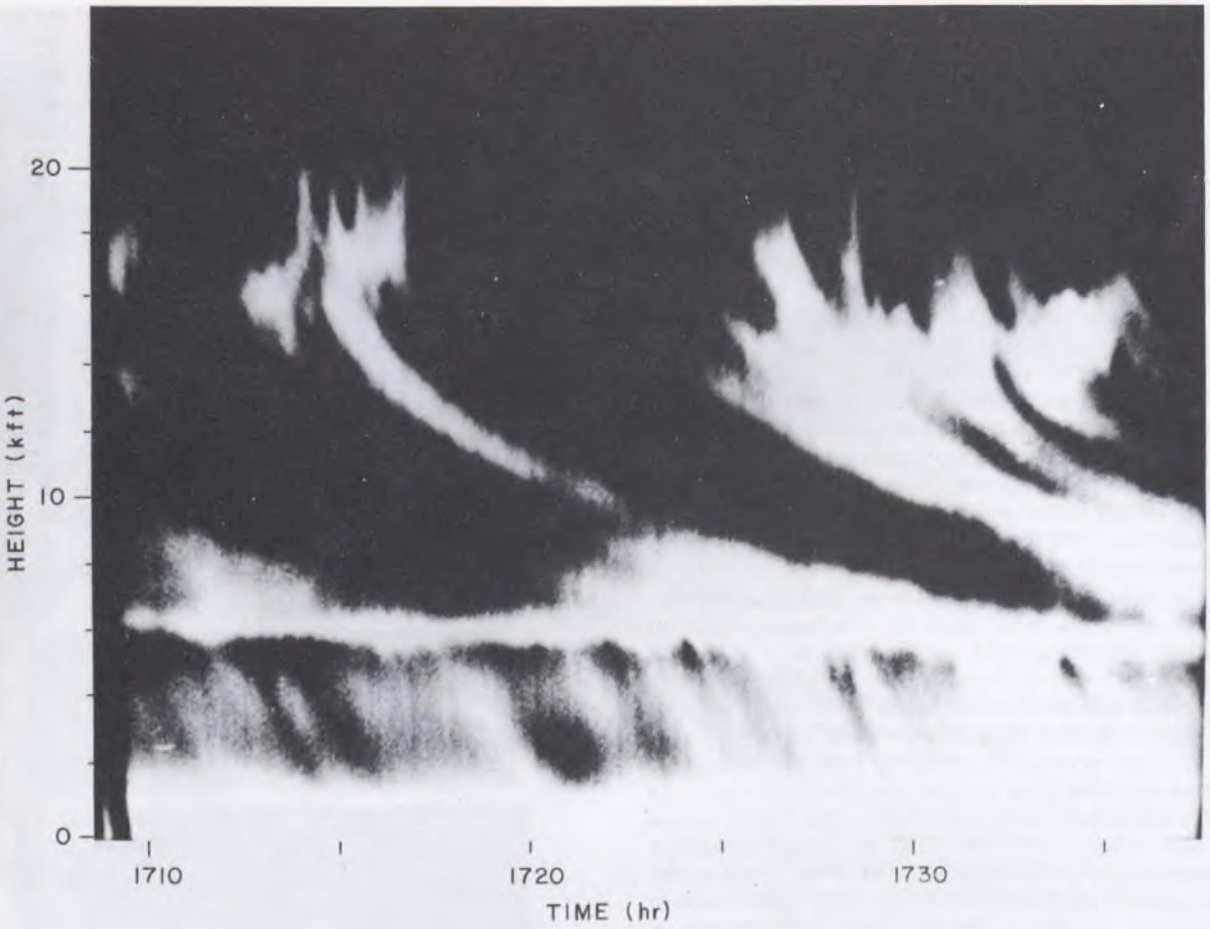
The range-height indicator, on the other hand, gives an edge-on view of a storm. Precipitation may appear as thin, bright strips, or in bands which look like tufts on a brush, or as irregular patches. But, according to Dr. Marshall, one limitation of the range-height indiactor is that it shows rain, snow or hail in only a narrow wedge of the atmosphere, as though in a slice of layer-cake.

The Stormy Weather Group has devoted much of its efforts to eliminating these shortcomings and achieved its greatest technological successes in the development of new radar screens. A major advance came in 1955 when Dr. Marshall developed



This three-dimensional view of a line of storms, shown in the upper photograph, is made of 17 cross-sections, which appear as bands across the picture. The height of each section is 40,000 feet, and the entire width represents the view from all compass directions, as shown in the scales below.

Up to a distance of 18 nautical miles — about 21 standard miles — from the Alberta Hail Studies Radar at Penhold, most of the precipitation is in clouds higher than 20,000 feet. Farther away, the bulk of the precipitation reaches the ground or lies at lower altitudes. At distances of 28 to 42 nautical miles, two distinct areas of precipitation are apparent. One lies to the southwest; the other is northwest of Penhold. The heaviest rain seems to be falling about 22 to 28 miles west of Penhold, and 28 to 40 miles southwest of the city.



In order to produce this time-height record of snow and rain, the radar was kept pointing directly upward for half an hour. Cells of snow-generating clouds — 18,000 feet high — were blown through the vertical beam by mile-a-minute winds. Therefore, the width of this picture can be thought of as 30 miles as well as 30 minutes.

As they fell, the snowflakes encountered winds of progressively less speed, and so were swept back in curving trails. At 10,000 feet they encountered warmer air. At 7,000 feet they were melting, and the stronger radar echo from wet snow shows up as a bright band at this height. Below the bright band the snow changed to rain, which appears as more nearly vertical streaks.

the constant-altitude-plan-position indicator (CAPPI), which sorts out precipitation echoes according to the altitude at which they originate.

This device enables scientists to create images of horizontal slices of a storm, like selected discs sawn from a tree trunk. The echoes from each particular altitude — usually 10-, 20-, 30-, and 40,000 feet — are then displayed on plan-position indicator screens and recorded on film or printed out on paper as maps.

The basic plan-position indicator map, however, has another drawback. Since the radar unit is at the centre of a circular map, the area within 20 to 30 miles of the radar is represented in wedge-shaped sectors which are thin compared to those representing regions father away from the radar. On a radar screen, the result is that precipitation echoes from storms close to Montreal appear to be jammed together.

In 1971, Dr. Marshall and E.H. Ballantyne, chief engineer of the McGill Radar Weather Observatory, developed a screen which "stretches out" the central part of a plan-position indicator's field of view in all directions. This screen allows scientists to study in more detail the storms, or parts of storms, closest to the weather observatory.

Another major development in radar display techniques came in 1967 when Mr. Ballantyne and I.I. Zawadski of the Stormy Weather Group built a screen which presented 17 different cross-sections in a storm. These cross-sections lie at different distances from the radar unit. Together, the sections look like slices in a leaf of bread. The new screen, therefore, does the work of many range-height indicators operating at once.

While intensity of radar echoes can distinguish types of precipitation, and sophisticated screens can reveal the structure of a storm, echoes can also be interpreted to indicate total amounts of rain, snow or hail likely to reach the ground.

In 1947, Dr. Marshall, along with R.C. Langille and Walter Palmer, showed that heavy rains consistently fall from clouds in which strong echoes are detected. These more powerful echoes are caused by a higher percentage of bigger raindrops; this high proportion of large drops is always present in heavy rains. The resulting "Marshall-Palmer" relation remains to this day the universally-recognized standard formula relating echo strength to the amount of rain that actually hits the ground.

In 1958, K.L.S. Gunn and Dr. Marshall calculated a similar relationship for snowflakes, and R.H. Douglas did the same in 1964 for hailstones. Today, the equipment at the McGill Radar Weather Observatory acts like a huge rain gauge. The amount of rainfall — anywhere within 120 miles of Montreal — agrees closely with predictions based on the intensity and distribution of radar echoes.

Finally, Dr. Marshall and his associates have developed methods of transferring radar-derived data onto computer tape. Part of the Stormy Weather Group's work is to simulate storms on computers to study possible rainfall patterns. In the study of big storms, simulations are used to determine where flooding will occur, given a certain set of precipitation echoes. The computer system will be fully operational in 1974.

Quebec Archaeology

CLAUDE BONENFANT

We are well aware of the existence of the odd museum of prehistory, the odd society of amateur archaeologists and a few university-sponsored excavations, but what, really, is the state of archaeology in Quebec? The first appearance of man in eastern Canada was certainly not that of the French settlers. How long, then, has Quebec been inhabited?

Archaeological research has long been regarded as depending upon luck and great patience. This is true even today. However, with modern techniques of planned excavation and data classification, there is increasingly less reliance on chance.

Archaeology in Quebec has made astonishing progress during the past decade. Its increased popularity among amateurs and in Quebec universities is clear evidence of the renewed vitality which this discipline is enjoying. As recently as 1960, archaeological research in Quebec was a haphazard and sporadic affair. Since then, however, it has become more stable and better-planned, especially since the recent passage of the Cultural Property Act to govern and protect Quebec's cultural heritage. Much remains to be done, for the task is an immense one. In fact, research operations must cover the entire territory of Quebec, New Quebec and Labrador. Moreover, a period of over 12,000 years is involved.

When Jacques Cartier first set foot in North America he must have been greatly surprised and very disappointed not to find the civilization he had expected. He was certainly not in the Indies. Nevertheless, the Indians of America (now known as Amerindians) had quite a history of their own.

The great explorer did not doubt that he had stepped out of modern history into prehistory; and indeed, archaeological research into precolonial Amerindian culture is still referred to as prehistoric, while studies of the colonial period constitute historical archaeology.

Both historical and prehistoric archaeology had difficult beginnings. It is only quite recently, since about 1960, that Quebec universities have been able to provide experts in archaeology.

From the middle of the 19th century until the turn of the 20th, archaeological research was carried out as circumstances permitted by local antiquarians and historians. At that stage it was mostly a matter of curiosity. Nevertheless, it can be seen that French-speaking Quebecers showed a great interest in historical research during this period.

Between 1920 and 1950, the Quebec-Labrador peninsula was the subject of research carried out by the National Museum of Denmark, Oxford University, the American Museum of Natural History, the University of Chicago and the R.S. Peabody Foundation.

In addition to the archaeological research work of several of its members and instruction given at both French- and English-language universities, the National Museum in Ottawa has since 1920 been making research grants to universities, amateur societies and numerous individuals. The work of the Archaeological Association of Quebec in Montreal between 1950 and 1960 has also been noteworthy.

Since 1960 we have witnessed a great interest among French Canadians in the archaeological work of Father René Lévesque. Amateur societies are being formed in all parts of the province: Sherbrooke, Quebec City, Trois-Rivières, Montreal, Chicoutimi and Rivière-du-Loup, as well as in Abitibi and on the North Shore.

Since then, Quebec universities have been offering a wide range of courses in archaeology. Laval University, through the initiative of Mr. Louis-Edmond Hamelin, founded the Centre for Nordic Studies. The University of Montreal has opened a department of anthropology, now considered to be the most advanced archaeological research centre in Quebec. The Quebec Prehistoric Archaeology Society (QPAS) has also made valuable contributions.

The University of Quebec followed suit by setting up the Archaeology Laboratory in Montreal and the Centre for the Study of the History of Religions and Archaeology, the Museum of Prehistoric Archaeology and the Notebooks on Quebec Archaeology in Trois-Rivières.

The Quebec government, too, has helped. In 1961, the Department of Cultural Affairs established the Archaeological and Ethnological Service. The National Museum of Canada is still sponsoring a large number of professional and semi-professional research projects, and it continues to play an important role in the development of archaeology in Quebec.

The Cultural Property Act, introduced to the Quebec National Assembly in April 1973 by the Department of Cultural Affairs to replace the Historic Monuments Act, will henceforth assume responsibility for the supervision and co-ordination of archaeological research in Quebec. It will make it possible for achaeological excavations and surveys to be planned and regulated.

The Act also provides for measures to be taken which will protect our cultural heritage: any property, monument or site, the preservation of which would be in the public interest, may be declared 'historic'. These steps will ensure the preservation of Quebec's cultural property and will prevent deterioration or destruction. Regulations are even envisaged for construction and posting of bills in areas designated as historic. All this is in the interest of putting our cultural heritage in its proper perspective.

Groups wishing to make excavations must obtain a licence from the provincial archaeology service to conduct archaeological research. Licences are issued on recommendation of a committee of at least three archaeologists, who determine whether the professional qualifications and material resources of those involved are sufficient to ensure that the project will be thoroughly and satisfactorily carried out. The project report is then fed into the archaeology service's extensive program for classifying archaeological data.

In the past, amateur societies would often undertake excavations without the assistance of co-ordinators and specialists. The groups would later be unable to describe or analyse their findings because of insufficient familiarity with typology and the proper terminology. They would consult archaeologists as a last resort, but the latter unfortunately could play only a limited role since they had no access to the large body of essential data which can be collected only in the course of the excavations.

It should not be forgotten that all archaeological research aims to answer specific questions. Each individual discovery fits into the pattern of interpreting the entire district — in this case eastern Canada, North America or even the whole hemisphere. Therefore, any analysis requires a theoretical frame of reference in order to reconstruct a way of life. The work also requires close liaison with such related fields as geology, zoology, ethnology and physical anthropology.

The archaeology service is at present engaged in compiling an inventory of some 1,500 known sites mentioned in literature and in the files of groups and individual researchers. Using as a basis the compilations made jointly in 1969-70 by the Archaeological and Ethnological Service, the University of Montreal and the National Museum of Man in Ottawa, it will now work in co-operation with local groups, museums, societies, university research centres and the New Quebec Branch.

Data will be processed by computer (description cards, data recorded on audio-visual media, microfilm and collections of photographs). Such an inventory will allow the service to provide information rapidly to all groups involved in archaeological

Prehistoric Sites of Quebec

studies. Also, the service can set up a plan for the systematic exploration of the entire province, for salvage operations and for preserving and utilizing archaeological property.

At this point it is appropriate to review the most important archaeological finds to date.

The prehistoric traditions are divided into three major periods: the Paleo-Indian, the Archaic and the Woodland. We should first note that the retreat of the Ice Age in southern Quebec began about -10,500 (10,500 B.C.). The flooding of the St. Lawrence lowlands and the formation of the ancient Champlain Sea took place about -9,500. A gradual retreat continued until about -4,000.

The Paleo-Indian Period (-9,500 to -5,000) comprises the Clovis and Plano traditions. No site belonging to the Clovis tradition has yet been discovered in Quebec, although traces of it have been found in sites near the border. Its chief archaeological marker is the flaked stone implement (fluted point), while Plano implements have lance-like points. Plano artifacts have been found at Rivière-à-la-Marthe, Mississippi Lake and Lac Albanel. The first postglacial inhabitants of Quebec, however, are thought to have been descendants of the Clovis tradition, who probably came from what are now the states of Vermont and New York.

The Archaic Period (-5,000 to -1,000) encompasses four traditions, named after their respective areas of distribution and identified by their means of subsistence and their specific patterns of settlement. As hunters, fishermen and gatherers, they were led to settle temporarily in those areas of Quebec most rich in resources. These traditions had a fundamental influence on later periods, both as regards their rudimentary technology and their ceremonial rites.

Remains of the Shield Archaic tradition have been found in the boreal forests and taiga of central and eastern Canada. In some places it persisted until the arrival of the first white men.

The Laurentian Archaic developed in the St. Lawrence Valley and in the valleys of its tributaries. The best known sites are Morrison's Island, Allumette Island and the Trois-Rivières regions. The chief archaeological marker is the wooden implement.

As its name indicates, the Maritime Archaic tradition belonged to the Atlantic seabord and the North Shore. Finally, the name Peri-Boreal Archaic has recently been given to the tradition being uncovered in the Gaspé Peninsula and in the Tadoussac region; it is claimed that this is the oldest of the Archaic traditions.

The Woodland Period stretches from -1,000 to about 1600, that is, until the beginning of the colonial period. During the so-called early stage (-1,000 to -500), the Indians in the south had already started making pottery and were tending to become more settled, as seen from remains at Batiscan and at Station 5 at Pointe-aux-Buissons.

During the middle stage (-500 to 1000), there was a cultural development which may have stemmed from the Mississippi and northern Ontario areas. Remains from this stage have been found at sites all along the St. Lawrence, at Lac St-Jean, in Abitibi, in the Eastern Townships and in the Gaspé Peninsula.

The late stage (1000 to 1600) saw the expansion of new means of subsistence, such as cultivation of corn, beans, squash, tobacco and other domesticated plants. The existence of settlements is indicated by finds at Dawson, Lanoraie, Mandeville, Berry and the Trois-Rivières region, as well as on the North Shore, in Abitibi, at Lac St-Jean and on the lower St. Lawrence.

This survey gives us some idea of what our prehistory may have been. However, we should not forget the Eskimo tradition of the arctic regions. It is thought that from -1,500 to -1,000 the Ungava area was the home of a Pre-Dorset culture: its remains have been found on the eastern shore of Hudson Bay and on the Labrador coast.

The Dorset culture (-800 to 1200) was a later development of the Pre-Dorset. The change is attributed to the influence during the Archaic Period of Indians coming from the Quebec interior and also to a hypothesized Viking influence in the 10th century — which would explain certain remains found in the Ungava.

Remains of the Dorset culture have been discovered along the shores of Lac Guillaume-Delisle and as far as Kegaska on the North Shore. In about 1350 this tradition was replaced through assimilation or extermination by the Thule culture, which appears to be the final stage in Eskimo culture development.

As might be expected, it is in New Quebec that archaeological research has proven most difficult, precisely because of the remoteness and vastness of the territory. Moreover, the James Bay development project has placed a deadline on the recovery and preservation of the cultural resources of this region. The archaeology service has therefore prepared a memorandum which provides guidelines for taking effective action in this area.

The hydro-electric development will probably raise the level of the lakes and rivers which are harnessed. As a result, a large number of archaeological sites and artifacts will be submerged. It is therefore important to speed up prehistoric, historical and ethnological research in the area.

The research already done in the region and the existing knowledge of the Amerindian populations are not sufficient to provide a truly valid interpretation of prehistoric events in northwestern Quebec. The first phase of the program proposed by the archaeology service calls for cataloging the estimated thousands of sites in the region in the summer of 1973. This work will provide a better knowledge of the settlement patterns of the Amerindian populations.

Once a choice has been made of sites which are likely to yield most information, a multidisciplinary program of excavations can be launched to retrace and interrelate the various factors which contributed to cultural changes. These factors include migrations of human populations in relation to fluctuations in animal population, and to forest fires and climatic changes; wars and religious phenomena; contacts with other civilizations. The archaeology and ethnology service recommends that a park be created to exhibit artifacts and provide information of public interest.

The Historical Period, covering the last 400 years, also merits a good deal of attention. It would be interesting to find out about the socio-economic system of the fur trade and the inevitable clashes of culture brought on by colonization, as well as to reconstruct some trading posts or Amerindian camps.

Finally, as a logical continuation of prehistoric and historical studies, an ethnological study has been undertaken. This study involves the important task of documenting traditional Cree and Eskimo cultures in order to determine the extent to which the vast James Bay project will affect these communities. The risk of assimilation and cultural decline is very great; we must at least preserve on paper as much as possible of the Amerindian cultural heritage.

As we have seen, the science of archaeology is experiencing a rapid growth in Quebec. Tremendous progress has been made in archaeological research and the work accomplished during the past decade has been impressive. Nevertheless, a vast amount of work still lies ahead. This is an indisputable sign of vigour and health. The science of the past has created for itself the possibility of a brilliant future.

Bioinsecticide

MARLENE SIMMONS

Reddish-brown patches of defoliated spruce and balsam fir trees stained over 30 million acres of the Ontario and Quebec landscapes in 1972, stark evidence of the destructive power of the spruce budworm.

But in one of these expanding seas of reddish-brown was an island of green, evidence of the effectiveness of a bacterial spray developed in Canada to control the budworm.

The island of green was a 10,000-acre area of a budworm-infested fir forest in eastern Quebec that was treated in 1972 with a bacterial spray developed at the Laurentian Forest Research Centre at Ste. Foy, Quebec.

This bioinsecticide, developed by a team of scientists headed by pathologist Dr. W.A. Smirnoff, had killed 80 per cent of the budworms in the treated trees within 10 days of spraying, saving 70 per cent of the foliage. Half of the untreated trees in the same area died and the other untreated half were badly defoliated. Three consecutive years of defoliation would probably be enough to kill them.

The spray contained a live bacterium, bacillus thuringiensis, and an enzyme called chitinase. Chitinase was the key because it sped bacteria into the bloodstream of the budworm by breaking down the protective coating of the insect's stomach.

''You just can't put a dollar value on the damage the budworm causes,'' said R.M. Prentice of the Canadian Forestry Service. ''Not only does it harm trees used in the pulp and paper and lumber producing industries of Eastern Canada, but it also causes extensive damage to trees in recreational areas of Ontario. What tourist wants to go camping and have budworms dropping on his shoulder?''

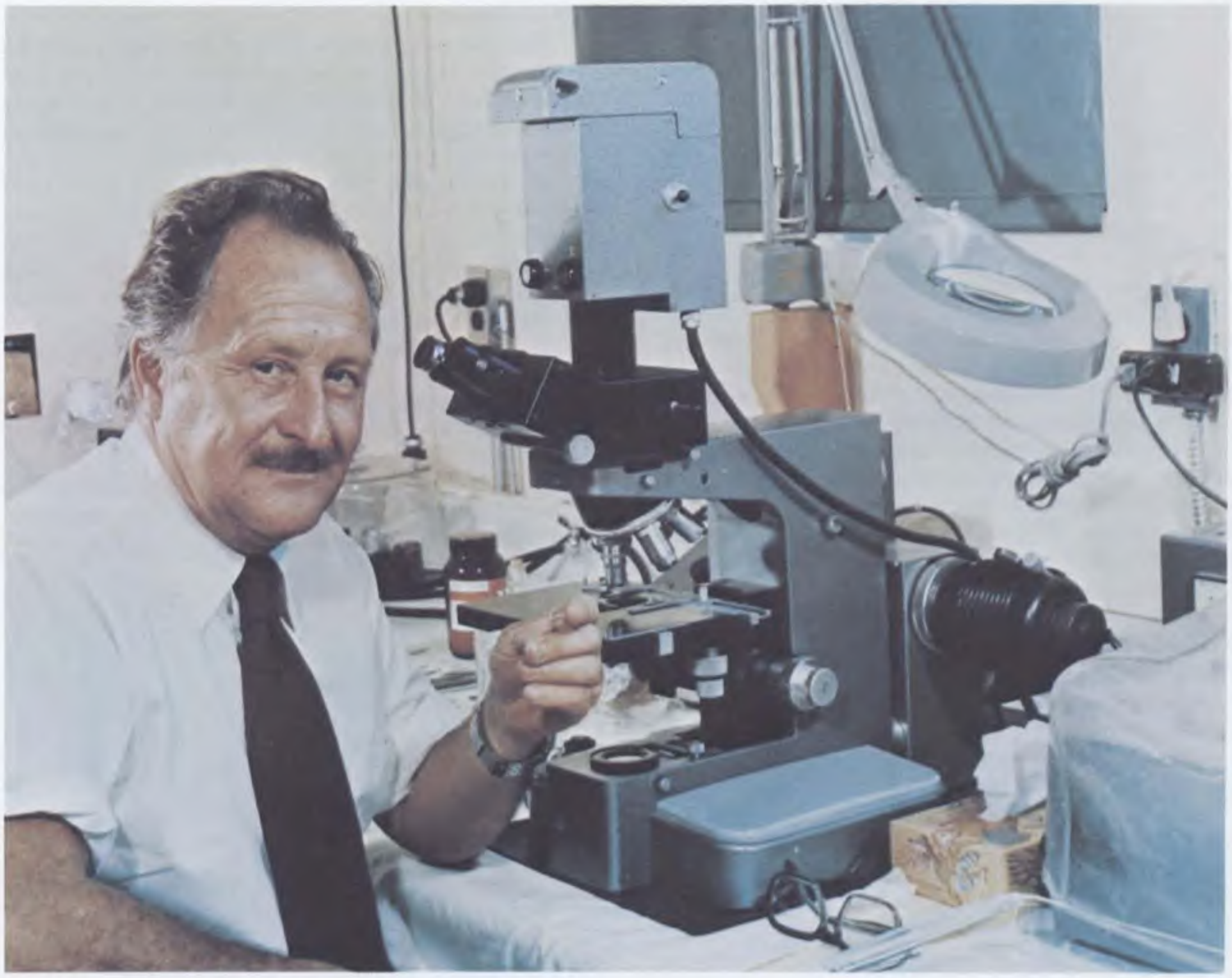
The only way to eradicate the budworm would be to destroy the entire forests it infests, a clearly unacceptable solution. Consequently, control programs employing chemical sprays were undertaken. But chemicals harm beneficial insects, plants, fish and other animals if used in large concentrations.

The chemical used most widely in 1972, fenitrothion, was sprayed in light enough dosages — three ounces per acre — that it did not seriously affect the environment. However, the possibility of operational hazards, such as a spray plane crashing while carrying the chemical, made the new biological spray a preferred alternative.

The Ste. Foy group's bioinsecticide contained a specific strain of bacteria that affected only spruce budworm. There was evidence that this spray, even in non-lethal doses, affected the fecundity of female budworms. This meant surviving females laid fewer eggs the year after treatment with the spray.

The typical spruce budworm larva shown here is about three-quarters of an inch long.

Trees heavily damaged by the spruce budworm turn grey.



Dr. W.A. Smirnoff examines a slide.

Dr. Smirnoff said if the spray passed all its tests it would be especially valuable in recreational areas, such as national and provincial parks where chemical sprays cannot be used because of the slight possibility of harmful effects to people as well as to other creatures.

The hazard of forest fires also would be reduced indirectly because the bioinsecticide would lessen the number of dead trees in a forest area.

In 1972 it cost $4 an acre to treat trees with the spray, but Dr. Smirnoff felt that further development would bring the cost down to $1 an acre by the end of 1973.

Two gallons of spray were needed to treat an acre in 1972, but by 1973 Dr. Smirnoff had devised a way to concentrate the spray so that half a gallon would cover one acre. Costs thus would be more in line with the cost of using the chemical alternative — 90 cents an acre.

Work on the bioinsecticide was begun by Dr. Smirnoff in 1969 at Ste. Foy and transferred each summer to a field station at Chutes aux Galets, 18 miles north of Chitcoutimi.

Identifying a bacterium hostile to the budworm was relatively easy. He decided to try some strains of bacillus thuringiensis because it had already been used successfully at the Insect Pathology Research Institute at Sault Ste. Marie against other moths and butterflies that destroyed food crops.

But the task of developing an effective spray was not that simple. The peculiarities of the budworm's habits meant it would be most vulnerable to the spray only for about 10 days in mid-June when it was voraciously eating spruce buds.

During this period it is in its larval stage and neither protected by a web it spins around itself for hibernation nor burrowed deeply into a spruce needle for feeding. At the same time, though, temperatures in most forests at the crucial time of year are in the relatively cool mid-60s, a factor that slows bacterial efficiency.

Dr. Smirnoff decided the best way to speed up the spread of the bacterial infection would be to break down the gut wall of the larva, which would make it easier for the infection to enter the budworm's bloodstream. Since the gut wall consists of chitin, he selected chitinase, an enzyme known to be effective in breaking down chitin.

Chitinase, which cost almost $200 a gram commercially, was the principal stumbling block in terms of cost and Dr. Smirnoff began looking for a natural supply of it. Since birds eat insects containing chitin, he thought the supply might be found in bird stomachs.

Further experiments proved his theory and he was able to extract chitinase for $13 a gram from the entrails of chickens. The mixture of the spray that was being used in 1973 required one gram of the enzyme to treat 200 acres of forest.

A small-scale test spraying of 100 acres near Chutes aux Galets in 1971 was successful; the trees remained green and healthy in 1972. This led scientists to believe the spray may have some residual effect and they hoped it would provide long-term control, but hesitated to draw any conclusions until the results of larger tests had been studied.

The bacterial spray was patented and Dr. Smirnoff said it would probably be on the market by late 1974 if the tests carried on in 1973 were satisfactory. Negotiations to market the spray had been completed with a Canadian company and interest had been shown by several U.S. companies in American marketing rights.

Television Fluoroscopy

DIANE HILL

When Dr. Albert Jutras, a Quebec radiologist, talks about the reluctance of his colleagues to accept change, he speaks from several years of experience.

In the early 1950s, Dr. Jutras united X-ray and television technology to produce a fluoroscopic system that 20 years later was to be standard equipment in major hospitals across Canada and abroad.

From the outset, Dr. Jutras' television fluoroscopy unit promised to make X-ray work safer and easier for physician and patient. It also promised opportunities for faster and more accurate diagnosis of some ailments and seemed likely to be useful as an addition to the tools of medical education.

But for all its potential, it took years for Dr. Jutras to convince even one medical equipment manufacturer that his television fluoroscopy unit would be marketable and to convince his colleagues that it would work.

In retrospect, it seems difficult to see why there was resistance to Dr. Jutras' unit. It meant that physicians would no longer have to spend long hours in darkened X-ray rooms, exposed to harmful secondary radiation as they positioned patients for X-ray shots. Instead, they could control X-ray procedures from remote-control rooms, watching on TV monitors what they otherwise would have to observe from inside X-ray rooms.

It cut radiation exposure for the patient to one-tenth that required using standard X-ray methods. Taking X-rays with the television unit could amount to a quick scan of the problem. The old method often required lengthy sessions of positioning the patient and shooting a series of high-radiation still X-rays.

Once videotape was perfected, with its instant-playback and easy stop-start capability, X-ray results could be available instantly. For the first time X-rays could be used for diagnosis in emergencies, since doctors no longer had to wait for stills to be developed.

Videotapes also could be stored and played back over closed-circuit television for groups of students, enabling them to see malfunctioning organs in action.

Finally, the television fluoroscopy unit allowed improved diagnosis in certain cases, such as heart or gastrointestinal disorders. The moving picture provided a complete record of an organ's functions, while the conventional still picture arrested only isolated moments and left motion to be recorded subjectively in the physician's memory.

Replayable tapes also made it possible for several doctors to confer on a diagnosis, without having to rely on one doctor's description of the problem for much of their information.

Freeing the physician from the discomfort and possible hazards of the X-ray room had been Dr. Jutras' preoccupation since the 1930s, but more than a decade was to pass before that goal would be possible.

In 1948 the device that made Dr. Jutras' remote-control television unit possible appeared on the market. Called an image intensifier, it was developed in the United States to clarify X-ray results.

X-rays have a wavelength of about one ten-thousandth that of visible light. Their extremely short wavelength enables them to penetrate materials that absorb or reflect visible light. Some objects, such as human bones, cannot be penetrated by X-ray beams, and these cast the shadows of light-and-shadow X-ray photographs.

In early X-ray photographs there was little contrast between light and shadow sections and the images were indistinct. The image intensifier brightened the picture coming out of the machine by about 5,000 times, producing more distinct images with greater contrast between light and shadows.

Since the intensifier was housed in the X-ray machine, the physician could finally work in a lighted room. However, to see the image and ensure that he got a photograph of a body process at the moment and from the angle he wanted, he had to stand next to the patient and peer into the machine at the intensified image through two tiny holes.

Dr. Jutras sought instead to capture the new, brighter image with a television camera, controlling the machinery from a console in an adjoining room.

In the early 1950s, he put together a very simple closed-circuit TV arrangement that worked. Since he had proven that even crude equipment could relay X-ray pictures over television, Dr. Jutras considered the arrangement marketable and set out to convince the two manufacturers of image intensifiers that TV could work with their X-ray machines.

At first he was unsuccessful. Recording X-rays with TV cameras rather then using still photographs, he explained, was a completely new concept. "Companies thought that it was like going to the moon. They thought that it was too futuristic, and television was too primitive," he said.

After being turned down by officials of Westinghouse Ltd. in the United States, Dr. Jutras visited Philips Electronic Equipment Ltd. in the Netherlands. At first, they were not convinced the machine was possible. However, after two years and other visits from the Quebec doctor, Philips agreed to build the machine he had in mind.

The unit was for the Jean-Talon Hospital in Montreal where Dr. Jutras' son-in-law, radiologist Guy Duckett, had convinced the hospital administration the machine was worthwhile. The apparatus, financed through federal and provincial health grants, cost $60,000. It arrived in Montreal late in 1957, and was quickly adopted for use in the hospital.

The unit included a motorized examining table, under which was mounted a television camera, and over which was suspended an X-ray camera. The table and cameras extended out from a circular track on the examining room wall, an arrangement that enabled technicians to move the entire unit from a horizontal to a vertical position at the push of a button in the remote-control room.

From the control room, the radiologist could watch the action in the examining room through a lead glass window and view the X-ray itself on a television screen.

It was not until 1959, said Dr. Jutras, that other companies began to accept the principle of uniting television and X-ray equipment. Even among radiologists, the idea of remote-control television fluoroscopy spread slowly.

The year after his unit won the annual award at the exhibition of the Medical Society of Montreal in early 1958, Dr. Jutras attended the Ninth International Congress of Radiology in Munich. There, to his surprise, he heard a U.S. speaker from Johns Hopkins University say that TV fluoroscopy on abdominal sections was impossible.

This was not because television and X-ray technology would be difficult to link, said Dr. Jutras. "The radiologists were trained in their mental routines and did not accept any changes," he said.

After he told delegates he had been conducting successful abdominal studies with a TV unit for close to a year, he said, "hundreds of radiologists came up to Quebec to see the machine."

Today, most medical equipment manufacturers in Europe and North America produce a version of the TV unit. Often the television equipment is detachable from the standard X-ray machine. The image intensifier and television equipment usually cost about $35,000 and the standard X-ray machine about $30,000.

The unit is now standard equipment in major Canadian cities. Spokesmen for one large equipment supply company estimate there were about 70 remote-control television units in Canada by 1973, and the highest number of units in relation to available hospital beds was in Quebec.

The machines are reported to be even more widely used in Europe. According to the supply company spokesmen, the western world's highest number of units in relation to population is in France where there are well over 500 remote-control television units.

Most of the machines in Canada are used for monitoring radiation therapy sessions, teaching, studying heart and gastrointestinal malfunctions, and monitoring certain surgical procedures, such as the repair of a broken hip. But any X-ray work can be done with a TV unit. Its applications are almost limitless, according to Dr. Jutras.

He said the concept has been realized, the tools created, and there is really not much to be added.

Dr. Jutras did not patent his concept because he lacked faith in the effectiveness of patents on medical inventions. Instead of profiting by his invention, he said he spent time and lost money travelling to promote the remote-control unit.

Dr. Jutras has practised radiology since 1926. Supposedly retired, in 1973 he was still practising radiology in the small town of Amos, Quebec, where he lived.

Glacier Inventory

MARLENE SIMMONS

The glaciers of Canada, untapped sources of fresh water equal in volume to all the Great Lakes combined, represent both a promise and threat for Canadian development.

Acting as natural reservoirs, glaciers provide water for irrigation, industry, hydro-electric power, recreation and domestic supplies. Current and future research may provide techniques for augmenting this supply in times of need.

At the same time, because their movements cannot yet be predicted, glaciers may pose a threat to roads, railways or pipelines.

Until the 1970s there was very little detailed information about the regional distribution of glaciers and their destructive potential. But recognizing the importance of understanding them, UNESCO sponsored a world glacier inventory as part of the International Hydrological Decade (IHD) spanning 1965 to 1974.

Canada has applied a computerized technique to its glacier inventory which ''has been held up to other countries as an example of how these inventories should be done,'' according to C.S.L. Ommanney, head of the Perennial Snow and Ice Section of Environment Canada, which is carrying out Canada's inventory.

Better glacier information may be crucial for the development of Canada's north. ''Oil pipelines could be broken by surging glaciers,'' explained Mr. Ommanney. ''For example, we know the Steele Glacier in the Yukon moved 1 1/2 miles a month at the height of its surge and it is important we locate, study and learn to understand any other surging glaciers in Canada so we can predict their probable behaviour.''

Some glaciers form a dam across valleys which fill with water from glacier run-off. This water causes major floods that could wash out mine roads and railroad tracks. Several of these sudden, catastrophic floods have occurred on the White, Alsek, Taku and Stikine Rivers in northwestern British Columbia, which are fed by glacier-dammed lakes. In fact, a road serving the Grand Duke Mines in this area has been washed out several times by floods caused by the Salmon Glacier.

''We don't know just what makes these dams break, so we cannot predict when a flood will occur. At first it was thought the warm weather altered the internal drainage of the glacier, causing the dam to break, but further studies showed these floods also occur in cold weather,'' Mr. Ommanney said.

''When the world inventory is finished, all information about these glaciers can be pooled and it is possible we will come up with some answers,'' he explained.

The Great Glacier, above the Stikine River in northern British Columbia, is an important contributor to the hydrologic balance of the area.

Glaciers hold 75 to 80 per cent of the fresh water in the world and although most glaciers are located in Antarctica and Greenland, about 3 per cent of this glacial area — about 51.8 trillion square feet — could be beneficial to man. Glaciers in Canada are located mainly in the Rockies and the Arctic regions.

On the basis of studies completed by the summer of 1973, it was estimated that there are between 70,000 and 100,000 individual glaciers in Canada, ranging in area from approximately 100 square yards to 1,520 square miles.

There is very little existing information about these glaciers, perhaps because so few Canadians are scattered over so large a land area that it is not necessary to live close to glacial regions.

One area in Canada that does depend heavily on glacier melt-water is the foothills of the Rockies in Alberta, on the leeward side (eastern) of the mountains where there is little rain. In hot, dry summers glaciers may contribute up to 80 per cent of the water in streams and rivers.

"Our studies have shown that there has been a gradual glacier retreat for the last 70 years or so, and several small glaciers have almost disappeared in this area over the last 10 to 12 years," Mr. Ommanney said.

He said that if this trend continues it could be serious because the glaciers are reservoirs for water. "When moist air crosses the glaciers, the water condenses on the ice and is stored there. But if the glaciers disappear, there won't be a cold sink to trap this moisture and many of these glacier-fed rivers and streams will be severely depleted," Mr. Omanney explained.

Canada first became involved in glacier inventories during the International Geophysical Year (IGY) when a special IGY committee decided in 1955 to amass a complete listing of the world's glaciers. This list would help create water balance models, estimates of how much water exists in the world and what form this water is in, as well as energy balance models which are a means of estimating the earth's temperature and predicting changes in it.

Glaciers exert a strong effect on the world's energy balance as well as its potential water supply because they have a high albedo — that is, they reflect back into space a lot of the radiation that strikes the earth. A serious decrease in the number of glaciers would raise the temperatures in temperate zones; a large increase in the numbers of glaciers could bring on another Ice Age, because they would reflect away a lot of the sun's warmth.

However, response to the IGY's proposed world-wide glacier inventory was poor and many inventories were not completed in time, so a similar program was suggested for UNESCO's International Hydrological Decade.

In 1964 Dr. Fritz Muller, then professor of Glaciology at McGill University, became the chairman of the working group that set up the guidelines for the world inventory of perennial ice and snow masses on and beneath the land surface.

"Canadian input to this manual was high and the preliminary studies of glaciers that were used in it as examples of how glacier inventories should be done were done by Canadians," said Mr. Ommanney.

Canada's contribution to the IHD is to be a computerized inventory of every glacier in Canada, a glacier atlas containing over 150 maps, glacier archives containing both old and modern pictures of glaciers and a bibliography of both published and unpublished work on Canadian glaciers.

Mr. Ommanney estimated the project costs about $75,000 a year, including salaries for a staff of six.

He said it would probably take until about 1980 to finish all the work on the glaciers, but was confident that an adequate staff — six to 12 people — could finish the main portion of the inventory by 1977.

The bulk of the work is done by university students trained in interpreting aerial photos. They

A glacial lake is one feature of the balance between snowfall, storage as ice and runoff to towns, ranches and farms.

Like tongues of ice, glaciers flow into a broad valley on Axel Heiberg Island.

look at photos of glaciers through a stereoscope, which gives them a three-dimensional effect, noting the direction in which the glaciers are flowing.

The students classify a glacier according to its shape and the shape of its basin. They describe whether it is surging or receding and whether or not it is damming a lake. Any extra features the glacier may have, such as moraines — trails of rock waste left either at the margins or at the front of a glacier — are also described.

A map of the glacier, showing its elevation and location, is made on a scale of one inch to 50,000 inches.

All the information is fed into a computer which calculates the area and volume of the glacier. The volume is actually an educated guess since the depth of an ice field will vary from one point to another and it is impossible to give a precise measure of its volume.

For the computer the glacier is assigned a 10-digit number, each digit of which is a part of a code that identifies it as belonging in one of 10 categories, describes some characteristic of the glacier or is a reference to its location. A computer printout is then published in a report series that also includes

Axel Heiberg Island, about 2,200 miles due north of Lake Superior, has over 1,100 glaciers which together cover nearly one-third of the land. In the last 9,000 years — a time during which most Rocky Mountain glaciers have receded substantially — the climate on Axel Heiberg Island has remained cold. It is unlikely the glaciers have ever advanced during this period more than a thousand feet beyond their present boundaries. This picture was taken on July 20, 1964.

This glacier on Axel Heiberg Island shows the patterns of cracking which are common in glaciers.

The McGill Ice Cap, part of which is shown at left, contains about 360 cubic miles of ice and is perhaps 1,500 feet thick. The lobe of ice in the foreground is about 600 feet thick and has an estimated volume of six cubic miles.

The three glaciers shown at right display patterns of ice flow. Although the two glaciers in the middle foreground touch one another, the bodies of ice remain essentially distinct.

general information about climate, history, maps and photographs.

"Eventually, when the total world inventory is completed, we will be able to run computer searches for every glacier of a specific type. It will be possible to find a fairly representative, easily accessible glacier that intensive study can be done on and important generalizations about that type made," Mr. Ommanney said.

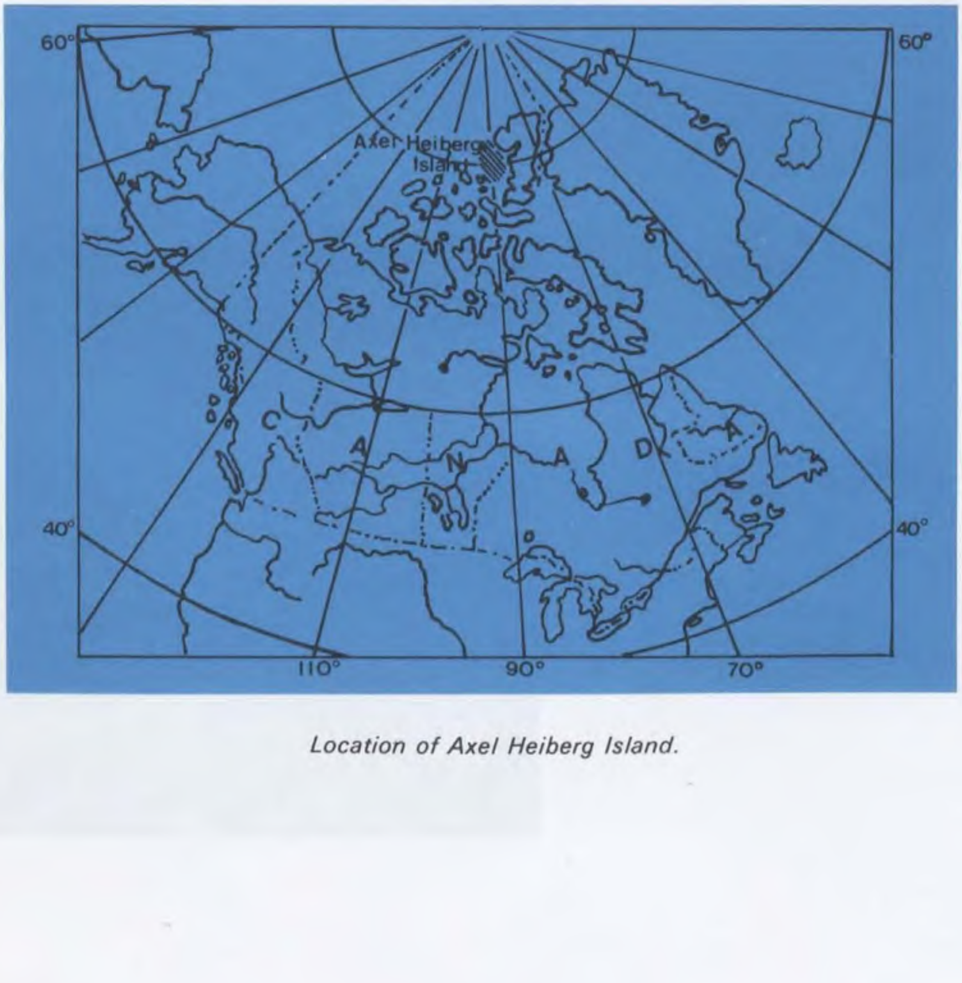
One of the problems with the work was that the photos used for Arctic study were 10 to 15 years old and those for study in the west were even older.

"We keep in close contact with field expeditions and have corrected several errors in our work," Mr. Ommanney said. "For example, field studies revealed several glaciers we mapped in the North Saskatchewan River area don't exist any more, and several glaciers on Baffin Island are now much larger than our aerial photos showed."

Mr. Ommanney said it is impossible to map every glacier in the field, but once the basic work is done it will be possible to correct the maps with yearly satellite photos of the earth.

By the summer of 1973 details of more than 2,500 glaciers, located on Vancouver Island, in the Yukon and on Axel Heiberg Island, which is west of Greenland, were stored on the computer. Approximately 30,000 glaciers located on Baffin, Devon and Axel Heiberg Island, in the Yukon, along the Nelson River and in the North Saskatchewan River Basin had been put on maps and indexed.

Extensive inventory work also was being done by Norway, the United States, Russia, Italy, Switzerland and Japan.



Location of Axel Heiberg Island.

Insect Trap

LINDA CHEMELLI

Dr. S.R. Loschiavo

J.M. Atkinson

When rusty grain beetles were discovered in some of Canada's 5,000 grain elevators in 1970, people in agriculture and government became concerned about the effects of possible insect infestation on Canadian wheat sales abroad.

But before infestations could be controlled, they had to be discovered, and existing techniques for doing so were inadequate for detecting low levels of infestation.

Meanwhile, a device was being fashioned at the Canada Department of Agriculture's Winnipeg Research Station that would be a reliable indicator of insect infestations in stored grain. A grain beetle detection device was developed in 1971 and two years of subsequent testing indicated that it was highly effective.

Designed by Dr. S.R. Loschiavo, a grain insect specialist, and J.M. Atkinson, a research and development technician, the device is actually an

These are three versions of grain insect detection devices. (A) is the earliest model, made in 1967. (B) is an economical version, produced in 1969. (C) is the latest improved model of 1973.

insect trap — a rocket-shaped, escape-proof cylinder that lets insects in but keeps grain out.

Experiments in 1972 and 1973 at the Winnipeg station indicated that the trap could be used successfully to detect insects in stored grain. Insects were released into plastic cylinders four to five inches in diameter and 2 1/2 inches high filled with grain. As many as 40 per cent of the insects were captured in a single trap within a week.

Until 1972, when the new insect trap was first tested under practical conditions, probe instruments designed specifically for detecting insects in grain had not been used for several years because probes had proven to be so ineffective. These earlier grain probes were inserted and withdrawn immediately. Consequently, the probability of detecting insects was not high, particularly in lightly-infested grain.

The old methods also caused some displacement and mixing along the route of a probe. It was believed that this resulted in the disturbance of nests of insects and their distribution throughout the entire store of grain.

With the suspension of probes designed exclusively to detect insects, insect checks became largely hit-and-miss affairs, byproducts of inspections designed more as matters of quality control. In quality inspection, a sample of grain was removed, sifted and scanned under a magnifier.

Insects might be seen in the process, and, in fact, the sample of grain was put in a funnel under a 60-watt bulb for seven to 24 hours. The heat drove insects and mites down through the grain into a jar containing water or alcohol. But this process was time-consuming and used largely in the major grain depots of Vancouver, Winnipeg and Thunder Bay.

The new insect trap, or some modified version of it, however, promised to be highly effective in indicating the presence of insects that invade grain at any point from farm granary to shipping docks.

About eight inches long and one inch in diameter, the grain beetle detection device looks like a miniature space rocket. Insects crawl through holes in the perforated brass cylinder. At the bottom of the cylinder is a reducing coupling, a funnel-like fitting which is broad at the top and narrow at the bottom.

Insects drop into a glass or polyethylene vial about 1 1/2 inches long and half an inch in diameter, which is housed in a copper sheath.

A glass or polyethylene vial is used because the rusty grain beetle, the foreign grain beetle and several species of fungus beetles, which are the most common insects found in infested or rotting grain, cannot climb vertically on these materials.

With some other plastics static electricity builds up on surfaces. This, in turn, attracts dust which insects could use as a foothold in attempting to climb out of the trap.

Insects that can climb glass, such as the saw-toothed grain beetle, are prevented from escaping because a metal spring at the bottom of the trap holds the open neck of the vial tightly against the reducing coupling in the perforated cylinder.

A brass, cone-shaped tip connected to the bottom of the vial allows the trap to be inserted as deeply as 12 feet into grain without pressure damage to the brass cylinder.

The trap is pushed into the grain on the end of a push rod. A diagonal groove at the end of the rod provides a passage for a propylene rope attached to the top end of the trap. When the rod is pulled out, the trap stays behind at one end of the rope.

The trap can be retrieved at any time by drawing on the exposed surface end of the rope. Since insects cannot escape, the trap can be left in the grain for any length of time from one minute to two weeks. If insects are moving about at random, the longer the trap remains in the grain, the greater is the probability of detecting them.

Since the trap is pressure-resistant and escape-proof, it can be used for prolonged — and, therefore, more valid — checks. It also allows for checks to be done while grain is in transit so that a shipment can be fumigated, if necessary, immediately upon arrival at a terminal, a time-saving factor.

Effective use of even one trap can be made by a farmer or inspector who knows where insects are most likely to be found. For example, pockets of grain that are wet will heat up to as much as 125 degrees Fahrenheit, ferment, then start to sprout and form two-inch to foot-deep crusts. These are favourite spots for insects to cluster.

Areas of high dockage, where dust or waste materials accumulate on or in the grain, are also favoured sites for insects. In tough or damp grain, traps should be inserted at different points and levels and examined every two weeks during the entire storage period.

Dr. Loschiavo and Mr. Atkinson developed the first model of the grain beetle detection device in 1967. However, the trap was expensive because it was custom-made of heavy-gauge brass and required considerable machining.

In 1969 they simplified the design and used less expensive materials. However, after continued use, particularly at depths of eight feet or more, the perforated brass cylinder of this model became distorted due to heavy grain pressure.

This view of the 1973 trap shows the perforated cylinder, copper sheath, the vial which fits into the sheath, and the tapered end piece.

In addition, in damp grain, the smooth metal nose-cone of the trap, which was the collection chamber of this model, and the iron centrepost became corroded. The rusty surface enabled insects to climb out.

Despite these drawbacks, field tests conducted in farm granaries and country elevators in Alberta, Saskatchewan and Manitoba from 1969 to 1971 proved that even this trap was highly effective in detecting many species of grain beetles and mites in grain. In one grain bin, over 9,200 rusty grain and foreign grain beetles were collected in one trap placed near a hot-spot for four days.

In 1971 a further-improved trap was developed. A local machine shop made 100 test traps for the research station at under $10 each. A modified version was installed in each of five railway cars during the summer of 1972 to check for infestations while the grain was in transit.

After about 40 round trips, on which the train travelled from loading points to terminals at Vancouver, Thunder Bay and Churchill, it was found that the trap indicated infestations that might not otherwise be noticed until a later date when a grain shipment was unloaded at a terminal elevator.

Tests underway during 1973 in the three Prairie provinces involved the monitoring of insect traps installed in 25 railway box cars loaned to the research station by Canadian National Railways.

The box cars had special markings to identify them on the track. With the help of the CNR tracing service, the Winnipeg station was informed of the location of the box cars every day.

When the box cars were unloaded at a terminal, a grain inspector removed each trap and put the contents in a plastic bag. This sample was then sent to Winnipeg for examination. The results of the 1973 experiment to date confirm those of 1972. Normally, when insects are found in grain cars the contents are fumigated. By use of the traps in box cars to aid in early detection, the infested grain may be fumigated before it is placed in the elevator.

Instant Foods

ANNE SADLER

Instant mashed potato is the key ingredient in a recipe for a range of protein-rich instant foods developed by an Ottawa food research team for export to protein-hungry, developing countries.

With his instant mashed potato already adopted by many food processors, Dr. Edward Asselbergs, head of food processing at the Food Research Institute in Ottawa, set out in 1960 to develop instant meat, fish, chicken and cheese products.

Using his mashed potato, this time as a catalyst rather than a product in itself, Dr. Asselbergs' group managed by 1962 to produce instant foods that were far more suitable for export than fresh, frozen or cured foods. In powdered form, they were less bulky, less susceptible to spoilage, less expensive and free from waste.

Moreover, they could be prepared anywhere water or milk were available and eaten without cooking if necessary.

McCain's Foods Limited, a New Brunswick food processing firm which markets Dr. Asselbergs' instant mashed potato with considerable success, sampled Dr. Asselbergs' fish products and, in 1973, was attempting to find a production facility. They saw in it major potential as an export to developing countries where protein was expensive and in short supply.

Dr. Asselbergs originally intended his dried products for export to northern Europe where, in the late 1950s, there were large low-income populations who could not afford many types of fresh, high-protein food and often lacked the refrigeration facilities to keep what they could buy. Consequently he set out to develop a variety of relatively inexpensive protein-rich products that could be stored without refrigeration for long periods of time without spoiling.

Dr. Asselbergs felt an acceptable instant product could be devised from meat, fish, chicken, or cheese, all good sources of amino acids from which the body's protein is constructed. His group first experimented with dried meat or cheese alone, but they found that the product was hard, rubbery and excessively granular.

They found, however, that if cooked mashed potatoes were added to ground meat or cheese before drying, the potato effectively separated the meat fibres and the cheese particles in the end product and prevented them from lumping together into rubbery granules or a hard, fibrous mass.

The group used the same technology to dry the mixtures that Dr. Asselbergs had used to dry mashed potatoes alone. The mixtures were passed between a pair of drums 7-3/4 inches long and six inches in diameter, internally heated with steam to

250 degrees Fahrenheit, rotating at an average speed of two revolutions per minute. A continuous, lacy layer formed on the surface of each drum. Best results were obtained when the layers were not more than .015 inch thick.

The layers were scraped off the drums after about eight to 20 seconds of drying, depending on the thickness of the layers and the speed of the drum rotations. When removed from the drums, the product contained about 7 per cent moisture. The sheets were readily broken to yield crystal-like particles.

In most cases the rehydration ratio was three parts water to one part mixture. If pregelatinized starch were added before or after the drying process, the product would absorb more water per unit weight upon rehydration. The addition of eggs during rehydration improved the texture of the mixture.

Three types of salt-water fish — cod, pollock and hake — and fresh-water white fish were used in the experiments. Fish was boiled first for three to five minutes in water containing salt, pepper, vinegar and onion, then finely ground to eliminate the hazard of bones. Then it was mixed with freshly cooked mashed potatoes and dried.

In the experiments with meat, freshly-cooked mashed potatoes were mixed with raw ground beef, pork or lamb and dried. The drying process also cooked the meat. In the case of chicken, the meat was cooked in boiling water containing salt, pepper, nutmeg and onion, which facilitated separating the meat from the bones. The cooked chicken was then ground, mixed with mashed potatoes and drum-dried.

Except for the chicken, the colour of the dried meat-potato products resembled the brownish-grey colour of well-done beef. However, if .05 per cent sodium nitrate and .05 per cent sodium nitrite were added prior to the drying, the dried product was the reddish-brown colour typical of cured meat.

The flavours of the cheese-potato and fish-potato mixtures were very good, pork was excellent, and lamb and chicken were described as "very palatable". The beef was less palatable and would require a flavour additive before drying.

There was no practical limit to the proportion of potato that could be introduced into the mixture. However, very low meat or cheese content seldom would be desirable because the protein value vould be correspondingly low. The best tasting, most nutritionally balanced and most easily dried mixtures were those that contained about 40 per cent to 60 per cent meat or cheese by weight.

By the time Dr. Asselbergs and his researchers had completed their work, they found that economic conditions had improved considerably in northern Europe and their product's potential market there had dwindled. Meanwhile, no attempt had been made in Canada to analyze the possibility of marketing it domestically.

Developing countries seemed, for the moment, to be the likeliest beneficiaries of the Asselbergs group's work, but a Food Research Institute spokesman said the products might eventually prove ideal as military field rations or handy foods for campers.

And if Canadian householders increased their dependency on quickly-prepared foods, the Asselbergs products might ultimately find a place in the home as alternatives to many existing snack foods that are low in protein value.

New Operating Table

MARGARET BRASCH

The first operating table made entirely in Canada was recently unveiled in Ottawa.

Described as "revolutionary" by its designers, the table was designed and developed jointly by the Quebec Centre for Industrial Research (CRIQ) and the Bio-Millet Company.

Fourteen months elapsed between its conception and the final manufacture of the prototype. Nearly $160,000 was invested, 50 per cent of it from a federal grant under the Program for the Advancement of Industrial Technology (PAIT) and the other 50 per cent lent by the Bio-Millet Company.

As CRIQ provided the manpower and technical know-how, the Company now assumes responsibility for the sale, manufacture and distribution of the table. This is how CRIQ generally operates: it undertakes a research project under contract to a company. The company in turn assumes the actual cost and retains ownership of all results such as patents, documentation, processes, products, and so forth.

The project director, Jacques Pageau, and the designer, Yvon Roy, both with CRIQ, studied 12 tables now on the market and attempted to incorporate their best features into the design of the Miro-Plus-2000 — trademark of the new operating table.

André Thibodeau, Bio-Millet's contracts and exports director, estimates that the table's selling price will be between $4,200 and $6,000. It will therefore be on a par with the operating table distributed by the firm's toughest competitor, AMSCO, an American firm which now corners over 80 per cent of the Canadian market.

At first glance, the table looks like something out of science fiction. In black foam rubber, it resembles a mechanical robot with joints that move in six different places. The foam rubber table on which the patient is placed is supported by a metal frame equipped with two metal runners under which standard X-ray plates can be inserted without moving the patient. It is precisely this feature that constitutes the table's innovative aspect, since the AMSCO table has a complete metal frame.

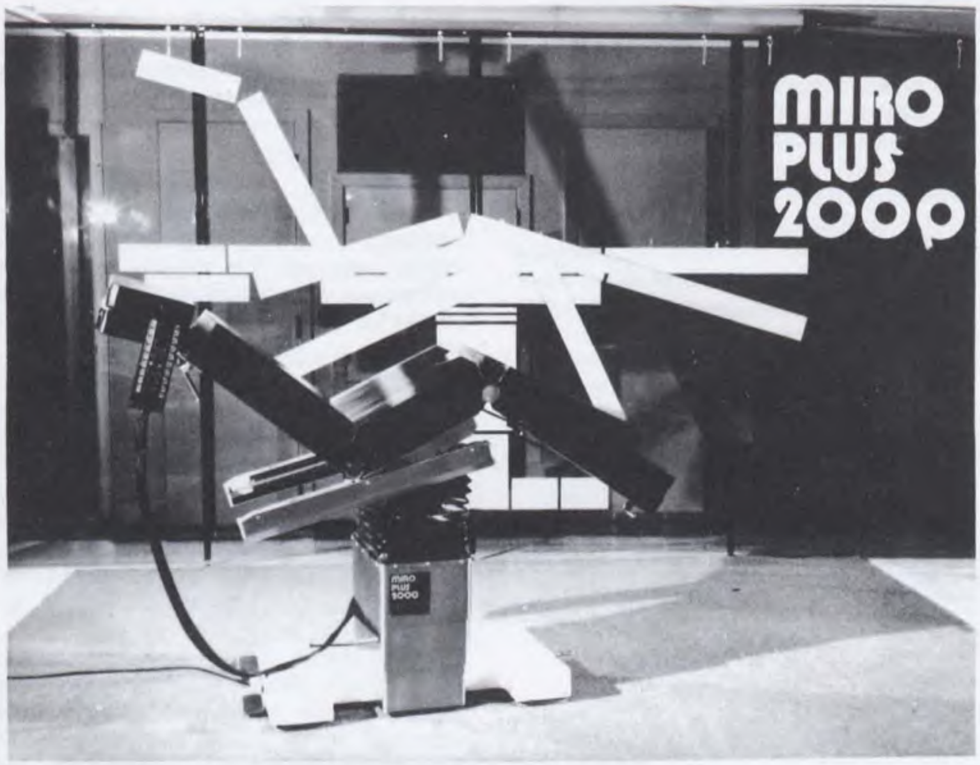
To fully appreciate this innovation, it should be noted that X-rays are transmitted more easily through air than through metal. For this reason, the Miro-Plus-2000 designers chose to create a space between the table and the X-ray plate; this gives a better picture of the details required by the radiologist, since more rays pass from the patient to the X-ray films.

In addition to its advantage for the radiologist, the table has several features of special interest to the surgeon. These include a hinged structure permitting a choice of 10 different positions for the patients during operations. The patient's head, trunk and legs can be raised, lowered, or moved individually to the angle wanted by the surgeon by means of an exclusive control system.

Proud of this creation, Mr. Roy maintains that "nothing currently on the market can compare with the Miro-Plus-2000".

In the face of heavy commercial competition, what are the chances of success of this new table? Mr. Thibodeau says that he has already received 10 firm offers from the province of Quebec, about 20 from the rest of Canada, and around 50 from the American market. So far, six patents have been submitted in order to protect the design and manufacture of the table. If everything goes as planned, mass production should get under way in September 1973.

Notwithstanding the obvious possibilities of this invention, it is still up to the surgeons, radiologists and anesthetists to judge its effectiveness in major surgery.



The new operating table, Miro-Plus 2000, adjusts into many different positions.

Mosquito Control

CLAUDE BONENFANT

We all know that familiar drone which tells us that a mosquito is about to bite us...and make us itch. Most of the time it is not serious, but still very irritating. And we can count ourselves lucky if we are not literally assaulted when we go to the cottage or into the country.

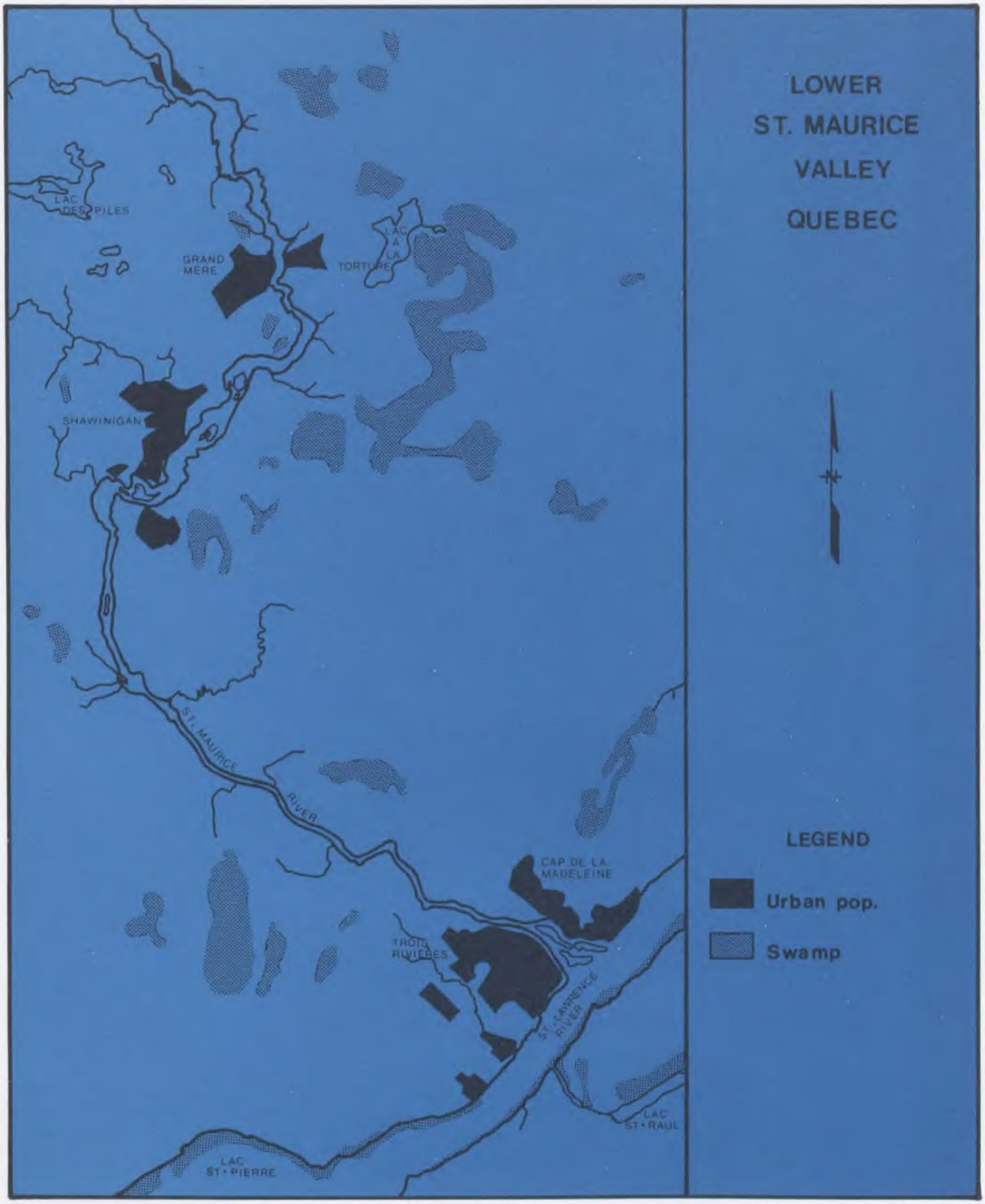
Take heart, for the mosquito hunt has begun — at least in the lower St. Maurice Valley in Quebec. A group of researchers from the Chemistry and Biology Department of the University of Quebec, Trois-Rivières campus (UQTR), began a mosquito control project in 1972 in the marshy areas of the region. This project aims to institute an ecologically sound control of harmful mosquitoes, of which there are 44 species in Quebec.

The project is following a new formula — the "integrated campaign" — which efficiently combines chemical and biological control. This pilot project is limited at present to the region bounded by Champlain in the east, Louiseville in the west, St-Jean-des-Piles in the north and Nicolet in the south. The leaders of the project are Antoine Aubin and Jean-Pierre Bourassa. Estelle Lacoursière, Serge Belloncik and Marc Pellissier are also participating in the study, which is funded by UQTR and the National Research Council.

Naturally, this anti-mosquito campaign requires a large number of preliminary ecological studies. First, the researchers drew up a map of the main forest areas from aerial photographs. Vegetation is the "ecological indicator" of mosquito populations — it makes it possible to draw up an inventory of the species and their distribution throughout the region under study. The most heavily populated zones are characterized mainly by an abundance of stagnant water, which is the natural breeding ground of mosquitoes.

The group of researchers has identified the most important physico-chemical components found in swamps: for example, oxygen and carbonic gas dissolved in water, water temperature and colour. The scientists also study the primary productivity of phytoplankton (algae) — that is, the percentage of solar energy in marshland used by the plants. Furthermore, in order to continue physiological studies on the mosquito year round and to better determine its growth rate and adaptability to the environment, the group set up a laboratory breeding ground for the four main species of mosquito.

According to scientific classification, the mosquito is a two-winged insect of the family Culicidae. It is hematophagous; that is, it needs blood. Only the female bites. Once fertilized, it seeks out human or animal blood, which contains proteins that are essential to produce the female mosquito's eggs.



Swamps in the Lower St. Maurice Valley.

Contrary to popular opinion, the mosquito does not necessarily die after biting. However, it does become more vulnerable to other insects, since its defences are weakened due to its increased weight.

The mosquito spends a large part of its life in water. The life cycle lasts about three weeks, depending on the species. Eggs are laid in moist places. Even if the place dries up, the egg can survive for months or even years. When temperature and humidity conditions are favourable, it changes into a larva. Larvae have a breathing tube and periodically come to the surface of the water for oxygen. The larva then evolves to a pupa. Several days later the aquatic phase ends, the mosquito emerges from its case and flies away.

Using these observations, the UQTR research group is developing an effective method for combating mosquitoes at the larval stage. The method used consists of pouring a biodegradable chemical into the water. The chemical weakens the larva and allows fungus, a natural parasite of the mosquito, to attack it. This microscopic fungus may block the breathing tube and the larva then dies from lack of oxygen. The chemical is used only to weaken the larva, and has no immediate effect on the environment.

However, mosquitoes will not be completely wiped out. This method aims at controlling mosquito populations rather than eliminating them, for in some areas mosquitoes are very important to the balance of nature, especially as food for birds and aquatic insects.

Several studies are being carried out in conjunction with the project, in order to identify the role of Culicidae in the food chain, and to determine their distribution in the area surveyed. One of the most important studies involves analysing the effect of the fungi and the chemicals used on other aquatic organisms. A quite thorough study is being done of the parasitology of the mosquito with a view to possibly using only pathogenic organisms (viruses, bacteria, fungi) to destroy it. At present, it seems that fungus is the most effective means.

Although the present studies do not make it possible to foresee entirely biological control, researchers predict that growth hormones, secreted by mosquitoes and used against them, will be the method of future control. The age of DDT may well be over. However, specialists in this field regret that governments are still not sufficiently aware of the mosquito problem to grant the necessary funds for research.

The team from UQTR regularly checks research done elsewhere on mosquito control. One of the chief consultants is Dr. Ronald Roberts, an entomologist at the Boyce Thompson Institute in New York. At the international seminar on mosquito control held at the Trois-Rivières Campus of the University of Quebec in May 1973, European, American and Canadian specialists reviewed current research and knowledge in the field of mosquito control. This seminar was made possible through the co-operation of the French-Canadian Association for the Advancement of Science (ACFAS) and UQTR.

Dr. Robert Harrison of the St. Hyacinthe School of Veterinary Medicine stated in a lecture that a mosquito control program is needed.

From the medical standpoint, mosquito bites often transmit diseases to humans. From the veterinary standpoint, the fight against mosquitoes will probably make possible a reduction of eastern equine encephalomyelitis — a sleeping sickness in horses — which recently appeared in Quebec.

Last but not least, some campgrounds and tourist centres which have been hurt by the overabundance of mosquitoes will be greatly relieved at the disappearance of these undesirable insects. Perhaps soon the only inconvenience in camping will be the overabundance of campers!

Ice Engineering

MARTIN McCORMACK

Dr. Howard T. Barnes studied the physical properties of ice to find methods which would prevent ice jams in the St. Lawrence River and reduce the number of icebergs which threatened shipping off Newfoundland and the coast of Labrador.

The old-timers of Jenkins' Cove remember Howard T. Barnes as the man who made ice burn.

On a hot spring day in 1926, the Montreal physicist and two assistants planted a 500-pound cylinder deep within an iceberg grounded in the cove off the east coast of Newfoundland. At sunset the townspeople heard a thunderous roar. Then a jet of flame spurted from the iceburg hundreds of feet into the evening sky.

Pieces of molten iron and fragments of ice — on fire — arced through the air and fell hissing into the sea several hundred feet from the iceberg. For many hours afterward the people listened to cracks and groans as the icy monolith slowly broke apart.

The display was in keeping with Dr. Barnes' appreciation of the spectacular, but there was no magic at Jenkins' Cove. The feat was simply one of the more dramatic achievements of a Canadian scientist who almost alone established ice engineering as a separate field of scientific study.

Ice engineering is devoted to the development of methods for monitoring ice movement and the conditions which cause ice to form, preventing lake and river ice from blocking the intakes to city water supplies and electric powerhouses, and breaking up ice jams in rivers and icebergs at sea.

It was this last purpose — breaking up a massive ice formation — which concerned Dr. Barnes that day at Jenkins' Cove. He employed his own method, which is believed to be the first scientifically-based approach to such a problem.

Dr. Barnes used an incendiary chemical called thermit, a mixture of powdered aluminum and iron oxide that burns at temperatures ranging from 2,500 to 4,000 degrees Centigrade. That amount of heat, when produced over 30 seconds to a minute, causes ice to crack hundreds of feet away from the thermit. The very high temperatures also transform a small amount of the ice into hydrogen and oxygen gases, which catch fire and may burn for five or six seconds.

The technique was so successful that many maritime communities in eastern Canada and the northeastern United States asked Dr. Barnes to break up ice jams that were clogging their waterways. In 1926 alone he demolished three different icebergs off Newfoundland.

The McGill University physicist first used thermit in February, 1925, to break up a 250,000-ton ice jam on the St. Lawrence River at Waddington, New York, about half way between Kingston and Montreal. In the next two years, Dr. Barnes split ice jams on the St. Lawrence near Ogdensburg, New York; on the Moira River at Belleville, Ontario, and on the St. Maurice River at La Tuque, Quebec, about 150 miles northeast of Montreal.

The largest ice jam Dr. Barnes ever cracked apart with thermit was a 25-mile-long pack which formed on the Allegheny River in Pennsylvania late in February, 1926.

Although Dr. Barnes' thermit treatment was highly successful, it is no longer used. In the last 30 years, icebreakers have prevented large jams from forming on the major rivers in most northern countries. Today, two Department of Transport icebreakers continually work up and down the St. Lawrence in winter.

However, Dr. Barnes was the first to analyze and scientifically describe the ice conditions these vessels encounter, particularly in the stretch of the St. Lawrence between Quebec City and the east end of Lake Ontario. Among the worst trouble spots here are shallow channels in which cakes of ice form most easily. Other hazardous areas are stretches of turbulent, open water where great numbers of small, disc- or needle-shaped crystals of ice form in sub-zero weather.

The crystals, called frazil ice, stick to anything in their path — rocks in shallow water, the bottom of an ice sheet, the undersides of floating cakes of ice, or grates over water intakes of power plants or city water supplies.

Dr. Barnes began his ice engineering studies at McGill in 1895 with work on the formation of frazil ice. During the next three years he conducted experiments in the laboratory and observations in the St. Lawrence to see how much heat is required to melt ice. If only a small amount of heat were required, Dr. Barnes reasoned, mechanical or electrical techniques could be used to heat and thaw turbines, clear intake grates and soften up small ice jams.

In experiments during 1895 and 1896 he added clean snow to beakers of water which had been rapidly chilled below the freezing point. The snow crystals caused ice to form in spongy masses exactly like lumps of frazil ice. Using a very sensitive thermometer, the physicist consistently found that the temperature of the water in the beakers was -.014 degrees Centigrade when the nearly transparent ice crystals began to form.

Since one-fifth of the water in open stretches of the St. Lawrence turns to ice in mid-winter, Dr. Barnes took temperature readings in his laboratory beakers again when 20 per cent of the water in them had frozen. In this phase of his experiments he consistently got readings of -.006 degrees Centigrade.

In 1897, Dr. Barnes measured air and water temperatures at the Lachine Rapids, five miles west of downtown Montreal. On February 7, he recorded a water temperature of .019 degrees Centigrade, and reported that St. Lawrence ice was melting rapidly under a cloudy sky and an air temperature at the freezing point. However, on February 12, frazil ice began to form quickly in -.007-degree water, chilled by a strong easterly wind and an air temperature of -19 degrees Centigrade.

Dr. Barnes concluded from his observations that only very slight changes in water temperature were needed to create or melt ice. Therefore, if operators of hydro-electric powerhouses could heat the water wheels that turned their turbines and heat the water intake gratings that kept out floating logs, power companies could prevent ice formations that clogged their machinery and reduced the power generated, or occasionally forced a complete shutdown. Similarly, municipal water companies could heat their intake grates to stop ice from choking off the flow.

In 1906, John Murphy of the Ottawa Power Company, who had read several of Dr. Barnes' articles, successfully forced steam into the turbines and around water wheels where frazil ice often created problems. Mr. Murphy, the first Canadian to use heat to stop ice from disrupting powerhouse operation, also used electricity to warm the bars of the water intake grate.

Dr. Barnes also recommended to power and water companies that:

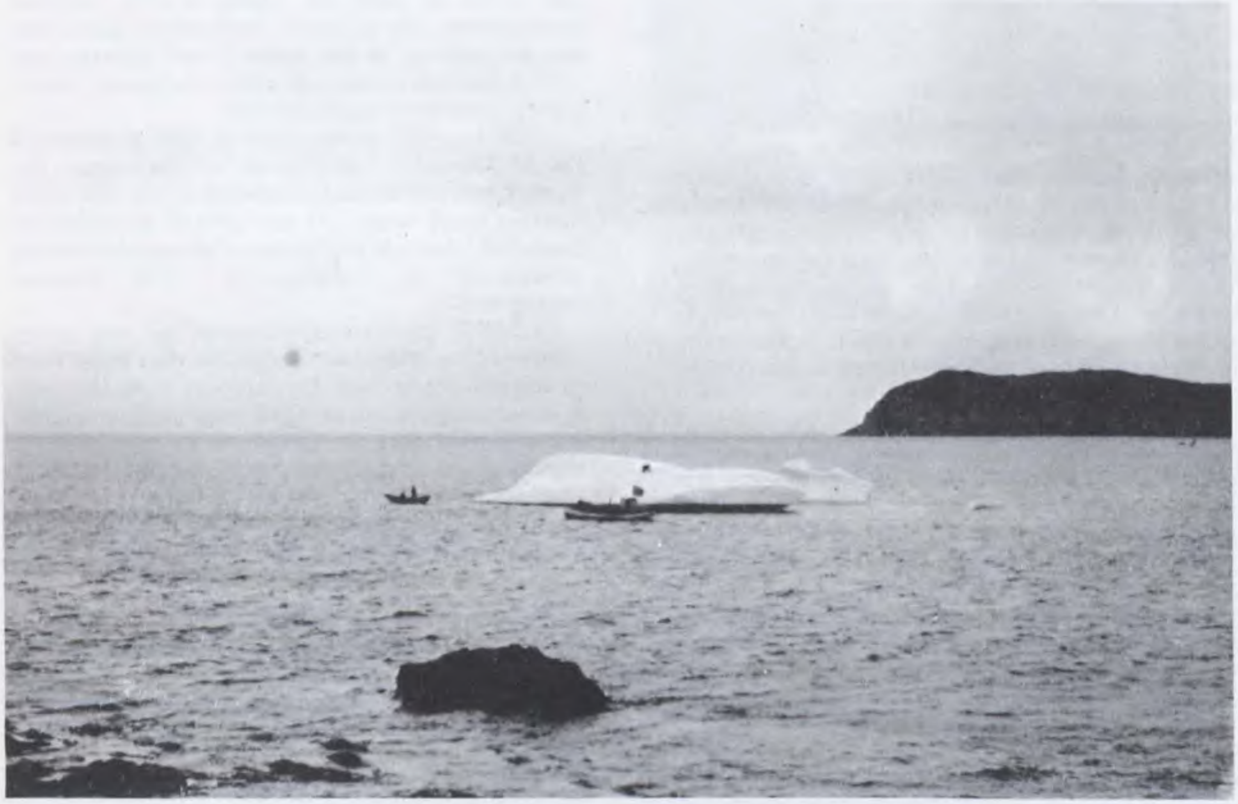
— Intakes should be in deep, quiet water which is usually covered by a sheet of ice from December to April. The ice would prevent the water from losing more heat to the air, a process which causes ice to form at river bottoms and frazil ice to form at the surface if the weather is cold enough;

— Intake canals, which channel water to turbines or reservoirs, should be deep and narrow to minimize the radiation of heat to the air. If it is not practical to build narrow, deep canals, engineers should use pipes instead.

Today, power companies in Canada and the northern United States take Dr. Barnes' suggestions as standard operating procedure, according to Dr. Elton Pounder, who succeeded Dr. Barnes in ice physics at McGill.

Nearly every winter from 1908 to 1926 Dr. Barnes was on board an icebreaker in the St. Lawrence River or the Gulf of St. Lawrence. He studied frazil ice and, with a highly sensitive thermometer — or microthermometer — of his own design, he measured water temperatures to within .001 degrees Centigrade over hundreds of square miles.

The microthermometer was essentially an electric coil that measured the water's resistance, a property which varies with temperature. Attached to the



Dr. Barnes and his assistants are getting ready to destroy this iceberg with a charge of thermit.

side of the ship five feet below the water surface, the coil sent its resistance measurements as an electric current back to a chart room where a recorder drew on moving paper a continuous line representing the water temperature.

Using his microthermometer, Dr. Barnes proved in the winter of 1924-25 that Lake Ontario acts like a huge heat reservoir. He set up continuous water temperature recorders at St. Lambert, on the south shore of the St. Lawrence opposite Montreal, and the Ontario cities of Cornwall, Morrisburg, Prescott, Brockville and Kingston, each further west along the river than the last. He then compared the St. Lawrence water temperatures from October 1 to June 30 with the date when the river ice began to form at each city.

Regardless of the sometimes colder weather near Lake Ontario, ice formed first at St. Lambert about December 10 and last at Kingston about February 1. The reason for this east-west freezing is a persistent outflow of warm water from Lake Ontario. According to Dr. Pounder, the lake water rarely becomes colder than 4 degrees Centigrade.

In Gulf of St. Lawrence studies, Dr. Barnes disproved the popular belief that water around an iceberg is cooler than sea water farther away. In 1908 he measured water temperatures about one degree Centigrade higher within five miles of a melting iceberg, a noteworthy difference in a science which regards variations of one-hundredth of a degree as significant.

Dr. Barnes explained that an iceberg cools the water that touches the submerged nine-tenths of its mass. The cooler water sinks, because it is denser than the water farther away from the ice. Warmer water then flows up to the surface around the iceberg to replace the chilled water.

In addition, the fresh water which melts from the

As the incendiary chemical thermit burns in the iceberg grounded in Jenkins' Cove, the intense heat changes iron oxide to flying sparks of molten iron, and transforms the ice immediately around the thermit into hydrogen and oxygen gases. These gases catch fire and burn.

iceberg forms a thin layer on top of the sea because fresh water is less dense than salt water. The fresh water mixes only very slowly with the sea; therefore, the melt-water from an iceberg stays at the surface long enough to be warmed by the sun.

Dr. Barnes described his observations and theories in Ice Formation (1906) and Ice Engineering (1928), two books considered fundamental to modern ice studies. During his career at McGill University, from 1890 to the early 1930s, Dr. Barnes became a member of numerous scientific organizations, including the Royal Society of Canada, the Royal Society of London, the Physical Society, the Canadian Institute of Engineers and the Royal Meteorological Society.

Rinderpest Vaccine

LINDA CHEMELLI

An animal vaccine, developed in Quebec to defend North American cattle against possible biological assault during the Second World War, has become a major weapon in developing countries against the fatal cattle disease, rinderpest.

The disease, which affects only cud-chewing animals, spreads through all organs, causing diarrhea, fever, then death.

Before introduction of the Canadian rinderpest vaccine, the highly-infectious disease killed over 2 million head of cattle and buffalo every year in Africa, the Far East and India. As recently as 1970, severe rinderpest outbreaks wiped out large cattle populations in 24 countries in Africa, particularly in the transcontinental belt stretching from Senegal to Somalia and as far south as Tanzania.

Following the successful attempt of four Canadian and four U.S. scientists to develop an effective rinderpest vaccine in 1946, the United Nations Food and Agricultural Organization (FAO) began assisting in its production and dissemination. To countries affected by the disease or threatened by rinderpest, the FAO sent information on the production and uses of the vaccine and technicians to help manufacture and administer it.

Estimates of the extent of rinderpest infection in specific developing countries, either before or after vaccination, were not available. However, in China, which had suffered severe epidemics in the past, no outbreaks of rinderpest were recorded in 1971. Incidence of the disease in Africa and India was known to have been greatly reduced as well.

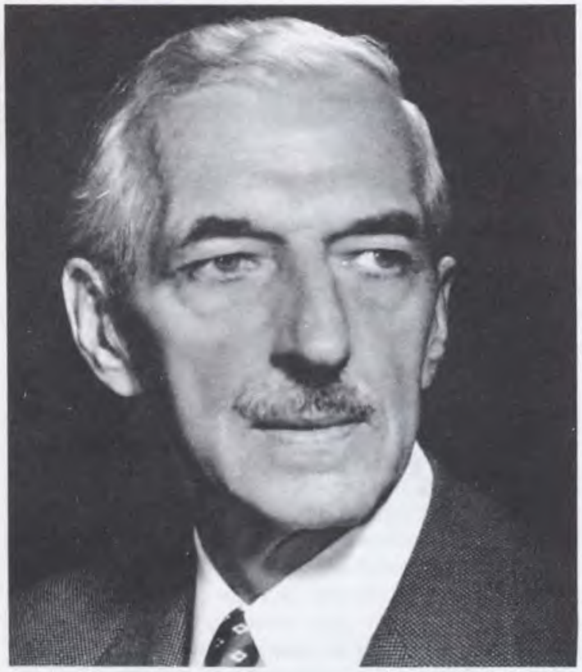
As part of Canada's foreign aid program, the Canadian International Development Agency sent seven veterinarians and one administrative officer to Ethiopia in June, 1973, to help in the Ethiopian Rinderpest Program which employed the Canadian vaccine.

Canada's part of the program, which had begun three to four years earlier, involved vaccinating 10 million cattle three times during the next three years in three of Ethiopia's northwest provinces.

Top-secret work on a rinderpest vaccine began in 1943 at Grosse Ile, a small island in the St. Lawrence River about 30 miles below Quebec City.

Although much of the story still is cloaked in official secrecy, it is known that Canada and her wartime allies feared the enemy might use rinderpest to infect cattle on the continent in an effort to cripple much of the food supply for soldiers overseas.

In 1943 a joint Canadian-U.S. commission of eight members, four of them Canadian, was appointed by the Canadian Minister of National Defence and the U.S. Secretary of War to establish



Dr. Guilford Reed

Dr. Charles A. Mitchell

the War Disease Control Station for rinderpest research and development of a vaccine.

Canadian members of the commission were Dr. Charles A. Mitchell of the Federal Animal Disease Institute in Hull, Quebec; Dr. James Craigie, head of the Division of Biology at the school of Hygiene in Toronto; the late Dr. Guilford Reed, head of the Department of Bacteriology at Queen's University in Kingston, and the late Dr. E.G.D. Murray, head of the Department of Bacteriology at McGill University in Montreal. The undertaking was to last until Feb. 28, 1946.

The vaccine is a preventive medication which contains a virus treated to reduce its virulence. The weakened or attenuated virus is introduced into the body to stimulate a low-level infection which, in turn, stimulates the development of antibodies, substances that combat infection and effectively immunize the body against further disease.

The immediate objective of the Grosse Ile group, therefore, was to collect an adequate stock of virulent rinderpest virus from infected cattle lung and spleen. They intended then to convert the virus into 100,000 doses of vaccine effective in giving cattle long-term immunity to the disease. With this small amount of vaccine, it was thought, it would be possible to limit the spread of isolated outbreaks of rinderpest in Canada or the United States.

Rinderpest vaccines made from cattle spleen had already been developed for use in Africa, India, China and other areas since the 1920s but had provided only short-term immunity.

The procedure the Grosse Ile group initially used to produce a virus sufficiently attentuated for vaccination was awkward and inefficient. First a calf was injected with an inactivated virus. Then, at the height of its fever, the animal was killed so that the largest possible amount of virus could be derived from its spleen.

One calf could supply virus for a maximum of only 350 doses of vaccine and only 15 calves could be processed every other day. This method of vaccine production would be impractical to control widespread outbreaks of rinderpest. It would have taken until the year 2002 to produce enough vaccine to immunize all 60 million head of Canadian and U.S. cattle, the long-term objective of the project.

The researchers decided to try establishing the rinderpest virus in eggs in which chick embryos had developed; eggs were known to be a good medium for virus cultivation. It seemed possible by this

Dr. James Craigie

Dr. E.G.D. Murray

method to cultivate the virus in greater quantity at less expense. Furthermore, the virus could be grown free of bacteria in eggs, whereas it was impossible to do so using cattle tissue.

After the eggs had been incubated for 10 days, a dental drill was used to cut a small, square window in each shell over the region of the embryo. Two- to four-tenths of a cubic centimeter of calf tissue, infected with the Kabete strain of rinderpest from Rhodesia, were dropped into each egg on the chorioallantoic membrane which surrounds and protects the embryo.

The virus-infected egg was incubated again for three days to allow the virus to grow. Then the embryo and chorioallantoic membrane were removed, ground up in a sterile grinder and frozen. It was found that the vaccine retained its potency when stored at -20 degrees Centigrade, but the viruses in it died when exposed to room temperature until, after 72 hours, the vaccine became completely inactivated. The ground tissue was dried in a vacuum to improve its storage qualities so that it could be transported without loss of potency from the place of production to the point where it was to be used.

For inoculation, one vial of dried vaccine was dissolved in about 60 cubic centimeters of distilled water and a saline or phosphate solution. Tests proved that the vaccine was effective against all strains of rinderpest.

Calves, which were kept in isolation cubicles, were inoculated just under the skin with one to five cubic centimeters of the vaccine. The first vaccine was too strong and killed the calves.

To obtain a less deadly virus, it was necessary to "passage" or transfer the virus through a series of eggs before inoculating a calf. It was not until the fortieth passage that the virus became fully attenuated, harmless enough that it caused only the low-level infection necessary to produce immunity.

Autopsies were performed on many test animals to obtain further information about the characteristics of rinderpest and to discover how the calf's metabolism attempted to resist the disease.

Most of the experimental animals were Holstein-Friesans, Jerseys or Ayrshires. A few were Herefords, Red Polls, Shorthorns and Guernseys. All of these breeds are about equally susceptible to the Kabete strain of rinderpest.

Rubber gloves, boots and overalls were worn by a scientist while in an isolation cubicle with an infected calf. Scientists and attendants were required to take soapy showers after leaving a cubicle, which amounted to a minimum of 20 showers a day for each.

Calves were fed no hay because particles in their manure would have been difficult to dispose of with Grosse Ile sewage facilities. Their diet consisted of a commercial grain feed mixed with dried beet pulp and ground alfalfa.

For disposal, dead calves were cut into pieces small enough to fit into large, metal garbage cans which were thoroughly scalded and removed from the unit to an incinerator.

All sewage from the isolation quarters was washed into 1,000-gallon concrete tanks where it was steam-sterilized. The sewage was heated for approximately four hours until it reached a temperature of 80 degrees Centigrade. Once safe, it was piped into the St. Lawrence River.

At the end of the war the Grosse Ile project was turned over entirely to the Canadians, each of whom was awarded the U.S. Medal of Freedom, the highest distinction that can be awarded to a civilian.

Dr. Mitchell was doing microbiological research at the University of Ottawa in 1973. He was leading a team that was attempting to develop an anti-serum for humans infected by rabies. The work was being financed by the Defence Research Board in Ottawa. Dr. Craigie had gone to London, England, to do cancer research.

Stuttering

MARGARET BRASCH

Diderot wrote: "I do not know of anyone who loves to talk more than a stutterer." Be that as it may, the stutter often sounds amusing or embarrassing to the 'normal' listener.

To the person who suffers from stuttering, of course, conversation is both difficult and embarrassing. Often of above-average intelligence and sensitivity, the stutterer feels handicapped when he tries to express an idea or participate actively in discussion.

Affecting almost 3 per cent of the Canadian population, stuttering can be defined as a neurosis of the speech organs symptomized by pronunciation defects in the form of a staccato repetition of syllables and involuntary interruptions of words.

Orthophonists or speech specialists recognize two types of stuttering: clonic and tonic. The first type is characterized by the convulsive repetition of a syllable at the beginning or in the middle of a sentence. For example: "The, the, the, the, wolf ate the lamb."

Tonic stuttering is a state of muscular immobilization which totally blocks speech; when the spasm subsides, the speaker's words come rushing out in a sort of characteristic explosion.

The causes of stuttering are as varied as are the differences among stutterers. Léonce Boudreau, a psychologist with the University of Moncton, New Brunswick, told the story of a five-year-old boy who acquired the habit of stuttering by imitating his uncle, and was still stuttering at the age of 15.

Mr. Boudreau has been interested in the causes of stuttering and in finding appropriate solutions to this disorder for five years. Under a Medical Research Council grant, he studied the generalization effects of the continuous ticking sound of the metronome on stuttering.

Stuttering is usually discovered as soon as a child can speak. In fact, it is now known that the percentage of stutterers is very high around the ages of three to five years, and decreases to 3 per cent around puberty. The degree of stuttering is calculated by measuring the number of words mispronounced out of a hundred by a stutterer.

In his experiment, Mr. Boudreau took a sample of male subjects aged 13 to 30 years, recruited through advertisements in a regional daily newspaper. There were two reasons for choosing male subjects. First, the rate of stuttering is three times higher in males than in females, and secondly, he wanted to limit the number of variables in the experiment.

Furthermore, the subjects were a mixture of

French Canadians and English Canadians, a fortunate combination which, according to the psychologist himself, occurred entirely by chance.

The group of 20 stutterers, classified at an average of 16 per cent stuttering, was divided into two groups of 10: the first group underwent treatment, and the other served as a control group. The latter group came to the laboratory, but did not undergo treatment.

For 21 days, the stutterers went to Mr. Boudreau's laboratory once a week for tests lasting about two hours.

The experiment was conducted in four steps: the pre-test, the 10 treatment sessions, the post-test, and the follow-up. The pre-test and the post-test were given without the metronome.

In the pre-test, the psychologist established the degree of motivation, the percentage of stuttering, and the individual needs of each stutterer. After the pre-test, the stutterer underwent the treatment which consisted of listening through earphones to the following sound rhythm: two seconds of ticking by an electronic metronome followed by one second of silence.

Assisted by Maria Hébert, a graduate student, Mr. Boudreau asked his patients to read a text for 20 minutes, following the rhythm of the metronome. After they had mastered the synchronized reading, the stutterers were asked to adapt this technique to spontaneous conversation for another 20-minute session. The reading and the conversation using the metronome constituted the experimental activity.

The post-test was only a re-evaluation of the percentage of stuttering during reading and conversation without the use of the metronome. The degree of success of the treatment was thereby established.

''We hope,'' noted Mr. Boudreau, ''that synchronization will become a matter of habit.'' In fact, the ultimate goal of the experiment was to teach the stutterers to 'generalize', that is, to make the transition from the laboratory situation to the normal, every-day life situation.

Mr. Boudreau noted a significant drop in the degree of stuttering between the pre-test and the first treatment session with the metronome. The progress thereafter was maintained at the same level during all the treatment sessions. At the end of each session, the stutterers were encouraged to practise the technique at home.

Four months after the experiment had ended, the 20 stutterers underwent a follow-up session. Mr. Boudreau noted enthusiastically that the 10 treated stutterers had retained the improvement achieved in the treatments.

It should be added, however, that Mr. Boudreau combined a systematic desensitization process with the metronome treatment, in order to reduce the stutterers' inhibiting embarrassment. First of all, situations most likely to increase stuttering in each stutterer were determined. Then, the stutterer was asked to imagine the least anxiety-producing situation. Once this was established, the stutterer was to practise speaking in the context of this selected situation. The desensitization was then gradually increased in intensity.

''We felt that a desensitization treatment was needed'', pointed out the psychologist, ''because we had noted that stutterers had much more difficulty expressing themselves alone than in a group of people sharing the same problem.

''It should be noted that none of the stutterers respond to the treatment in the same way. Their response depends highly on degree of motivation'', said the psychologist.

It can therefore be said that much of the success of this method depended on the motivation of the stutterers. Confronted with situations in which they had to converse, the stutterers become tense and anxious. At that point, the psychologist's role was to teach the stutterer the art of relaxation. This was often not immediately successful. The psychologist observed that the age factor played a major role in the stutterers' degree of motivation, the youngest being more open to treatment.

Treatment of stuttering through the use of a metronome is not really a novelty; the technique dates back more than a century. However, the combination of the metronome treatment with the systematic desensitization treatment constitutes the innovative aspect of Boudreau's method. The proof lies in the results of the follow-up.

But what is the practical value of this experimental technique? According to Mr. Boudreau, it could be easily adapted to schools for the treatment of young stutterers. ''The beats of the metronome would be recorded on tape, and then an unlimited number of stutterers, using individual earphones, could practise their conversation and reading without interruption. Also, the installation cost would be minimal.''

Mr. Boudreau is currently applying this method in three Moncton regional schools, with promising results. By increasing the number of metronome sessions and personal practice at home, and by developing a portable metronome-earphone, the Acadian psychologist hopes to help stutterers lessen their impediment and to lead a normal life.

Restocking of Caribou

CLAUDE BONENFANT

More and more is being said about conservation of natural resources and protection of the environment. Most often this takes the form of people speaking out against deplorable situations, imputing blame for acts of carelessness which threaten to upset the balance of nature, or justly fighting the laxity which is so prevalent in the area of ecology. Nevertheless, some ecological projects have been successfully carried out. Such is the case with the caribou, also known as the North American reindeer.

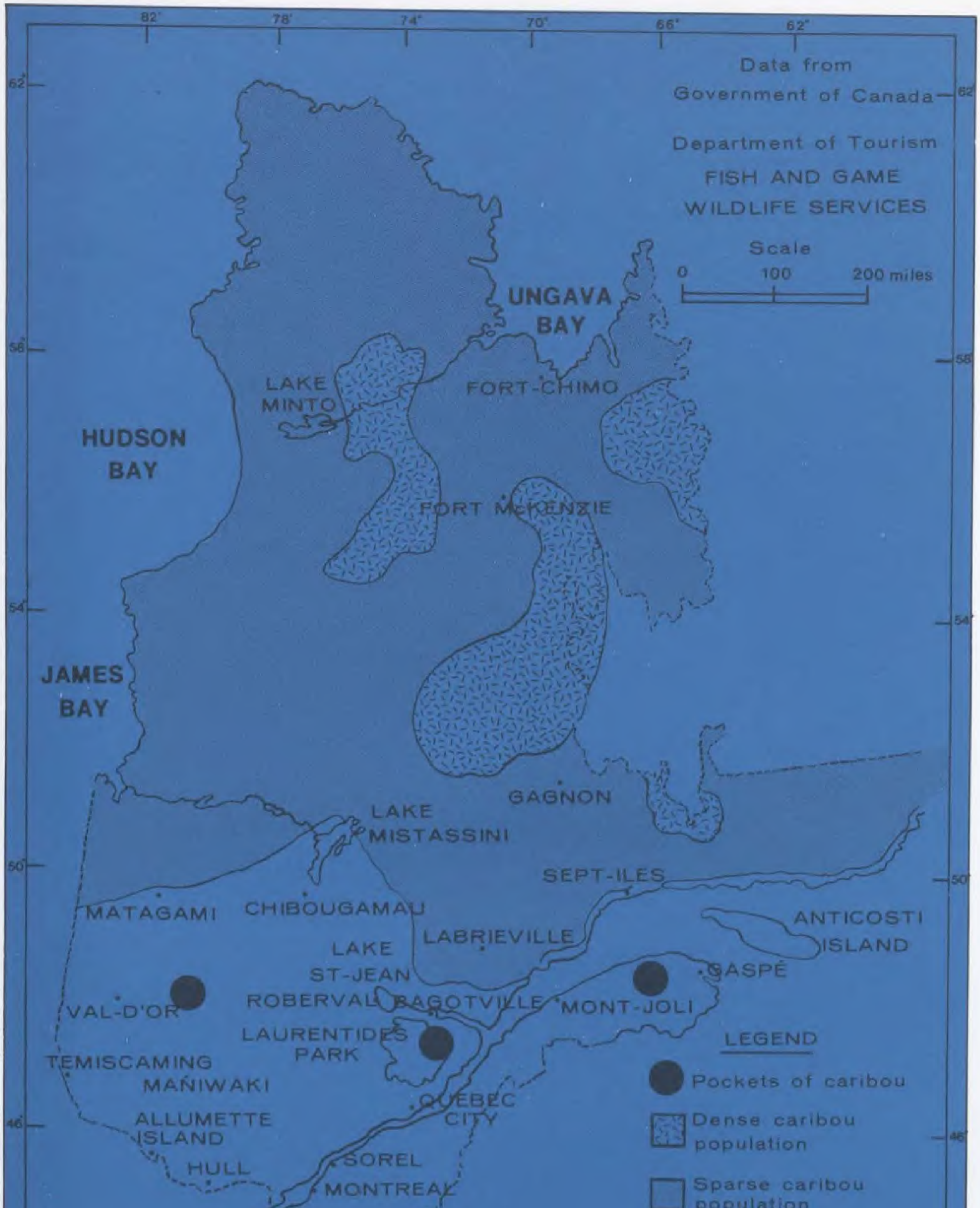
Some 20 years ago, it was predicted that the caribou would disappear from Quebec. Instead it has multiplied so rapidly that its numbers have now reached 100,000 in New Quebec and Ungava. Unfortunately, the caribou has not been equally fortunate everywhere. Thus, at the instigation of Pierre Desmeules, a project has been underway since 1966 to reintroduce the caribou into Laurentides Park, from which it disappeared about 1930.

The caribou is a member of the deer family. It first arrived on the North American continent, by way of Alaska, more than 10,000 years ago at the end of the Pleistocene Epoch. It is designated Rangifer tarandus. Its cousin in the arctic regions of Europe and Asia, the Eurasian reindeer (R.t. fennicus), is often domesticated.

Once in North America, Rangifer tarandus proliferated rapidly and its range soon extended as far as the central United States (Wisconsin). However, it preferred a rugged life and gradually withdrew towards the north, following closely the retreat of the last continental ice sheet. It was already being hunted ages ago by the American Indians and Eskimos.

When the first European explorers arrived, Rangifer tarandus had populated most of Canada, from Newfoundland to Alaska. The colonization of the northern United States and southern Canada forced the remaining caribou in these regions to retreat northward. These settlers gave it the name "caribou" derived from the Micmac word, xalibu, which means pawer or scratcher.

Rangifer tarandus is now found over large areas of northern Canada, including Newfoundland, the Arctic Islands and the coastal regions of Greenland and Alaska. This magnificent animal is known by various names: in the Northwest Territories it is called groenlandicus (barren-ground caribou); in Alaska, granti (Grant's caribou); on the Arctic islands pearyi (Peary's caribou) and in Greenland, eogroenlandicus. And those in eastern Canada are simply called caribou (woodland caribou).



The distribution of caribou in Quebec.

All these designations stem from the environment. There is no well-defined demarcation between the various types, except perhaps by size.

The caribou population in eastern Canada, where hunting of this animal is permitted, appears to be thriving, if the statistics are to be believed. From 3,000 head in 1950 it increased to 40- or 50,000 by the 1963 census. The total figure for 1971 is somewhere between 75- and 100,000.

It goes without saying, however, that no hunting is allowed of the small herd of 500 caribou in the Shickshock Mountains in the Gaspé Peninsula, where the population has remained stationary since 1954. The climate and vegetation in this area resemble those of the taiga, the far northern evergreen forests.

At the start of the century there were about 10,000 caribou in the Rivière Malbaie drainage basin, an area in Laurentides Park better known as "Grands Jardins". Despite the park's creation in 1897 to protect the herds of caribou, their numbers gradually declined until in about 1930 there were none left.

To what may we attribute this disappearance? It could not have been caused by legal hunting, since the last kill was recorded in 1914, nor by poaching, because a herd of 10,000 caribou increases by more than 1,000 head each year. Nor, say experts, can it be attributed to predation by wolves, to fire or to epidemics.

Were winters perhaps too severe and the snow too crusted to allow the caribou to get at the lichens on which they feed? Was there perhaps a shortage of lichens because of an over-population of caribou? These are the lines along which Mr. Desmeules explains their disappearance: "The Grands Jardins caribou population was confined to a very restricted area, and its growth, unchecked by hunters, soon surpassed the environment's capacity to support it. The supply of lichens, the staple of the caribou, decreased rapidly and progressive migration followed."

It is interesting to note that caribou were disappearing at about the same time in Ontario and the Maritimes. There must have been 10 times as many caribou in Grands Jardins in 1900 as the area could support. A study undertaken in 1964 showed that this region could sustain, over a long period of time, a caribou population of about 1,000.

The Quebec Department of Tourism, Fish and Game therefore approved without delay a project to reintroduce the caribou into its former habitat. However, they first had to be caught. About 50 caribou are needed to form the basis of a herd. Capturing caribou individually requires too much time and money; a mass capture method was therefore developed.

To begin with, a mixed herd of between 30 and 100 animals must be located, preferably a group which contains a large number of females, since early in the year they still have their antlers and are therefore easier to catch in the nets. The end of winter or beginning of spring is the most favourable time.

The herd should be on a frozen lake large enough to allow the animals to be driven in certain directions. Nets are hung across the worn paths leading from the lake into the forest. Nylon fishing line with a three- or four-inch mesh was first used, but seal nets with a 10-inch mesh were later found to be stronger. The nets are hung in a U-shape to a height of 20 feet over a width of 300 or 400 feet, and about 50 to 100 feet from the shore. Noose-type leg traps, firmly attached to trees, were occasionally used. This method was soon abandoned, however, because a frightened caribou could harm itself easily.

With the help of two airplanes the herd is manoeuvred toward the paths. Not wanting to leave the packed snow on the lake for the soft snow at the lake's edges, the caribou follow the path and get caught in the nets, camouflaged by the forest.

The success of the operation depends entirely on the control the airplanes have over the herd. The planes begin by circling above the herd, trying to drive the animals together into as small an area as possible. It is very important that the planes do not pass directly over the herd, since this would cause it to scatter.

The plane then lands on the lake and begins to steer the caribou toward the paths, following them at a distance of some 100 feet and at a speed which forces them to move forward at a slow trot. The plane can thus round up any animals which might stray from the herd. At a distance of 1,000 feet from the nets the plane accelerates and the caribou file onto the paths, where they become entangled in the nets.

A ground team of five or six men then takes over. The caribou's legs are bound together as swiftly as possible. When the first animals were caught in 1965 they were injected with a succinylcholine tranquilizer. Later, as the team became more skilled, the drug was no longer necessary.

In this way the team made 33 captures at 15 different sites. The first capture period, in March 1965, involved 13 expeditions. There were four expeditions in March 1966 and 16 more in March 1967. On 11 of the expeditions airplanes were used, but without landing for ground manoeuvres; 19 caribou were taken in this way.

The "air-to-ground" method gave the best results. It was used on 21 expeditions to capture 60 caribou. A similar expedition using an airplane and a snowmobile yielded the best single catch yet: eight caribou.

The operation does not take long. A ground team of six men fastens the nets within the space of an hour. About a quarter of an hour is required to chase the caribou into the nets, and another half-hour to tie up the captured animals and transport them to the enclosure in which they will await departure. Thus the entire operation takes less than two hours to complete.

Of 18 caribou captured on Lac Raimbault in 1966, 13 were transported south to Lac Turgeon in Grands Jardins. Two females died on arrival due to handling, and two others were wounded during the summer. Including new offspring, 11 caribou remained. In 1967, 35 caribou were transported from Lac Pierre, Lac Dolbel and Lac Go, north of Sept-Iles. Nine females died because of the stress of capture and transportation.

Thus 37 caribou remained at Grands Jardins in 1967. In order to prevent these "deportees" from migrating from their new home, those in charge of the project gradually released only the youngest animals from their enclosure; that is, those caribou which had become accustomed to their new habitat. It was found, nevertheless, that a great number of them left the region. Many were rediscovered in the Tadoussac area.

In the winter of 1973 a population study of caribou in their wild state established that the Grands Jardins population was 42 — not a very impressive increase. According to the experts, however, there is every reason to believe this new herd is made up almost entirely of fresh blood. The youngest of the herd, born in captivity and having no knowledge of their ancestral home, will choose to live in this new habitat. Observers, now less rash in their hopes than at first, confidently predict an annual increase of six or seven per cent.

In 1973, the Wildlife Service was attempting to end the poaching which threatens this herd whose existence is already so precarious. During the last two years 12 cases of poaching have been reported. This portion of Laurentides Park is now under the surveillance of conservation authorities. Regular aerial surveillance gives additional protection.

Finally, access to the region is restricted and controlled. During the winter of 1973 the remaining caribou in the enclosure were released. The herd is now considered to be able to survive on its own, although strict surveillance and protection are still being indirectly maintained.

Although there has been no spectacular increase in the herd's numbers up to now, the captive caribou have at least provided an opportunity for carrying out numerous studies which would otherwise have been impossible. These dealt in particular with the animals' feeding habits, behaviour, growth and reproduction.

Caribou are able to subsist on a large variety of foods, from mushrooms and tree bark to mosses and lichens, which are related to algae and mushrooms. A study carried out in 1966 showed that caribou have a preference for reindeer moss, the most abundant species of lichen in the Grands Jardins region. Each of the caribou in captivity consumed an average of 17 or 18 pounds (moist weight) of lichens a day, and five pounds of commercial fodder.

Their reproductive habits were also studied. The gestation period is 240 days, and calving takes place towards the end of May or at the beginning of June. From a study of 28 females mated in wild surroundings and then transported to Laurentides Park during gestation, it was established that the period in which the animals go into heat is later for the northern Quebec caribou than for those of Newfoundland or Alaska, but earlier than for those of the Northwest Territories. Calving among females mated in captivity regularly takes place one week earlier than among those mated in the wilderness.

The project to restock the Laurentides Park with caribou has been subsidized and supervised by the Wildlife Service of the Quebec Department of Tourism, Fish and Game. At a time when there is such concern for ecology, it is encouraging to see a project such as this — even though far from completed, as the restocking of Grands Jardins will take another 20 or 30 years — which will make amends for the destruction caused by man and occasionally by the vagaries of nature. Caribou will continue to be an irreplaceable natural resource in severe climates.

Waste Products and Incineration

CLAUDE BONENFANT

If you live in Quebec and if, like most people, you are a consumer, every day you are responsible for approximately 6.2 pounds of urban waste products. Of this amount, 2.5 pounds are produced by households in the form of garbage, 3.3 pounds are of commercial origin including, among other things, debris left by construction and wrecking, and human and medical waste products. And finally there are 0.4 pounds of public refuse, including things as varied as residue left behind after treatment of your drinking water, the corpse of the cat you had which just died and even the remains of your old car.

You probably never thought that you created so much garbage in a single day! Nevertheless, as a study done in Quebec in 1970 has shown, you are definitely the culprit. And that isn't all. Since we all share good air (whenever there is any) and good water and everything good, why not also share the responsibility for the production of waste products, whatever they might be?

When we do so, we find that industrial wastes (lumber, furniture and paper industries) add 31 pounds per person per day (pppd) to your credit. Refuse of agricultural origin accounts for 27 pounds pppd and that from mines, a whopping 91.7 pounds pppd. That gives a round figure of about 150 pounds of garbage which is produced by each one of us every day.

In 1970 Quebec produced 163 million tons of solid waste; this figure does not include either liquid waste such as sewage or industrial effluents discharged into the water, or gaseous waste products such as factory smoke spewed out into the atmosphere. As we have seen, solid waste includes noxious products produced by cities, industries, farms and mines. As these waste products cannot be left where they are, they must somehow be hauled away.

In most cases, except for urban refuse, disposal is the responsibility of those producing it. Thus, all industries are required to handle their own refuse problems, except for radioactive wastes, which come under federal control. It is hoped that in the near future, this jurisdiction of the federal government will be extended to chemical, human and medical wastes, all of which constitute a danger to public health and the environment.

Urban refuse, which we will deal with in more detail later, is the responsibility of the municipalities. Although the report of the Committee on the Management of Solid Wastes, submitted to the minister in charge of environmental quality in December 1972, recommends future planning of waste product disposal methods by the Quebec government, the latter's powers in this area have so far been mainly ancillary in nature, although certain laws have been passed. The legislation includes the Public Health Act (for the control of waste disposal methods and maintenance of dumps), the Highway Code, the Explosives Act and the Mining Act.

The end result is that the municipalities are to a large degree left to their own initiative. The method most commonly used by them is the mere burial of waste products. This method is a particularly economical one for Quebec because of the keen competition among private enterprise for garbage removal contracts and in other cases because of the lack of interest in getting rid of the garbage itself. As a result, burial is inevitably the method used. Thus there are only nine supervised dumping grounds in Quebec, compared to 1,000 non-supervised ones (some of which burn garbage and others do not). Vacant lots, which are becoming rarer and rarer in urban areas, are often chosen willy-nilly and, when used as dumps, constitute a health hazard and threat to the environment.

The main argument used against burial is the waste of natural resources which it implies, for the raw materials used in making the finished product cannot be re-used afterwards. Although burial is very economical, it nevertheless deprives the market of potentially re-usable materials and hence should be strictly regulated.

For this reason, the Report of the Committee on the Management of Solid Wastes recommends strict governmental control over this method of garbage disposal entrusted by most municipalities — either wholly or in part — to private enterprise, which usually worries little about the quality of the environment. On a similar topic, what about the 5,000 "automobile graveyards" scattered throughout the province?

Composting, a method rarely used because it is not profitable, makes it possible to recover organic matter. Compost, which is a type of fertilizer, is produced by the fermentation of organic and mineral matter found in waste products. By adding chemicals, this fermentation can be completed in three or four days. Compost generates physical, chemical and biological changes and acts as a fertilizer when spread over soil. It can also be used as a covering material for dumps.

However, the market is rather uncertain, especially the farm market. Another drawback is that during the winter months the compost must be stored somewhere, and synthetic material, found more and more often in garbage, lowers its quality.

Incineration is the most efficient method for use in urban areas. To handle the garbage of a large city, the burial method calls for huge dumps which necessarily must be quite far from the city. The relatively small space required by incineration facilities and the reduced transportation costs incurred make this method the most appropriate one at the present time for large urban areas. An added advantage of using this method is the fact that energy can be recovered in the form of steam and then be sold, or used for the operation of the incinerator.

However, one of the major drawbacks of the incineration method so far has been the local air pollution it has caused. The prime culprits in this regard are small incinerators in apartment blocks and commercial buildings. In these incinerators, open-air combustion is usually incomplete and anti-pollution devices either ineffective or non-existent. Since 1970, 3,500 of the 4,000 small incinerators on the island of Montreal have been rendered inoperative.

In 1970, the Montreal Urban Community (MUC) acquired an incinerating plant for household garbage. This incinerator, with a rated capacity of 1,200 tons per day, is considered to be the most modern one in North America. Considering that the MUC produces 5,000 tons of garbage per day, the Carrières municipal incinerator alone treats about 20 per cent of the household garbage produced in greater Montreal.

Incineration is a high-temperature combustion process which changes solid combustible wastes into carbon dioxide, water vapour and ash. To control the pollution produced by combustion gases — which carry small particles and ash containing inert and incompletely oxidized matter — emission levels must be strictly watched.

The MUC's incinerator meets even the strictest requirements, as it is equipped with electrostatic precipitators which reduce the amount of dust released into the atmosphere by 95 per cent.

The MUC's incinerating plant has made several improvements in this method, which is already in use elsewhere. The unloading platform has 18 stations where garbage can be dumped into a central pit having a capacity of 2,500 tons. The refuse is then transferred from the pit to a furnace using a travelling crane. Before being thrown into the furnace, the refuse is shredded by a grinder equipped with cutters.

The four furnaces used are the "water-tube" type. In other words, each furnace has a thermostatically-controlled, cooling water jacket around the central combustion chamber. It is possible to automatically regulate the amount of air used in combustion.

Each of these incinerating furnaces has three gratings set at an angle one below the other, so as to form a kind of cascade; one is used for drying and firing, another for burning, and the third, for the latter stages of treatment.

The amount of residue left after the treatment of approximately 1,000 tons of waste varies between 200 and 250 tons per day. This amount represents 20 to 25 per cent of the total weight of refuse. The initial volume is, however, reduced by seven to 10 times. The residue, which normally can be re-used, contains approximately 10 to 20 per cent iron, which can eventually be recovered due to its magnetic properties. Another 40 to 50 per cent of the residue is glass, often used for road beds or filler material. Finally, 15 to 20 per cent of the residue consists of non-combustible material, 0 to 5 per cent metals other than iron and 5 to 10 per cent slag. Fly ash, produced during incineration, can be used for making bricks or concrete.

The incineration plant also has a system for recovering energy in the form of steam. This thermal energy is used for heating the plant and for operating turbines, F.D. fans and water pumps. The average heat value of refuse is 4,000 BTU per pound.

The Carrières incinerator is in operation 24 hours a day. To operate it, eight-man shifts changing every eight hours are used. The cost of building the incinerator was $13,200,000: $4,500,000 went for the central building and appurtenances, and $8,700,000 paid for the incinerating and steam-producing systems.

The new incinerator for the Quebec Urban Community (QUC), currently under construction, will, like the one in Montreal, be equipped with an air pollution control device and a system for producing steam. Any surplus heat energy will be sold to a nearby pulp and paper plant. In Europe, this energy is often used for producing electricity and urban, commercial or industrial heating. The QUC's new incinerator will have a capacity of 1,000 tons per day and will serve the 425,000 people in the 27 municipalities making up the urban community.

Because incineration makes it possible to recover energy, it is a first step towards a closed-loop economy; that is, an economy in which the production-consumption-recycling process re-uses the raw materials in some way or another. Incineration recovers only a small part of this available energy, however. For this reason other methods, such as pyrolysis, deserve our attention.

Pyrolysis is a chemical process whereby organic matter changes to gases by the action of heat in the absence of oxygen. Instead of only a partial feedback of refuse into the ecosystem — as in the case of residue produced by incineration, or a total return of waste material to the system, as can happen with burial, shredding and composting — pyrolysis is an artificial cycle enabling one to recover almost all the heat value contained in refuse. The heat may come in the form of non-polluting fuel or recycled products for the chemical synthetics industry.

It costs approximately the same amount to build and operate pyrolyzers as it does incinerators. However, most cities are still unfamiliar with this technique, but many experts would like to see this method much more widely used in the future; it is particularly well-suited for breaking down plastics which are being used more and more in the packaging industry.

The Club of Rome, an international association of 75 famous scholars, has predicted a world-wide catastrophe within the next 50 years if we continue to accumulate garbage at our present rate. This by-product of our so-called consumer society and "disposable" mentality will mean that, in the future, there will be a lack of space and intolerable pollution levels. We must, therefore, learn our lesson and meet this problem head on by calling upon the most advanced means which technology puts at our disposal.

Ionospheric Satellites

MARTIN McCORMACK

Space physicists at the University of Calgary and the Canadian government's Communications Research Centre have taken the clearest satellite pictures yet of the Northern Lights in an effort to help predict disruptions in vital northern radio communications.

Their eye-in-the-sky is a mechanical one — a device called an auroral photometer — aboard the Canadian-built satellite ISIS-II, in orbit 890 miles above the Earth. The photometer, essentially a primitive television camera, is one of 12 ISIS-II experiments which together give information on many aspects of the upper atmosphere.

One important use for this data is in the prediction of rather frequent disturbances in the high atmosphere that interfere with Arctic and Antarctic radio communications. Since isolated villages over a vast area of northern Canada depend on radio for contact with the outside world, and pilots rely on radio beams for navigation, breakdowns in radio communications cause considerable inconvenience and sometimes severe hardship.

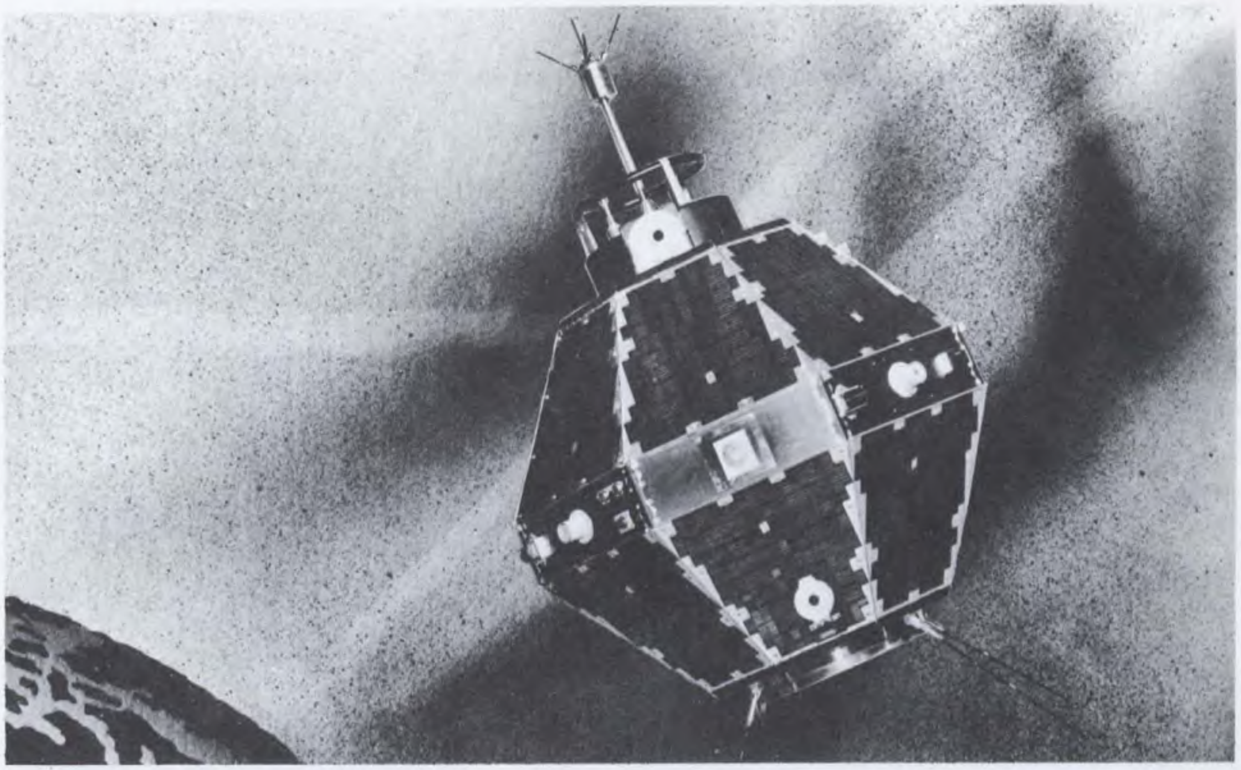
The quality of radio communications in high northern latitudes is largely controlled by the amount and distribution of energy in the upper atmosphere. This energy creates the Northern Lights as well. In Arctic areas, where energy conditions often change quickly, the brightness and persistence of the Northern Lights indicate how severely the high atmosphere has been disturbed.

As a rule, when the Northern Lights are bright and long-lasting, Arctic radio communications are bound to suffer. And, although Canadian scientists are interested largely in the Arctic phenomenon, the same effects result from atmospheric disturbances high above Antarctic areas.

The photometer's pictures show the entire Arctic region. At night, the Northern Lights — or aurora borealis — appear as a wide, bright ring which encircles the north magnetic pole in northwestern Greenland. The doughnut-shaped band of the aurora, about 200 miles wide, passes over Iceland, northern Labrador, northern Manitoba, Great Slave Lake, northern Alaska, and then swings out over the Arctic Ocean.

Every 113 minutes, ISIS-II completes a nearly polar orbit. Thus, a completely new scan of the northern or the southern auroral zones is possible at less than two-hour intervals. The physicists can turn on the photometer during any of the twelve 20-minute passes the satellite makes over a given polar region each day and interpret upper-atmosphere disturbances almost instantaneously on a hemisphere-wide basis.

Of all the countries in the world, Canada is in the



The ISIS-II satellite was built by scientists and engineers from the Communications Research Centre near Ottawa, RCA Victor in Montreal, Spar Aerospace in Toronto, and was launched by the U.S. National Space and Aeronautics Administration.

ISIS II

Experiment	**Experimenters**	**Organization**
Cylindrical Electrostatic Probe	L. Brace J.A. Findlay	GSFC
Retarding Potential Alanyzer	J. Donley E. Maier	GSFC
Soft Particle Spectrometer	W.J. Heikkila	U. of Texas
Ion Mass Spectrometer	John H. Hoffman	U. of Texas
Energetic Particles	I.D. McDiarmid J.R. Burrows	NRC
Auroral Scanner 3914/5577A°	C.D. Anger	U. of Calgary
Atomic Oxygen Red Line (6300A°) Photometer	G. Sheperd	York U.
VLF Receiver, Antenna Impedance	R.E. Barrington	CRC
Radio Beacons	P.A. Forsyth G. Lyon	U.W.O.
Cosmic Noise	T.R. Hartz	CRC
Radio Sounder	L. Petrie G. Lockwood	CRC

This table reviews all experiments on board ISIS-II.

best position to study the aurora because most of the land beneath the Northern Lights is Canadian. During the International Geophysical Year (1957-58), Canadian and U.S. scientists sent up rockets from the Churchill Research Range to probe the aurora, which occurs almost every night over far northern Manitoba.

In late 1958 the Canadian Defence Research Telecommunications Establishment — which became the Communications Research Centre in 1969 — proposed to the U.S. National Aeronautics and Space Administration that a satellite be launched in a joint program of upper-atmosphere research.

Since then, the Communications Research Centre, Canadian industry and the Goddard Space Flight Centre in Virginia have designed and built four satellites — Alouette I, launched in 1962; Alouette II, 1965; ISIS-I, 1969, and ISIS-II, 1971 — at a total estimated cost of $30 million. All the satellites were launched by the United States.

The satellites were equipped to answer key questions: How much solar energy comes into the upper atmosphere? What kinds of energy reach Earth? How is the energy distributed in the high atmosphere? What kinds of chemical and electrical reactions take place? How long do "clouds" of excess energy remain hundreds of miles above the ground?

To answer these questions, scientists from Canada and the United States were encouraged to submit proposals for experiments. ISIS-II carries experiments from the CRC, the National Research Council of Canada, the Goddard Space Flight Centre, the University of Texas, the University of Western Ontario, York University and the University of Calgary.

All 12 experiments are specifically designed to work together. No matter how sophisticated, no experiment alone can successfully probe the complex phenomena of the upper atmosphere. Therefore, ISIS-II is virtually an orbiting observatory, which simultaneously provides data on such quantities as the number of electrons present in the upper atmosphere, the amount and energy of cosmic rays reaching Earth, as well as examining the characteristics of the aurora.

Every three months, the ISIS-II researchers meet to share and discuss the latest results sent back from the satellite. According to Dr. Eldon Warren, CRC director of radio research, this co-operative arrangement was, until recently, a unique feature of the International Satellites for Ionospheric Studies (ISIS) program.

The results from all of the experiments contribute to the design of more reliable space instruments for scientific or military purposes and the understanding of disturbances that interfere with radio communications. Once the characteristics of these disruptions are established, radio operators could be advised to try different routes of broadcasting or temporarily switch to microwaves, which are less affected by high-altitude disturbances.

For a clearer understanding of how observation of auroras can contribute to keeping radio transmissions free of disruption , a brief explanation of how the upper atmosphere affects radio waves might be in order.

For long-distance communications, radio beams are bounced off several reflecting layers in the ionosphere, the outer region of the atmosphere extending from a height of about 50 miles up to many thousands of miles. In the ionosphere, ultraviolet radiation from the sun strikes air molecules and splits them into electrons and larger, electrically-charged ions. At certain altitudes these ions and electrons may be concentrated enough to act collectively like a "mirror" that reflects radio waves.

Unfortunately, these mirrors are not completely stable. Under some conditions, floating islands of ions suddenly form local reflecting layers where they are not expected. Other conditions cause the shorter radio waves to be absorbed. This phenomenon is usually due to exceptionally frequent collisions between electrons and the neutral air molecules.

Over most of the world the ionosphere is relatively stable, but at high latitudes instability is almost the rule. As a result, communications in northern Canada are often disrupted to some extent.

The major disruptions are caused by solar flares, eruptions on the sun which hurl unusually large amounts of energy into space. While solar flares may occur any time, they tend to follow a cycle with a maximum every 11 years. The last maximum occurred in 1967.

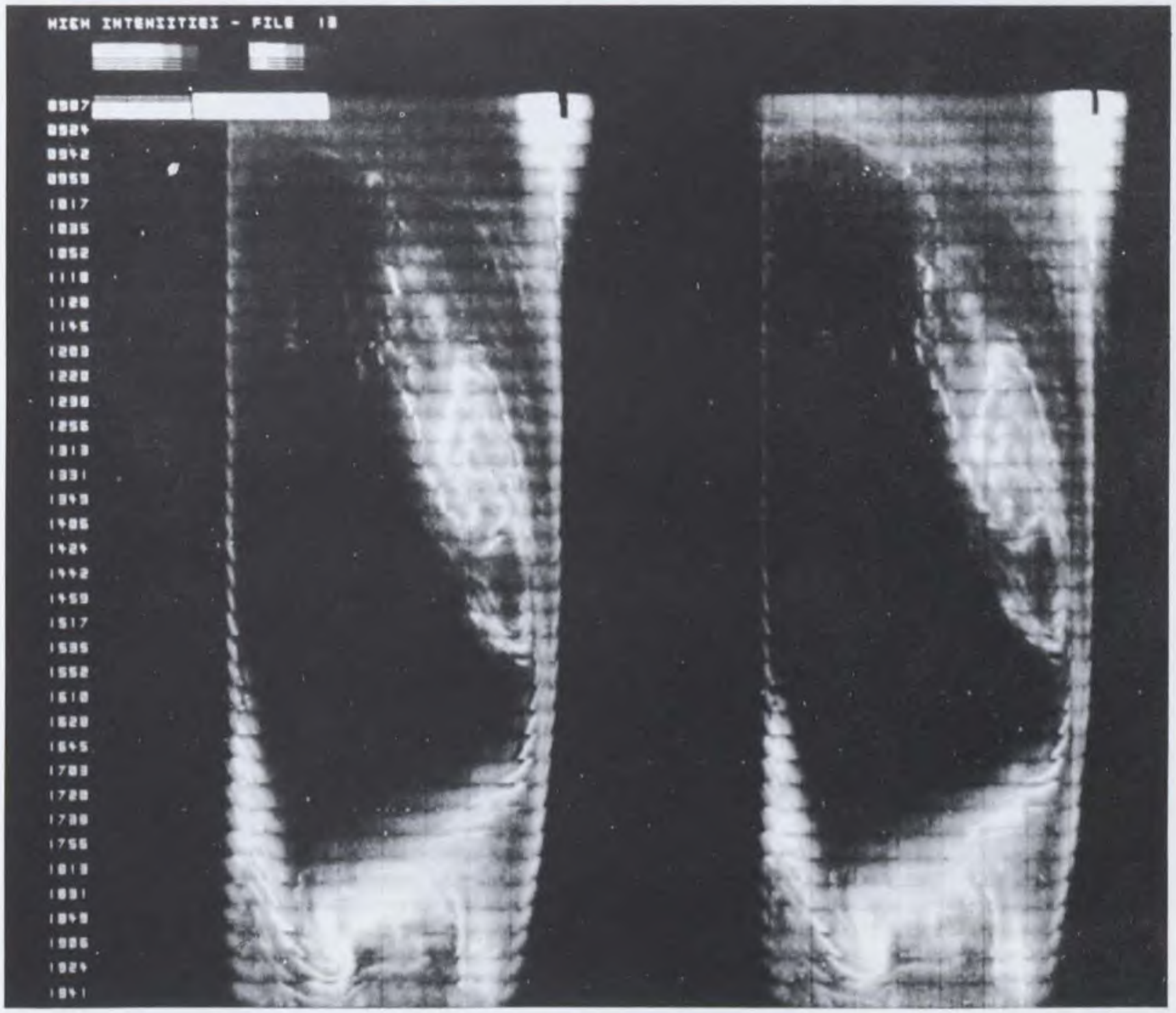
Aside from radiating the more familiar kinds of energy, heat and light, the sun also gives off variable amounts of X-rays, ultraviolet waves, protons and electrons. Dr. Theodore Hartz, Upper Atmospheric Consultant with the CRC at Shirley's Bay near Ottawa, explained that the energy from a solar flare reaches Earth according to a general schedule.

The X-rays and light waves arrive about eight minutes after the flare occurs. High-energy electrons and protons take 15 minutes to several hours to reach Earth. And the bulk of the energy may arrive a day or two after the flare occurs.

Due to the shape of the Earth's magnetic field, the electrons, protons and X-rays penetrate the ionosphere most deeply at high latitudes. These kinds of energy, when too abundant, cause bright auroras and most of the disruptions in radio communications. Consequently, monitoring changes in the aurora can yield information about potential disturbances.

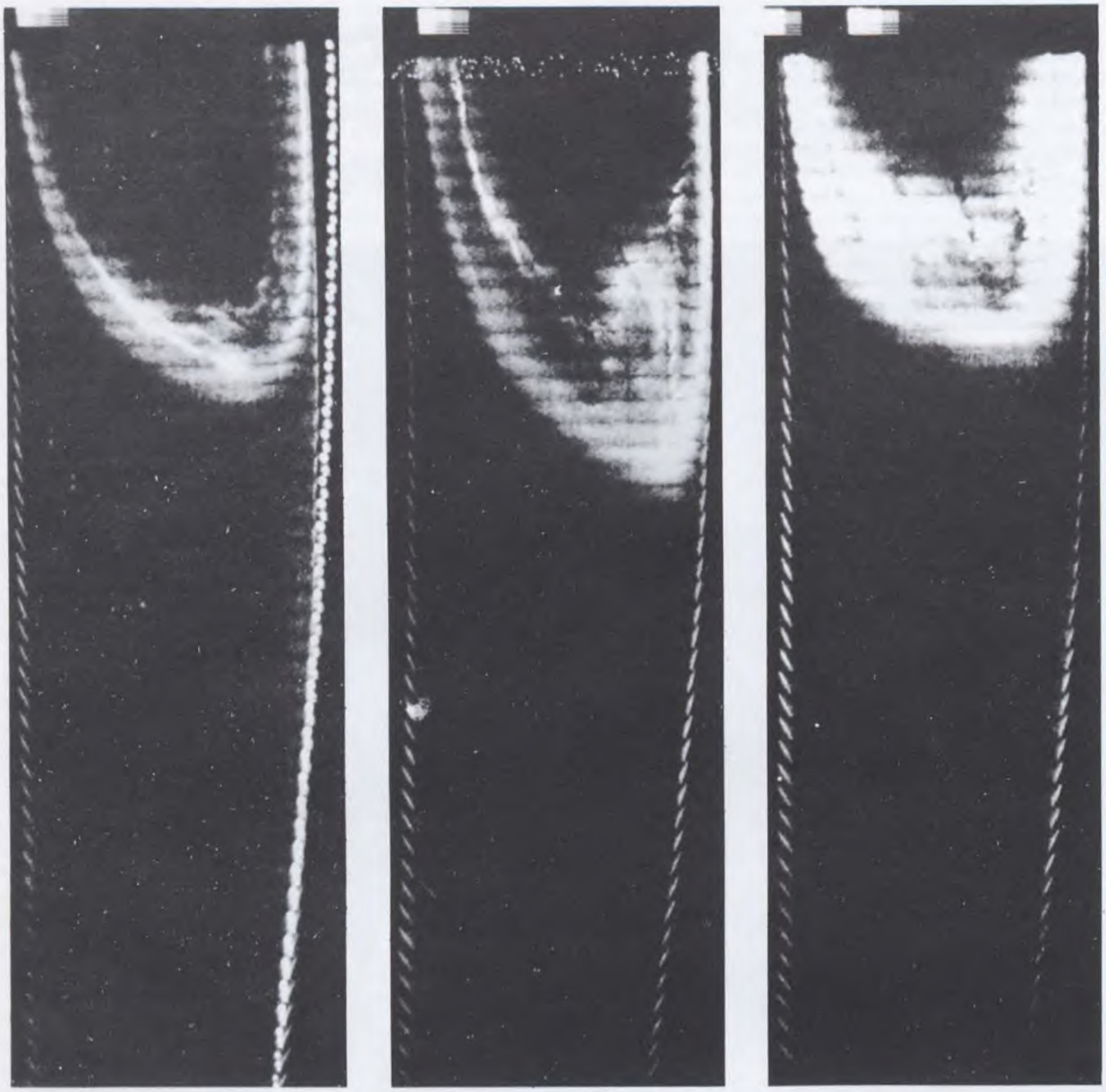
Both the auroras and the radio-wave absorption can last several days during severe "storms". Then, some of the excess energy dissipates. The rest leaves the ionosphere and travels out into space.

Until September, 1962, scientists had to be content to study the radio-wave absorption and other ionospheric phenomena from the ground or from occasional, rocket-borne probes. The ground-



The unique swirling structure in the aurora appeared one night but has not returned since. The upper left edge of the structure lies above the north geographic pole; the lower edge of the picture lies off the north coast of Norway.

Numbers to the left show the minutes and seconds as ISIS-II moves from north to south. Therefore, the picture represents an interval of about 10 1/2 minutes as recorded in successive horizontal strips by the satellite. The right-hand, curved edge is the edge of the Earth.



This series of photographs shows, from left to right, the northern auroral zone in quiet, slightly disturbed and highly disturbed states. Each photograph was taken during a different orbit of ISIS-II. The curved trace at the right is again the edge of the Earth. A slight brightening about three quarters of the way to the bottom was caused by latitudinal variation in the intensity of airglow.

based radio studies provided a great deal of information, but only up to a height of 190 miles. Radio waves energetic enough to reach higher altitudes are not reflected at all, and simply travel on into space. Therefore, they cannot give observers on the ground any information about the ionosphere above the 190-mile altitude. Rockets lifted instruments above this height for periods too short to allow extensive observation.

A satellite in an orbit high enough, however, can carry instruments to look down on the ionosphere. Alouette I, Alouette II, ISIS-I and ISIS-II have done just that and provided valuable information on conditions between altitudes of 150 and 1,800 miles.

The images from the auroral photometers are undoubtedly the most dramatic results to come from ISIS-II, according to Dr. Warren and Dr. Hartz. The satellite's principal experiment dealing with the aurora is sponsored by the University of Calgary and directed by physicist C.D. Anger. The equipment in this study examines the far violet and the green light of the aurora, and, as a final step, composes the pictures which show the Northern Lights in remarkable detail.

A related experiment, directed by G.G. Sheperd of York University in Toronto, examines the red light present in some auroras and in phenomena called airglow. This glow is present at altitudes of 150 to 200 miles everywhere in the ionosphere, not just in high-latitude regions.

The photometers used in these experiments have four major capabilities which analyze auroras in enough detail so predictions and more thorough studies of ionospheric disturbances can be made.

First, the equipment scans a large area as the satellite orbits the Earth. To get a complete picture, a wide-angle scan is necessary. The auroral photometers examine a succession of horizontal strips of Earth at night. These strips extend from horizon to horizon, or from the horizon to the sunrise line on Earth.

Secondly, it takes ISIS-II only a short time to examine a large area. After 10 to 15 minutes, the photometers build up a large enough picture to show the whole Arctic region, said Dr. Anger. These pictures have shown that an auroral zone is indeed a continuous ring around the Earth — one ring encircling the north magnetic pole, another around the south magnetic pole — a concept long disputed by some scientists.

Third, a sequence of the photometer's pictures can show how the aurora changes with the influx of energy from solar flares. When the sun "acts up," the auroral bands get brighter and wider.

After the excess energy from a solar flare has worked itself out of the ionosphere, the auroral rings dim and shrink to normal size, and the quality of northern radio communications improves.

Fourth, the equipment in Dr. Anger's experiment is designed to interpret the altitude of the aurora by measuring the intensity of its green and deep violet light. When high-energy electrons hit the neutral nitrogen atoms in the lower ionosphere, the deep violet light is produced, said Dr. Anger. As a general rule, bright violet light indicates the aurora occurs at lower altitudes.

However, the green light comes from higher altitudes, where single atoms of oxygen are excited by solar radiation. Therefore, a greenish aurora is higher than a blue or a violet display. On the average, a bluish aurora occurs about 60 miles up.

This information on altitude — along with measurements of brightness, size and duration — is fed to an office of the U.S. National Oceanic and Atmospheric Administration in Boulder, Colorado, which issues bulletins two or three times a day on the condition of the ionosphere. The advisories warn radio operators and pilots of any forseeable difficulties in communication caused by disturbances in the upper atmosphere.

Ernest Lepage

MARGARET BRASCH

''With our satchels under our arms, we set out despite the cold, fog and freezing drizzle, to search for plants.''

It is in this spirit of adventure that Father Ernest Lepage, a pioneer of northern flora, begins the account of his first expedition into far northern Quebec.

Indeed, if we owe ''Laurentian Flora'' to Brother Marie-Victorin, we owe ''Subarctic Flora of Quebec'' to Fr. Ernest Lepage. Even if James Bay becomes studded with hydro-electric dams, we will always be able to observe prime specimens of the flora bordering northern lakes and rivers, thanks to Fr. Lepage.

Born in Rimouski on June 1, 1905, young Ernest soon became interested in exploring the Gaspesian vegetation. He was ordained a priest in 1929 and then took a course in agronomy at the St. Anne de la Pocatière Institute of Agricultural Technology at Laval University, from which he graduated in 1936.

Seven years later, he returned to the Quebec City university to increase his knowledge of botany and obtain a master's degree in agricultural science.

In 1943 Fr. Lepage made the first of 20 long expeditions to the land of tundra and nomadic Indians. An American, Arthème Butilly, was his travelling companion on this first expedition and on 16 subsequent expeditions as well.

Equipped with a simple canoe and essential provisions, the two men set out to explore and identify the varieties and species of plants in the James Bay and Ungava Bay regions. Here are some of their expeditions:

— In 1944 they surveyed the subarctic flora — particularly mosses and lichens — of the eastern James Bay and Hudson Bay littoral regions.

— In 1945 they crossed the Ungava Peninsula and assembled several collections along the Koksoak, Mélèzes and Kaniaspikau Rivers. From this expedition and a later one in the same regions in 1951, we have specimens of 129 plant species.

— In 1946, Fr. Lepage and Mr. Dutilly explored the Harricana River at its mouth on southern James Bay. They conducted brief surveys of the geology and flora of this region.

— In 1950 the men explored the Albany and Attawapiskat Rivers in northern Ontario along James Bay.

— From 1953 to 1956 they explored the southwestern and eastern littorals of James Bay and gathered more than 300 different plant species.

In all, Fr. Lepage, who is now 68 and priest of St.

Ernest Lepage stands next to his tent on the Gulf of Richmond in northern Quebec.

Simon parish in Rimouski, has navigated about 15 rivers and covered more than 4,500 miles in northern Quebec.

According to Dr. Fabius Leblanc, a botanist at the University of Ottawa, Fr. Lepage has identified and classified several northern plant species which until then had been unknown. "He is without doubt one of the pioneers in the field of northern Quebec flora — especially because of his work in the classification of higher plants," Dr. Leblanc added.

"Higher" plants are plants which have reached a certain level of complexity in the development of their organs — stalk, leaves, roots and sexual organs. In this category, for example, are trees, roses, oats, orchids and shrubs. On the other hand, mosses, lichens and algae are classified as "lower" plants.

Fr. Lepage considers that the classification and identification of hawkweed was his most successful work from the scientific point of view. Indeed, nearly 30 species (including different varieties) owe their identification to the research of this botanist-priest.

The hawkweed is a higher dicotyledon of the family of composite flowers. This illustrious family, the most numerous of the plant families, includes the artichoke, chrysanthemum, dahlia, lettuce, sunflower, daisy and dandelion. Taxonomists, who study the laws of plant classification, have given it the Latin name of Hieracium and have identified several varieties including the hawkweed (mouse-ear) and the wall hawkweed (golden lungwort).

This plant of European origin, with its characteristic little tufts of yellow flowers, was introduced into Quebec near the beginning of the 19th century. To date more than 400 different species have been found in Canada, the majority in northern Quebec.

The hawkweed adapts so well to a new environment that its growth often becomes a nuisance. "Spurned as feed by most farm animals, it is also detested by farmers because it checks the growth of better feed plants, and during harvesting its fine tufts become wind-borne and cause an unpleasant cough," explained Fr. Lepage.

The hawkweed Hieracium ungavense, identified by Fr. Lepage in 1945, is found in northern Quebec "on sand and acidic granitic rocks, sometimes along the shore of James Bay, but especially in the interior, from the Fort George River area to the Eastmain River."

Here is how Fr. Lepage describes it in an article published in the Canadian Naturalist in 1958: "Strong root, horizontal and subascendant. Stem (2-7 cm high) without basal rosette, with 1 to 12 heads, slender to sturdy (1-5 mm diam. at base), erect, glandless, more or less densely villous (white, feathery, flexible hairs, 1.5-3.5 mm long) on the lower part with scattered hairs higher up, more or less downy (stellate or branching hairs) especially on the upper part ... yellow styles. Rusty purple achenes, 3.8-4.0 mm long. Dentate receptacle."

A taxonomist, whether amateur or professional, must have unlimited patience. Like Fr. Lepage, he must set out to look for plants with a knowledge of the environment as well as an idea of the type of specimens he hopes to find.

Plant classification follows very rigid laws and the taxonomist must pay minute attention to all the structural details of a specimen, for the presence of three instead of five petals in a flower places a plant in a completely different category.

Fr. Lepage would set out at dawn with his satchel under his arm and stop here and there to gather a sample plant of a particular species. He had to dig up the plant carefully, for, as already mentioned, every aspect of its structure is essential for classification and exact identification of the species. Back at camp, he would place each specimen of his collection in a press which resembled a thick encyclopedia — the exterior was made of wood and the interior consisted of sheets of blotting-paper and newspaper — in order to absorb any moisture and preserve the natural shape of the plant.

This stage of the work — the drying — could often take up to two days. Back in Rimouski, he would begin the job of complete identification of his specimens or "harvest". Once that was finished, he would often send his treasures to the National Museum of Natural Sciences in Ottawa, where, in the National Herbarium (plant collection), classifiers give each specimen an index number which is subsequently used for international reference.

If the study of hawkweed almost dominated Fr. Lepage's work, it did not mean that he neglected other plant species. He also studies oats, algae, mushrooms, firs, mosses, lichens, orchids, irises ... in fact, the whole range of plants in northern Quebec.

People sometimes look down on this type of work, preferring more spectacular research or research that will have a direct effect on their daily well-being. They forget that the work of amateurs in the field of astronomy, geology and other natural sciences has been the cornerstone on which the research of many a professional has been based. In fact, taxonomy has advanced only because of the work of countless amateurs. Dr. Leblanc states that "Father Lepage has contributed much more to science than some professionals, despite the fact that he was not eligible for grants from the National Research Council of Canada".

This country priest has written more than 60 articles. His 30 years of research have borne fruit in especially two areas: they have contributed to our knowledge of northern flora and they have also given ecologists a better base for their study of the relationship between various plants and the environment.

One might wonder whether, at 68 years of age, Fr. Lepage can still undertake such long expeditions. He certainly has the will to go on, but unfortunately Arthème Dutilly died in January 1972. Without him, Fr. Lepage could not raise the necessary funds for such projects. He now is content to share his knowledge with the young people of Rimouski interested in agriculture.

Long-Baseline Interferometry

MARTIN McCORMACK

Canadian radio astronomers added a new dimension to the study of how the universe originated when, in 1967, they developed a telescope system so sensitive it could measure golf ball-sized objects 4,000 miles out in space.

The system, called a long-baseline interferometer, was established to measure bodies in space known as quasars, powerful radio wave emitters thought to be the most distant objects from Earth. Since the discovery of quasars in 1960, when these radio signals first were monitored on earth, astronomers have felt a better understanding of them would help verify the theory that the universe was born in a huge explosion billions of years ago.

Analyses of their radio waves indicate quasars are 100 to 1,000 times smaller than the tiniest objects in space visible through the biggest optical telescopes, which use mirrors or lenses to magnify and focus a visual image of a star, a planet or a galaxy. Quasars, however, show up better in radio telescopes, large dish-like instruments that receive radiation from a body in space and reproduce it as a graph rather than as an image of the object itself.

Astronomers realized objects as small as quasars would appear in some detail only through a system employing two radio telescopes thousands of miles apart and operated in concert — virtually as a single large telescope.

Prior to the Canadian effort, British astronomers in 1965 had used two radio telescopes 76 miles apart to pick out or resolve objects which, as seen from Earth, appeared to be .1 second of arc in diameter, about 18,000 times smaller than the apparent size of the moon. However, perhaps half the quasars known in 1965 were smaller than .1 second of arc. Astronomers around the world agreed the distance between two radio telescopes, the baseline, had to be much longer than 76 miles to pick out the smaller or more distant quasars.

A team of astronomers and engineers from the National Research Council in Ottawa, the University of Toronto, Queen's University in Kingston, the Dominion Radio Astrophysical Observatory in British Columbia and the Algonquin Radio Observatory in Ontario, decided to size up the more remote quasars.

Principal members of the group included astronomers Allen Yen of the University of Toronto, John Galt of the Dominion Observatory, Jack Locke and Norman Broten of the National Research Council, and an electrical engineer at Queen's University, the late Robin Chisholm.

The group met in Ottawa in October, 1965, to organize efforts to build the world's largest interferometer. Essentially, an interferometer determines

The Algonquin Radio Observatory, with its 140-foot-wide "dish", was the eastern end of the 1,900-mile-long baseline used in 1967.

the size of a small, distant object by measuring the angles at which two different light or radio waves from the single source in space reach Earth.

A star, a galaxy or a quasar emits radiation from different points on its surface or from within its interior. Therefore, the waves which come from the top of a quasar will travel to Earth along a slightly different path than will the waves which originate from the bottom. During their long journey the radio and light waves may cross each other, causing interference.

Two radio telescopes, if sufficiently far apart and tuned to the same signals from the same source at the same wavelength, can detect the interference. A visual image of the interference is projected on a television screen or printed out on paper, appearing as a series of regular peaks and valleys, a bit like an electrocardiogram print-out.

Once interference patterns — the jagged lines of regular crests and troughs — have been recorded for a number of wavelengths, the astronomers then concentrate on the shortest wavelength for which they have a sharp, clearly defined pattern. Radio astronomers assume that this wavelength, when divided by the distance between the radio telescopes, represents the diameter of the object that emitted the radio waves.

The Canadian group chose a baseline which ran 1,900 miles from the Algonquin observatory 160 miles northwest of Ottawa to the Dominion observatory 15 miles south of Penticton, B.C. Both observatories had the necessary equipment and experienced enough staffs to conduct the experiment. The 1,900-mile baseline would permit resolution of objects smaller than .1 second of arc, the best the British could do in 1965.

When two radio telescopes, or "dishes", are widely separated they behave like opposite points on the rim of a much larger dish. The Canadian astronomers in effect created a dish 1,900 miles across when they chose the Algonquin and Dominion observatories to form the interferometer.

If so huge a dish actually could be built, the radiation from a distant quasar would hit the edge farthest away from the quasar slightly later than radiation would strike the nearer rim. When two radio telescopes are used instead of a single enormous dish, a time delay must be built into the telescope nearest the quasar, because it is essential to compare waves which left the quasar at exactly the same time.

This operation requires a clock which gains or loses no more than a millionth of a second in a day. However, the Canadian astronomers and engineers had to make do with an atomic clock which allowed errors of several millionths of a second a day. The team overcame the errors by manually adjusting the tapes of interference patterns until the tapes synchronized and produced the necessary clear, sharp peaks and valleys. These adjustments took weeks of patient effort.

Both telescopes in a long-baseline system also must be sensitive to the same range of wavelengths. Otherwise, the interference patterns will be fuzzy or distorted. The Canadian group used devices called oscillators to make sure both telescopes received virtually identical "packages" of radiation. The oscillators were so accurate they enabled the astronomers to measure wavelengths with a margin of error of less than one centimeter in 100 billion.

Finally, the machines which record the interference patterns must do so for a number of wavelengths. Most conventional tape recorders cannot record as great a range of wavelengths as are needed for quasar study.

Furthermore, radiation from objects in space reaches Earth at high speed. If individual peaks and valleys are to show up clearly, they must be recorded on rapidly-moving tape.

The Canadian scientists found videotape recorders and two-inch videotape met both requirements.

The Canadian long-baseline interferometer project, which took 19 months of hard work and cost about $300,000, yielded its first results in May, 1967, when the astronomers found one part of a quasar to be .02 second of arc across. This diameter was by far the smallest ever substantiated for an object in extragalactic space.

The Canadians beat the Americans by one week in successfully operating a long-baseline interferometer. For their achievement, the Canadian group won a gold and a silver medal from the American Academy of Arts and Sciences. It was the first time the medals, called the Rumford Premium, were awarded to a group of scientists.

In the wake of this achievement the Canadian group, along with astronomers from other countries, explored the internal structure of quasars and other powerful emitters of radio waves. The scientists used longer baselines and shorter wavelengths, which permitted interferometers to resolve objects as small as .0003 second of arc — a feat comparable to standing in Winnipeg and reading a newspaper in the sky over Vancouver.

Astronomers also have found some quasars are not just one big ball, but rather contain two or more super-bright spots thought to be as small as 100 billion miles across, tiny by galactic standards. The diameter of our own galaxy, the Milky Way, is five million times larger. And astronomers think the diameters of quasar nuclei all the more remarkable because several of these hot spots put together will emit the energy of 30 to 100 normal galaxies, or about 10 trillion stars.

Moreover, quasars are thought to be 1.5 to 12 billion light-years away. A light-year is the distance over which light travels in one year, about six trillion miles. Since the radiation from quasars which reaches Earth must be billions of years old, the ancient sizes, shapes and structures of quasars may give clues to what the universe looked like billions of years ago.

"Right now most astronomers feel a tremendous explosion must have created the universe," said Dr. Locke of NRC. "One clue to this is the evolution of galaxies. We're fairly confident galaxies do evolve, and part of the game is to trace this evolution. There is a possibility quasars are related to normal galaxies in some way. But we need a lot more information before we can say quasars are newly-born or dying galaxies, or remnants of a primeval explosion. Our group will try to get some of that information."

Gammabeams and Gammacells

MARLENE SIMMONS

While the building of nuclear arms by major powers dominated world attention in 1956, Canadian nuclear scientists developed the technology to harness nuclear energy for peaceful — in some cases, life-preserving — purposes.

With the development of the Gammacell, the world's first commercial research irradiator, and the subsequent development of the more powerful Gammabeam, Canadian scientists made it possible to safely expose objects, animate or inanimate, large or small, to controlled doses of nuclear radiation.

This work, carried out at a cost of $ 50,000 by the Commercial Products division of Atomic Energy of Canada Limited in Ottawa, paved the way for a vast range of advances in medicine, chemistry, space research, food technology and agriculture.

''Canada is a pioneer in this field and I don't think that anyone would seriously consider buying any other commercial irradiator,'' said Dr. H.E. Johns, head of the physics branch of the Ontario Cancer Institute in Toronto.

Over 300 Canadian-made Gammacells and Gammabeams, ranging in cost from approximately $ 16,000 to $ 70,000 plus installation charges, had been sold by 1973. ''Not only do major countries buy our irradiators, but smaller countries like Bangladesh, Guam, Jamaica and Chile have bought them as well,'' said an AECL spokesman.

A few examples of the ever-increasing range of uses to which these machines have been put indicate their extraordinary versatility.

One of the newer industrial products they have made possible is an extremely durable flooring made of wood permeated with plastic. Air is pumped out of the wood, plastic is injected into the evacuated pores and the plastic-wood combination is irradiated to alter the plastic's molecular structure and make it very tough.

In Canada, the United States and other countries, Gammacells and Gammabeams also have been used in both experimental and commercial food sterilization to kill bacteria that cause spoilage. For example, experiments indicate that it is possible to prolong the shelf life of fish, poultry and meat for seven to 10 days with radiation treatment.

Canadian government authorities have approved the exposure of potatoes and onions to very light doses of radiation which will stop sprouting for up to 10 months by inhibiting cell division. Slightly higher doses are also used to kill insect pests in white flour and brown whole wheat flour.

Gammacells and Gammabeams have also been used to determine the effect of differing radiation

The Gammacell 220 was one of the first general- purpose irradiators.

doses on various forms of cancer, as well as to sterilize medical instruments.

Male insects have been sterilized in attempts to reduce populations of insect pests such as the codling moth and Mediterranean fruit fly.

To grasp how irradiators can be applicable in such diverse fields, it is important to understand at least basically how radiation works on various forms of matter.

There are three main types of nuclear radiation which have been labelled alpha, beta and gamma. The alpha particles are helium nuclei and the beta particles are electrons, both with very little penetrating power. Gamma rays are very-short-wavelength waves that can penetrate large thicknesses of material. Cobalt 60, the radiation source most often used in Gammacells and Gammabeams, gives off beta and gamma rays. But it is the gamma rays which are important in this application.

Gamma rays interact with the atoms that constitute inorganic substances and with the cells of plants and animals. In inorganic substances, molecular structure is changed. In plants or animal substances, the result is cell mutation or death.

An atom is composed of a positively-charged nucleus around which orbits a number of negatively-charged electrons. The sum of their negative charge is equal to the positive charge of the nucleus, so atoms are neutral.

When atoms are bombarded with nuclear radiation the radiation can either take away electrons to make the atom a positively-charged ion, or bring electrons into orbit around the nucleus, making the atom a negatively-charged ion.

Ion pairs — a positive and negative ion produced simultaneously by the transfer of an electron from one atom to another — are often formed in this reaction.

In cells nuclear energy affects the chromosomes, thread-shaped bodies located in the nucleus, the cell's centre of growth and development. Arranged in single file along the length of each chromosome are genes which contain the hereditary characteristics for the organism.

Nuclear radiation causes chromosomes to break and rejoin in ways that result in "scrambling" or redistribution of their genes. It also affects the structure of individual genes. Since the order of the genes and their structure dictates the characteristics of the organisms, scrambling or structural change can lead to mutations in either plants or animals. Or, if the radiation is sufficiently concentrated, the cells will die.

According to the AECL spokesman, Gammacells and Gammabeams were developed because there was a need for a small, versatile irradiator. "Most labs interested in irradiation had built their own special hot cells — concrete rooms with walls three feet thick and leaded glass windows — to do their experiments in. Mechanical arms were used to put the material to be irradiated in place and the whole thing was rather clumsy and inconvenient," he said.

"The beauty of these machines is their simplicity. Not many things can go wrong with them and they are relatively easy to repair. Since their development we've only made minor changes like improving switches; it's still pretty much the same machine we started out with."

The Gammacell, the first of the commercial irradiators developed, is completely self-contained. It can be installed in an ordinary laboratory because it does not require a specially built room with shielding to prevent radiation leaks.

The Gammacells are used mainly in relatively simple irradiation experiments with seeds, insects or small animals. Although all Gammacells are about the size of a wringer-washer, they range from the box-like Gammacell 20 which weighs about three tons and is used mainly to irradiate small objects, to the jug-shaped Gammacell 220 which weighs 8,300 pounds and is a general purpose irradiator that can be used with animals as large as rats. The AECL will also build irradiators to customers' specifications.

The Gammacell 220 is the best-selling model. The AECL spokesman called it the "four-door passenger car of the irradiation field".

It costs about $16,000 and the Cobalt 60 sources used in the device to generate radiation range in price from $1,000 to nearly $16,000. "It's like buying different powered engines for your car," the spokesman said. "The amount of radioactivity of the source you buy determines the cost."

Because the Gammacells are self-shielded — the source is fixed inside the machine within a lead shield — the material to be irradiated must be lowered into the machine to be treated.

In the core of the Gammacell 220 there is a cavity with a ring of Cobalt 60 sources. The material to be irradiated is put in a circular sample chamber about eight inches high and six inches in diameter which is automatically lowered into place by a simple elevator.

The lead shield around the source opens automatically, allowing radiation to escape. The material "cooks" for the desired amount of exposure to radioactivity and is then lifted by the elevator and taken out by the operator.

A system of electrical and mechanical interlocks

prevents the source from being exposed unless the sample chamber is properly closed, so operators of the machine are never exposed to radiation.

The Gammabeam, on the other hand, is used to irradiate bulkier specimens which would not fit into the small chamber of the Gammacell. These machines are about twice as high as a wringer washer and about the same width. Most have a box-shaped base on which is mounted a cylinder shaped like a giant soup can.

The Gammabeam 650, the largest of the Gammabeams, differs in structure from the others. Twelve curved tubes rise from its cylinder, which is shaped more like a tuna fish can than a soup can.

A Gammabeam must be installed in a shielded room with three-foot-thick concrete walls, ceiling and floor. The cost of a shielded room ranged from $25 to $1,000 a square foot, depending on the level of radiation used in it.

Instead of putting the material to be irradiated in the core of the machine, the material is placed at calculated distances from it and the Cobalt 60 source is raised by a compressed-air mechanism from inside the machine, exposing everything in the room to radiation.

The Gammabeam is activated by an operator at a console outside the shielded room. When the Cobalt 60 source is exposed, the door to the room cannot be opened. In the event of a power failure, the engine supplying the compressed air that pushes the Cobalt 60 up from the core of the Gammabeam shuts down and the source drops back inside the Gammabeam.

Gammabeams come in three strengths — the Gammabeam 100, 150 and 650. The first two are panoramic irradiators, but their radiation can be restricted with the addition of a beam port — a lead or lead-alloy covering for the source with an opening which allows the radiation to beam out in only one direction.

The Gammabeam 650's Cobalt 60 source is divided among its 12 independently controlled tubes. By altering the number of sources exposed, the operator can vary the amount of radiation. A central sample platform makes it possible to give small materials high doses of radiation.

The curved tubes can be pivoted so that the curved portion is turned either in towards the sample platform to increase the strength of the radiation dose, or turned outwards to lessen the dose.

The Gammabeam can irradiate large samples, or large numbers of samples, at varying distances from the radioactive source. This cobalt-60 source is stored in the lower, shielded part of the machine. When needed for experiments, portions of the source travel upward through one or more of the 12 pneumatic tubes. Therefore, the amount of radiation varies according to how many tubes are used.

A low-pressure area, shown by the swirling pattern of the clouds, begins to break up over the Pacific Ocean.