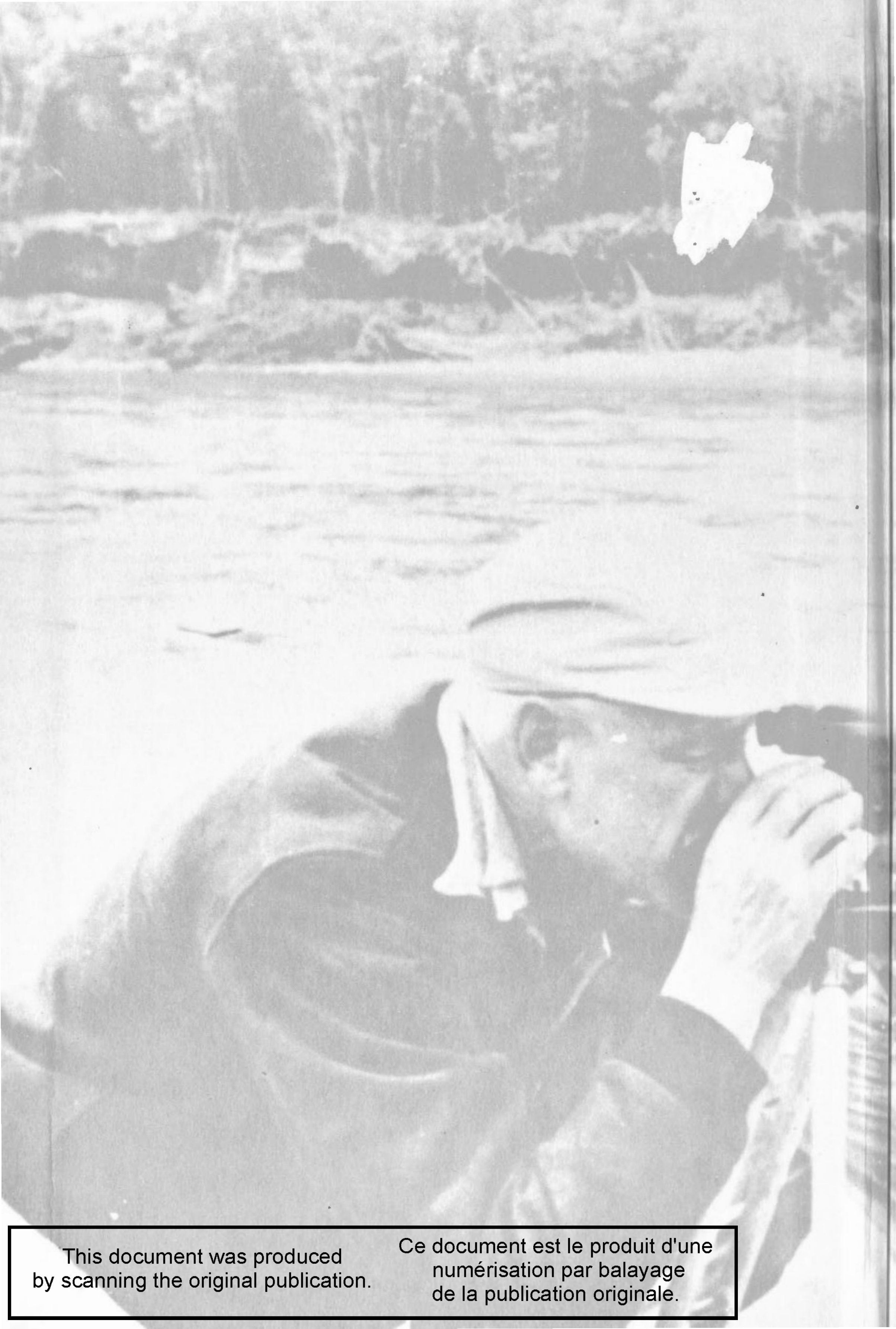

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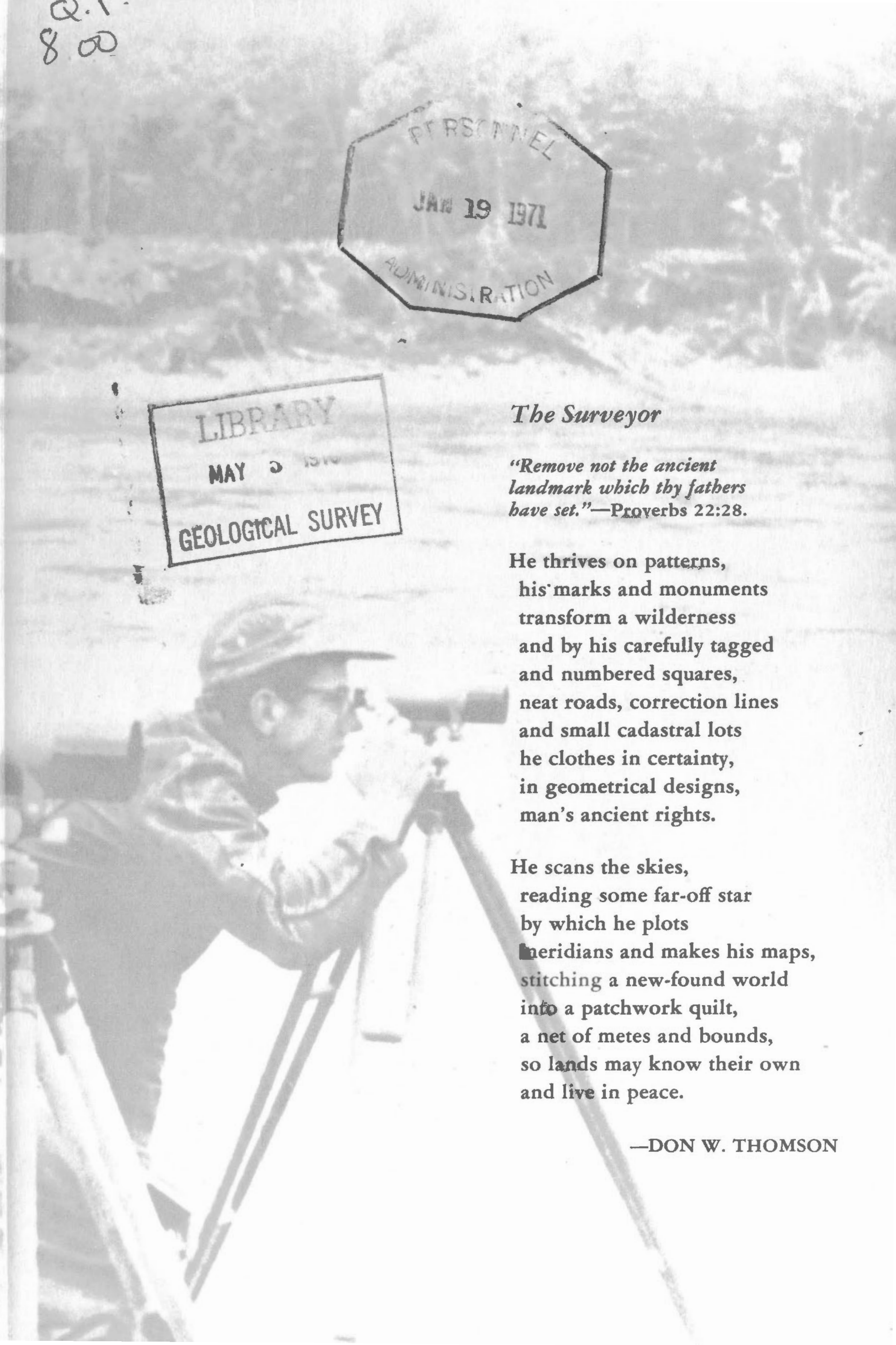

The Surveyor

"Remove not the ancient
landmark which thy fathers
have set."—Proverbs 22:28.

He thrives on patterns,
his marks and monuments
transform a wilderness
and by his carefully tagged
and numbered squares,
neat roads, correction lines
and small cadastral lots
he clothes in certainty,
in geometrical designs,
man's ancient rights.

He scans the skies,
reading some far-off star
by which he plots
meridians and makes his maps,
stitching a new-found world
into a patchwork quilt,
a net of metes and bounds,
so lands may know their own
and live in peace.

—DON W. THOMSON

Surveyor on triangulation
work, Snake River area,
Northwest Territories.

MEN

AND

MERIDIANS

CREDITS

Figures

Frontispiece	R. G. Snowling
8	Sketch by H. Schöne, Leipzig, 1903
1, 3, 11, 23, 24, 162, 163, 166, 167, 168	Public Archives of Canada
9	The New-York Historical Society, N.Y.C.
13	Smithsonian Institution, Washington, D.C.
14, 16, 17, 18, 19, 128, 129, 130, 131, 132, 133, 134, 135, 136	Geological Survey of Canada
15	Department of Lands and Forests, Ontario
21, 24, 26, 27, 28, 32	Ontario-Manitoba Boundary Commission Report, 1955
22, 31	John G. Pierce, O.L.S.
47, 48	The McCord Museum, McGill University
55, 94, 96, 97	Department of Public Works, Ottawa
56, 58, 107, 112, 115	National Film Board of Canada
57, 58, 60,62	U.S. National Archives, Washington, D.C.
58	Karsh of Ottawa
63, 64	U.S. Bureau of Public Roads, Washington, D.C.
65	James Quong
68	Department of Transport, Ottawa
90, 91	Hunting Survey Corporation, Ltd.
93, 111, 114	Lockwood Survey Corporation, Ltd.
95	Canadian Government Travel Bureau
98, 148	Canadian Forces Photo
103, 105	Army Survey Establishment, R.C.E.
104	United Press International, Ottawa
110, 113, 149	Association of O.L.S., Toronto
116	Départment des Terres et Forêts, Québec
125, 126, 127	David Dunlap Observatory University of Toronto
137, 139, 140, 141	Nova Scotia Land Survey Institute
142	Manitoba Archives, Winnipeg
143, 144, 145	Canadian Air Force, Royal Canadian Air Force: National Air Photo Library, Ottawa
146	Canadian National Railways, Montreal: Royal Canadian Air Force
147	Engineering News-Record, N.Y.C.
150, 154	Department of Forestry and Fisheries, Ottawa
152	Department of Lands, Forests and Water Resources, British Columbia
155	Board of Examiners, D.L.S., Ottawa
157, 159, 160	Glenbow Foundation, Calgary
170	*The Canadian Surveyor*, March 1967
4, 20, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 68, 70, 71, 72, 73, 75, 76, 77, 78, 80, 81, 82, 83, 105, 118, 143, 153, 169, 171, 172	Department of Energy, Mines and Resources, Ottawa

MEN AND MERIDIANS

The History of Surveying
and Mapping in Canada

Volume 3
1917 to 1947

Don W. Thomson

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Prefatory Note

The contents of this third volume of MEN AND MERIDIANS pertain, in the main, to the story of surveying and mapping in Canada from the closing stages of the First World War to the conclusion and immediate aftermath of the Second World War. In Volume One Canadian activity in these two closely related fields of constructive endeavor, leading up to union in 1867, was traced in the context of world developments. The 50-year period following Confederation in this country, highlighted by a lively increase in surveying and mapping, is covered in the contents of Volume Two. This included the age in which steam, steel and rail came to British North America to a steadily increasing extent. The construction of transcontinental rail routes and of numerous branch railway lines attracted hundreds of thousands of immigrants to prairie homesteads and helped in a major way to open up the western interior to ordered settlement. This transformation resulted from the new availability of world markets for the early-maturing hard wheat of the region. The Peace River country, far to the northwest but possessing excellent agricultural possibilities, became a new frontier for eager land seekers.

Post-war prosperity in the 1920s brought in its wake a new era of oil production, hydro-electric development and expanding base-metal output as well as of automobiles, planes and motor boats. Montreal surged ahead on the commercial and industrial fronts. Toronto began to grow into an important financial centre. The success of the Panama Canal contributed greatly to the growth of Vancouver, British Columbia, into a thriving ocean port. Mining, pulp and paper, and water-power projects brought vigorous industrial activity to northern latitudes of the nation. The motor boat, tractor and plane combined to aid the development of natural resources in the Hudson Bay and Mackenzie River drainage basins.

The opening years of the 1930s were featured by swiftly changing patches of light and shadow on Canada's road to fuller nationhood. With the transfer of natural resources from federal control and management to the jurisdiction of the provinces of British Columbia, Alberta, Saskatchewan and Manitoba, new regional functions and frontiers were brought into being. The provinces also embarked upon ambitious programs of highway construction, including the paving of important traffic arteries. During the first post-war decade, in fact, development activities of the provinces doubled. During this same span of time Canada achieved Dominion status and full equality with all other nations of the British Commonwealth and began to establish its own diplomatic representation abroad. On the darker side of events the advent of the Great Depression, aggravated in the western interior by severe and prolonged drought conditions, created widespread hardship and despair and slowed Canada's economy to a stumbling pace.

All these far-reaching changes and calamities exercised their varying beneficial and baneful influences upon the fortunes of surveyors and mappers. But with the profoundly significant mineral discoveries of 1947—the opening of the rich Leduc oil field in Alberta, about 16 miles southwest of Edmonton; the startling realization of the extent of iron-ore deposits in northern Quebec and in Labrador; the uncovering of new deposits of uranium together with renewed life and vigor in base-metal mining enterprises, particularly in Central Canada—all these lifted the curtain on an era of greater promise for Canadian surveyors and mappers than the nation's history had ever known.

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ENERGY, MINES AND RESOURCES

CONTENTS

Chapter

1. Deville and the Twentieth Century, 1
2. Survey Instruments: Ancient and Modern, 16
3. The Ontario-Manitoba Boundary: Completion Surveys, 33
4. Map Production and Reproduction, 47
5. The Role of Surveys in the Story of Montreal, 65
6. Alcan and Canol: The Surveys Story, 79
7. Canadian Hydrographic Surveys: 1917-1947, 99
8. The Geodetic Survey of Canada: 1917-1947, 119
9. Evolution of Canadian Highway Surveys, 133
10. Canadian Military Surveying and Mapping: 1917-1947, 155
11. Town Planning and the Toronto Surveys, 179
12. The Unsurveyed Interprovincial Boundary, 197
13. Canadian Astronomy: The Stewart-Plaskett Period, 211
14. Thematic Maps in Canada, 233
15. Geological Survey of Canada: Thirty Years of Mapping, 1917-1947, 241
16. Major Church's Survey School, 257
17. Representative Railway Surveys in Canada: 1917-1947, 267
18. The Role of Mapping in Forest Surveys, 285
19. The Canadian Eight-Mile Map in Peace and War, 297
20. Finder of Alberta's Black Gold, 306
21. Men and Meridians in Canada's North, 311

APPENDIX, 331
ACKNOWLEDGMENTS, 335
REFERENCE NOTES, 336
MAP AND FIGURE GUIDE, 348
INDEX, 351

1

DEVILLE IN THE TWENTIETH CENTURY

"I have done the state some service . . ."
—*Othello*, Act 5, Sc. 2.

As the 20th century dawned the profession of land surveying in Canada had reached a standing generally considered to be equal to that of any similar body in the world. Much of the credit for this notable achievement rested with Edouard Gaston Daniel Deville (1849-1924). Following the commissioning of Deville as a Provincial land surveyor (Quebec) in 1877, and as a Dominion land surveyor and Dominion topographical surveyor in the following year, this exceptionally gifted former officer of the French Navy rose rapidly to become Surveyor General of Canada in 1885. For the greater part of the four following decades Deville exercised an unparalleled and beneficial influence upon the entire range of land surveying activities in this country and, in the later years of his career, on initial developments in the realm of Canadian air photographic surveys. Possessed of a remarkably inventive mind, linked with marked prowess in mathematics and a genius for administration, Deville was stamped from the beginning of his residence in Canada as a brilliant leader in his chosen field of endeavor. These special qualities, combined with unflagging industry, enabled him to bring world renown to the organization he directed for almost 40 years.

Testing of Survey Instruments

Deville, whose passion for accuracy was legendary, insisted that as the function of a land surveyor is to measure land, the first requisite of his occupation ought to be a correct, reliable measure. In the earlier days of post-Confederation surveying every surveyor, upon receiving his Dominion land surveyor commission, was supplied by the secretary of the Board of Examiners with a pine yardstick by which he was required to verify his chains periodically. One of Deville's first official acts as Surveyor General was to recommend the substitution of an adequate, properly tested standard of length to replace the rather rudimentary wooden verifier. In later times, and in support of his early action Deville pointed out that "if lengths had been correctly measured the land survey of the Dominion would have been the most perfect and remarkable in the world".[1]

The reform advocated by the Surveyor General was not adopted overnight. In fact, 28 years passed before his ambition in this respect was realized. In 1885 the Board of Examiners recommended, on his urging, that a 66-foot steel band should be substituted for the three-foot wooden rod and that such standards should be issued to surveyors after testing and stamping procedures by the Department of Inland Revenue, Ottawa. W. F. King, as a Board member, tried to persuade that department to provide a comparator suitable for testing line measures. The comparator that was set up some six years later proved unsatisfactory. Plans for its construction were drawn up by Deville but the workmanship based on the plans was defective. Nevertheless the comparator was in use for some years and 135 measures in all were tested by it and released for use by land surveyors. Experimental tests on sample 100-metre tape were illuminating. Five separate examinations were made, some in Canada and some in the United States, under identical conditions of temperature and tension. These tests revealed variations in tape length of more than two inches, equivalent to about three feet per mile, whereas the permissible discrepancy should not have exceeded two-tenths of an inch per mile.

Finally, after persistent representations to the government, a rough wooden shed was erected on Cliff Street, near the present Supreme Court Building in Ottawa, to accommodate a new comparator. Deville and King, who greatly respected each other's abilities, sometimes allowed their personal relationship to become quite cool. One clear indication of the existence of such a period of chilled attitudes was the decision of King to build a structure on the Dominion Observatory site for the purpose of testing steel tapes of the Geodetic Survey of Canada while Deville was directing the construction of the Cliff Street laboratory for testing the tapes of Dominion land surveyors. King made an interesting reference in an official report to the latter structure, stating that "the Cliff Street house had been the reference point of all longitudes observed up to 1905. As the reference point will now be the Observatory this longitude connection [between the Cliff Street house and the Observatory] was a necessity to correlate future longitudes with the past. It seemed advisable further that an independent connection between the two points should be made by a survey. As the two stations are not intervisible the survey had to be carried out by a triangulation extending to the hills north of the Ottawa River so as to secure points from which both stations could be seen".[2] From the beginning there could have been a single organization and structure for the advancement of these comparator projects. Long after Deville's death in 1924 the two functions were, in fact, merged.

In 1902 thieves broke into the Cliff Street building, stole steel tapes and parts of the comparator and left the interior of the structure in a shambles. Not until 1911 was a new building for these testing purposes erected on the Cliff Street site. A new comparator was installed, designed by C. E. Guillaume, Assistant Director, International Bureau of Weights and Measures. Plans of the apparatus were provided by *La Société Genevoise pour la Construction d'Instruments de Physique et de Mécanique.* In 1925 this Surveys Laboratory, as it had been known, was renamed the Physical

FIGURE 1
Cliff Street, Ottawa, pioneer instrument-testing laboratory and survey reference point, about 1911. Central Hull and Interprovincial Bridge in background.

Testing Laboratory. "A surveys laboratory for testing instruments has lately been built", Deville reported, "and it has already proved very useful. Although only a portion of the equipment has been installed, facilities will be provided for testing and adjusting surveying transits, levels, aneroid barometers, measuring tapes, etc., and for rating chronometers and watches".[3]

Much of the notable work carried out by the Dominion Lands Surveys organization in the West owes its excellence, in part, to practice work at the Cliff Street site. As instrumental precision was of greater consequence to Deville than any consideration of human comfort, the only source of heat in the building during winter months was a gas stove in the front office. In later years it was found that the premises could be warmed by electrical heating without adversely affecting precision tests. Telescopes were also tested for their optical properties. Judging from the number of flaws detected in instruments by investigations in this laboratory it soon became apparent that the relatively small cost of providing a reliable test of a surveying instrument before accepting it from a dealer, was a sound investment.

G. Blanchard Dodge, as Chief of the Special Surveys Division, Department of the Interior, supervised the Cliff Street project but W. H. Herbert was placed directly in charge of its operations. He was succeeded in 1913 by W. C. Way. Soon after Way became supervisor a new tape comparator building was erected in the New Edinburgh district of Ottawa. Way was personally responsible for important improvements made in aneroid (survey) barometers, devised as a result of experiments conducted in the new premises. These instruments, in conjunction with better systems of barometric levelling, began to make possible the production of highly useful information on heights for contouring purposes. Mr. Way also developed a reliable method of testing telescopes intended for use on surveys. In 1927 a notable advance was made in the Physical Testing Laboratory when verification of the Dominion Standard Yard was achieved.

In 1921 Frederic Hatheway Peters (1883-), who became Surveyor General three years later, sponsored the establishment of an instrument repair shop at the Laboratory, fulfilling previous unsuccessful efforts made by Dodge, Deville and Way

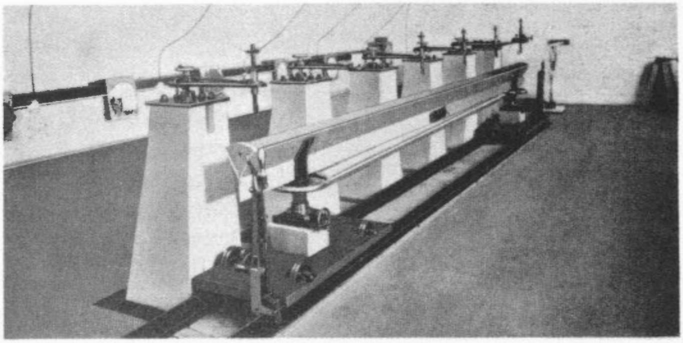

FIGURE 2
Comparator in Standardizing Building, Ottawa, about 1915.

to meet this special need. Soon the laboratory was assigned the tasks of repairing and testing dashboard instruments for the Royal Canadian Air Force and, in fact, began to assume an important place in the genesis and growth of air surveying in this country. Laboratory calibration of ground-survey cameras had been instituted by Deville and the same methods were readily extended to apply to the earliest air cameras to be used in Canada. Stereoscopes and other instruments employed in the first air-survey operations in this country were designed and constructed in the Laboratory shop. Means were provided for the purpose of intercomparing rules used as standards of measurement and for verification on base standard tapes of any length.

By 1929 Reginald Hugh Field (1890-   ) had succeeded Way as supervisor. Field later became president (1943) of the Canadian Institute of Surveying. He was a prolific contributor of technical articles to *The Canadian Surveyor* and other publications. The independent existence of the Physical Testing Laboratory came to an end in 1931 when it became part of the then newly-established National Research Council Laboratories. It was mainly owing to Deville's determination to maintain instrumental equipment at the highest possible level of precision that brought into existence testing facilities in Canada long before light waves and radar beams became available for these important purposes. On the wider scene Deville persuaded government authorities in Ottawa to arrange for Canada's membership in the International Bureau of Weights and Measures (*Bureau de National des Poids et Mesures*). Canada thus became the first member nation of the British Commonwealth, apart from Great Britain, to belong to this world organization.

Air Photographic Surveys

During the First World War the aeroplane underwent major changes in the race of combatant nations to develop the heavier-than-air machine into a military weapon. Improvements in propeller shape, power plant and body design were greatly accelerated in this violent and fiercely competitive environment. In appearance, in its greater flight stability and control the aeroplane of 1918 was an age ahead of the flimsy, kite-like *Silver Dart* which, in February, 1909, at Baddeck, Nova Scotia, was the first plane to be flown within the British family of nations. In addition, as a result of practical applications of photography to the exacting tasks of military observation, a number of refinements had been made to air cameras. At the end of the war several significant factors combined to attract official attention to the aeroplane as a means of expediting and advancing the scope, range and general effectiveness of land-survey work. Developments in aerial photography during the war years convinced surveyors generally that the new technique could be applied to all aspects of topographic surveying. At the conclusion of hostilities warplanes became available for peacetime uses and a number of such aircraft, including a few flying boats, were turned over to Canada by the British government. It was obvious, too, that trained pilots and navigators, former air force officers, could form the nucleus of a civilian flying service. Another significant element in the post-war situation was the formation in June, 1919, of an Air Board in Canada. Here then, in timely conjunction, were the four principal ingredients indispensable to the successful growth of air surveys (or "aerial phototopography" as it was then described); the aeroplane, the air camera, pilots and navigators and, above all, an organization capable of providing national support of the enterprise at the official level in Ottawa.

In the forefront of revolutionary developments in the fascinating and promising new field of air surveying, and soon to be named to the reconstituted Air Board, was Dr. Edouard Deville.[4] Initial work in the application of aerial photography to survey projects, accomplished in the autumn of 1918 and involving the participation of Canadian Naval Air Service officers, was continued under auspices of the Air Board.[5] In addition to the creation of the Board, an Air Survey Committee of the Department of the Interior, with Deville as chairman, was established and shared with the Board the responsibility of assessing practical possibilities of air photographic surveying. It was decided that an experimental aerial photographic survey should be undertaken in the summer of 1920.

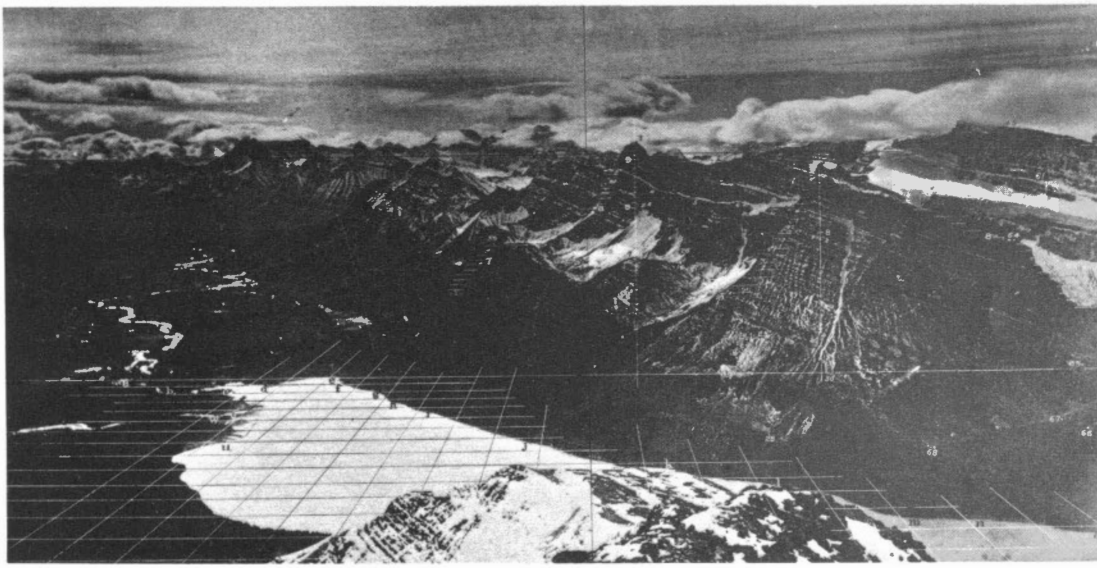

FIGURE 3. Photograph taken in Canadian Rockies portraying use of perspective grid in map plotting.

FIGURE 4. Surveyors marking site of a photo-topographical mapping station with stone cairn in mountain country, 1929.

Ottawa and area offered physical features particularly favorable to such a test. In the district land and water occurred in fair proportions at varying elevations and all within a reasonably small compass. It was considered essential that a control survey of the region should be first undertaken so that various points and elevations could be accurately fixed by triangulation. By this means it was intended that the relative positions of photographic prints making up a mosaic, could be fixed and controlled to the highest possible degree of accuracy. It was also hoped that data could be obtained by which photographs, badly distorted by the tilt of the camera plate to the horizontal, would be rectified. In all these activities the navigator was the key man in the operations and the best stabilizing device a plane could possess was its pilot. At the beginning Dominion land surveyors such as R. D. Davidson, Eric Fry and John Carroll acted as air navigators and photographers.

Two flying charts were prepared for the guidance of each pilot on the experimental surveys, one for flights at 6,000 feet and the other for flights at 10,000 feet. These charts were necessary to help keep the plane on course, to tell the pilot where to start and stop the camera, and to maintain the proper separation between parallel flights. In these early stages of the project attempts were made to join the edges of photo prints but the existence of different scales and of image displacements due to ground relief did not always permit close coincidence.

An interdepartmental conference met in Ottawa late in 1920 to draw up a program of air-survey work for the following field season. The gathering took place in an aura of optimism resulting from epochal events in aviation that had caught the public imagination, achievements such as the first non-stop flight across the Atlantic Ocean, west to east, in June, 1919; and by the first trans-Canada flight, made from Vancouver to Halifax in October, 1920. The latter feat occupied a total of ten days (October 7 to 17), the actual flying time being 49 hours, 7 minutes. In addition to members of the Air Board this conference was attended by the Superintendent of the Geodetic Survey of Canada, the Controller of Surveys of the Topographical Surveys Branch of the Department of the Interior, as well as by several other key departmental officials. The committee noted with satisfaction the completion of air photographic surveys during the summer of 1920 of Vancouver harbor and of the Fraser River delta region, of water storage basins in southern Alberta for the International Joint Commission, and of a mosaic of airphoto prints of the St. Croix River.[6]

In the pioneering stage of air camera work in Canada the value of the mosaic sheet was not fully realized. But before long it was found that the more the mosaic was studied, the more information it yielded. It had the definite advantage also of being more easily read and understood by the public than a map, although it was not as useful as the latter when precise measurements were required. Very early in the experimental program in this country it became clear that aerial photography would revolutionize topographic surveying, although some system of triangulation control remained indispensable to successful operations. For a time the problem of maintaining effective, constant communication between pilot and photographer, so essential in this type of flying work, remained unsolved. Experimental flights revealed that the Bristol Fighter aircraft, providing good

FIGURE 5. Mosaic based on 1925 RCAF photography of parts of Ottawa and Hull from 10,000 feet. Approx. scale: 1,200 feet to the inch.

visibility in all directions and capable of taking photographs at 20,000 feet, possessed the most satisfactory characteristics for air-survey work.

In the 1921 season the scope of this work widened considerably. In that year, at the request of the government of Ontario, a mobile unit was established on the National Transcontinental Railway between Sioux Lookout and the Ontario-Manitoba boundary for a distance of 200 miles east of the interprovincial border. During that same summer a large area of Ontario was surveyed from the air by forest engineers of the Ontario government service. Complete and accurate maps were then prepared, showing the nature of the country photographed in considerable detail. Other important air surveys accomplished in 1921 included areas adjoining the proposed St. Lawrence Seaway. These activities, requested by the International Joint Commission, provided highly satisfactory representation of the ribbons of land portrayed. The results were most useful in the revising of existing maps and in the preparation of new sheets. Especially valuable photographs were obtained during the same season of principal streams flowing east from the Rocky Mountain watershed. Used in mosaics these photographs were particularly helpful as information in support of water conservation studies of the western interior. The most impressive aspect of all these operations was the fact that, after only four months of flying, information was available for surveys and mapping that would have consumed years of effort without the use of aircraft. The end of 1921 marked the conclusion of a period of preliminary organization and experimentation in Canadian civil aviation. In the service of governments the usefulness of aircraft in forest survey and forest protection work had been proved beyond question. This new method of travel was particularly helpful in providing rapid transportation for surveyors and others across vast, unsettled regions of northern Canada.

In January, 1922, an interdepartmental conference in Ottawa on the subject of the use of aircraft by federal government services was attended by Surveyor General Deville and representatives of the Geodetic Survey Branch and Topographical Surveys Branch of the Department of the Interior, and by the Director of Geological Surveys of the Mines Department. It was decided that in 1922 there would be a continuation of air transportation of survey parties and their equipment from Vancouver eastward along the Fraser Valley and of supplies to survey parties in northern Manitoba and Saskatchewan. There was to be, as well, photography from the air from Jasper along the continental watershed forming the British Columbia-Alberta boundary in conjunction with similar flights for the Geodetic Survey. Similar flights were to be made in aid of survey parties along the north shore of the St. Lawrence River from Clarke City to the Straits of Belle Isle. It was also decided to construct a mosaic of a complete township in the Calgary district for comparison with results of ground surveys undertaken in the same locality.

For the Topographical Surveys Branch, Interior Department, mosaics of the Bow River west of Calgary and of the Moose Mountain Reserve were made for the purpose of providing topographical detail in connection with surveys of those areas. Mosaics were prepared by the Branch based on air surveys carried out at a number of different stations. All photographs were compared with existing maps of the same areas and where the latter were incomplete, revisions were made in them from information gleaned from the photographs.

The veteran surveyor and author, A. O. Wheeler, asked for an opportunity to fly over stretches of the British Columbia-Alberta boundary line as an observer on reconnaissance flights during the 1922 season. He clocked nearly twenty hours of flying time in this connection. "As a means of mountain reconnaissance", Wheeler reported, "the aeroplane offers exceptional facilities. Given a clear day and the ability to keep known landmarks it is, to a topographer, a study of a living map, the most accurate that can possibly be had. I was enabled to get a clear conception of the country my future [land] surveys would cover and the nature of the access to them . . . I may say that the aeroplane service can be applied to distant and difficult surveying work with great advantage and I should think could be used as a means of saving expense".[7]

FIGURE 6. A. M. Narraway

For the Topographical Surveys Branch, Athos Maxwell Narraway (1888-), Controller of Surveys, Department of the Interior, was flown a total of 14 hours between July 3 and 11, 1922. These flights demonstrated how survey inspection work could be simplified and extended. An extract from his report on these flights conveys vivid impressions of his experiences:

"The flight, consisting in the neighborhood of 1,100 miles, mostly over unmapped territory, commenced at Victoria Beach, Lake Winnipeg, and ended at The Pas. No mishaps or delays occurred and the trip was made in ten days, including six days at surveyors' camps. By ordinary methods of travel this inspection work would have taken practically the whole season and would have been expensive.

"The first survey party to be visited was engaged in the surveying of the Manitoba-Ontario boundary. No reports had been received from this party and as they were in unexplored and unmapped territory only an approximate idea could be formed as to their location. A very conservative estimate of the time that would be required in reaching this party by ordinary means of travel would be somewhat over two weeks and would have entailed considerable paddling and searching out routes and portages, the usual endless contest with mosquitoes, the difficult task of finding the party and a very restricted view of the country traversed. The trip was actually made in one hour and forty-five minutes and permitted of the sketching of the main topographical features, examination of the forest growth and by flying low, an unobstructed view of the completed boundary line . . . The camp was located without difficulty by the smoke from camp fires and a very easy landing was effected, ending with the machine tied to the trees less than twenty feet from the tents".[8]

Narraway was especially enthusiastic in describing that part of his northern trip from The Pas to Churchill River:

"Flying over the course of the survey [of waterways of the region] oblique photographs were taken by the K2 camera at intervals of about two minutes. In some of the photographs the survey pickets are clearly discernible and in all of them the prominent land features surveyed can be accurately located. Using the survey of these main features as a control, the details of the shore line and the intricate mass of islands can be filled in from the photographs with accuracy consistent with the requirements. The surveyors [on the ground] were obliged to spend considerable time mapping the shore-line detail and islands, and even then could only obtain what was confined between the two shores. With the plane, the time required to get in the details, can be estimated in minutes instead of hours, and in some cases, days, and the scope of the camera widens the survey to several miles on either side of the waterway and includes lakes and topographical features which otherwise would be left unmapped.

"As a result of this trip I am of the opinion that invaluable service to surveying in unexplored and unmapped territories will be rendered in the future by the seaplane in transporting supplies and men, thereby saving for the work many days of the working season, which is already short enough; in permitting reconnaissance and exploratory flights for purposes of planning surveys; in keeping in communication with the surveyors during the season and in taking photographs along the course of the survey for filling in detail.

"To those who have a thorough knowledge of the ground conditions and experience in sketching and mapping such as surveyors have, the value of flights over the districts to be surveyed can scarcely be overestimated".

On Narraway's return to Ottawa a systematic examination was made of photographs taken on his inspection tour with a view to evolving a method of transferring the illustrated topographical information to existing maps of the areas covered. Some highly favorable results were obtained, foreshadowing far-reaching reconnaissances by air in the exploration and mapping of large areas of northern Canada.[9] It was in this period of air photographic work that surveyors such as R. D. Davidson, John Carroll and Eric Fry played such an active, useful and pioneering part.

It was now apparent that in an unsurveyed country, possessing no great variations of elevation but some form of geodetic control, topographic detail of an entire district or region could be filled in from air photographs with a speed and accuracy unobtainable by the most exacting ground surveys. Because Canada was in possession of such an immense unsettled territory over which aircraft could operate with great advantage, it was inevitable that aviation would play an increasingly valuable role in the surveying and mapping of the country. We have seen that some of the most useful services provided in this manner included fast, reliable and relatively easy transportation and maintenance of survey parties in the field in remote places, surveying by aerial photography and sketching, as well as mapping from the information supplied by air photographs. In 1922 alone some 2,000 photo prints were supplied by the Air Board to the Topographical Surveys Branch.

Meanwhile Deville worked diligently on the perfection of a camera which, when suspended from an aeroplane at right angles to its line of flight, would be capable of photographing terrain from horizon to horizon. It was also desirable that when the plane banked during the photo-making process, the horizon line would indicate in any one photograph the direction and extent of tilt, information essential to any effective plotting of maps based on a set of photographs produced by the air camera. At this time the Topographical Surveys Branch did not possess any instruments capable of facilitating plotting from photographs. At Deville's request the Air Board authorized a series of experiments on a new camera and system of air survey devised by H. L. Cooke, Professor of Physics, Princeton University. For mapping purposes he proposed the use of low oblique views of a single area photographed from two different air stations. Although Professor Cooke's method was sound in theory, suitable photogrammetric equipment, such as a special convergent plotter, was not then available. There are indications that the photographs produced by the Cooke method proved difficult to process. In any event vertical or near-vertical (low oblique) air photography could contribute little toward reconnaissance mapping of Canada's northern areas because of the limited amount of ground that could be covered by a single exposure. Only flying boats could be used effectively in vast wilderness areas, largely devoid of landing strips yet interlaced with innumerable waterways. This type of aircraft could operate, however, only under relatively low ceilings, varying between 6,000 and 8,000 feet. By the standards of the 1960s the cameras in use were narrow of angle.

In the summer field season of 1922 an official probe of Canada's Far North was launched from Ottawa with a view to ascertaining the extent to which aeroplanes could operate efficiently in Arctic conditions for transporting, surveying, mapping and other purposes. A Dominion land surveyor (1914), Squadron Leader Robert Archibald Logan, was appointed to carry out this investigation. On July 18 he sailed aboard C.G.S. *Arctic* from Quebec City, returning on October 2 to that port after visits to Bylot, Ellesmere and North Devon islands and to the north end of Baffin Island. An experienced flying officer and well qualified in meteorology and aerial navigation, Logan submitted a comprehensive report to the Department of the Interior Provided there were machines adapted to the special conditions in the Arctic and operated under proper precautions, it was evident that planes could be used to advantage in the far northerly latitudes of Canada.[10]

In 1922 Fairchild Aerial Surveys Company (of Canada) Limited was formed with head offices at Grand'Mére, Quebec. The Fairchild aerial camera was generally considered, at the time, as the most perfect and most modern instrument of its type. It had been adopted as a standard by the Royal Canadian Air Force and by the United States Army and Navy Air services. Utilizing its own Curtiss Seagull flying boat the company produced a complete mosaic of 320 square miles of unmapped forestland in the Rouge River valley of Quebec. Strip mosaics were also made of the Batiscan River covering a number of projects for the development of water power, including the location of related power lines. Complete mosaics were also produced of Trois Rivières and Grand'Mère for town planning purposes.

At this stage in the growth of civil aviation in Canada references began to appear concerning the use of the Fairchild stereoscope, an instrument enabling the observer to look simultaneously at a pair of air photographs and view the pictured terrain in three dimensions. The stereoscope, for example, made it possible for a timber limit owner to study in detail any section of his forest domain. In vertical air photography a new type of Fairchild camera, gyroscopically controlled, was put into use in 1923.[11] It is interesting also to note that in the same year hyper-sensitized, panchromatic film was being used in air survey work but with exposures at speeds only one-quarter as fast as those occurring forty years later.

On January 1, 1923, when the Department of National Defence came into being as such, the Air Board of Canada ceased to exist as a separate entity. Annual reports of the Board were supplanted by annual reports on Civil Aviation in Canada. Experimental oblique stereoscopic photographs were taken during the 1923 field season in the vicinity of Ottawa and vertical stereoscopic photos were taken along Sheep Creek, Elbow River and Beaver Creek in Alberta. Two other flights were made over the course of the Ontario-Manitoba boundary and three parallel flights took place over the New Glasgow, Nova Scotia, sheet area. Up to the end of this particular field season more than 4,500 photo prints were supplied by the Royal Canadian Air Force to the Topographical Surveys Branch, Ottawa.[12]

In the winter of 1922-23 Canadian Vickers Limited had undertaken work on several equipment supply contracts for Canadian civil aviation firms, including the construction of floats for seaplanes and skis to serve as winter-landing gear. During that same winter season experimental flights clearly demonstrated that cold-weather flying was feasible.

As an appendix to the 1924 Report on Civil Aviation, a report by H. K. Wicksteed was included on the use of air photography in railway location work.

During the 1924 field season, as a result of successful operations in the several previous years, aerial methods of mapping on a large scale were adopted. No less than 9,000 square miles of territory were photographed from the High River, Alberta, air station. The photographs were then plotted in the drawing offices of the Topographical Surveys Branch. Maps of the district were then revised on the basis of the new information made available. Land surveyors were enthusiastic over the advantages of airphotos in guiding their efforts, a service that cut their ground work in half. A mosaic covering 520 square miles of the Edmonton area was produced after four flights. Edmonton's city engineer at the time, on receiving copies of the mosaic, was greatly impressed by the possibilities of their use. "One of the striking features of the map", he stated in a written report, "is the way in which one can visualize the density and distribution of settlement. This is particularly useful in Edmonton where the fundamental problem was brought about by over-expansion. The photographs show at a glance the accurate location of all settlements and these could be obtained by ordinary survey methods only after laborious field work . . . I have been in fairly close touch with the Dominion land surveyor who was carrying on the work in connection with the survey of the district and I can see that in his work there is a remarkable saving of time and labour by having available the aerial photos . . ." By September, 1924, the whole of the Edmonton sheet map, 3,224 square miles, had been photographed from the air in 14 flights totalling 32 hours.[13]

Exceptional foresight was exercised by Deville, Peters, Narraway and others in the earliest days of aerial photography in Canada in laying the foundations of the unique organization that came to be known as the National Air Photo Library.* In 1920 the

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*Known, until 1948, as the National Air Photographic Library.

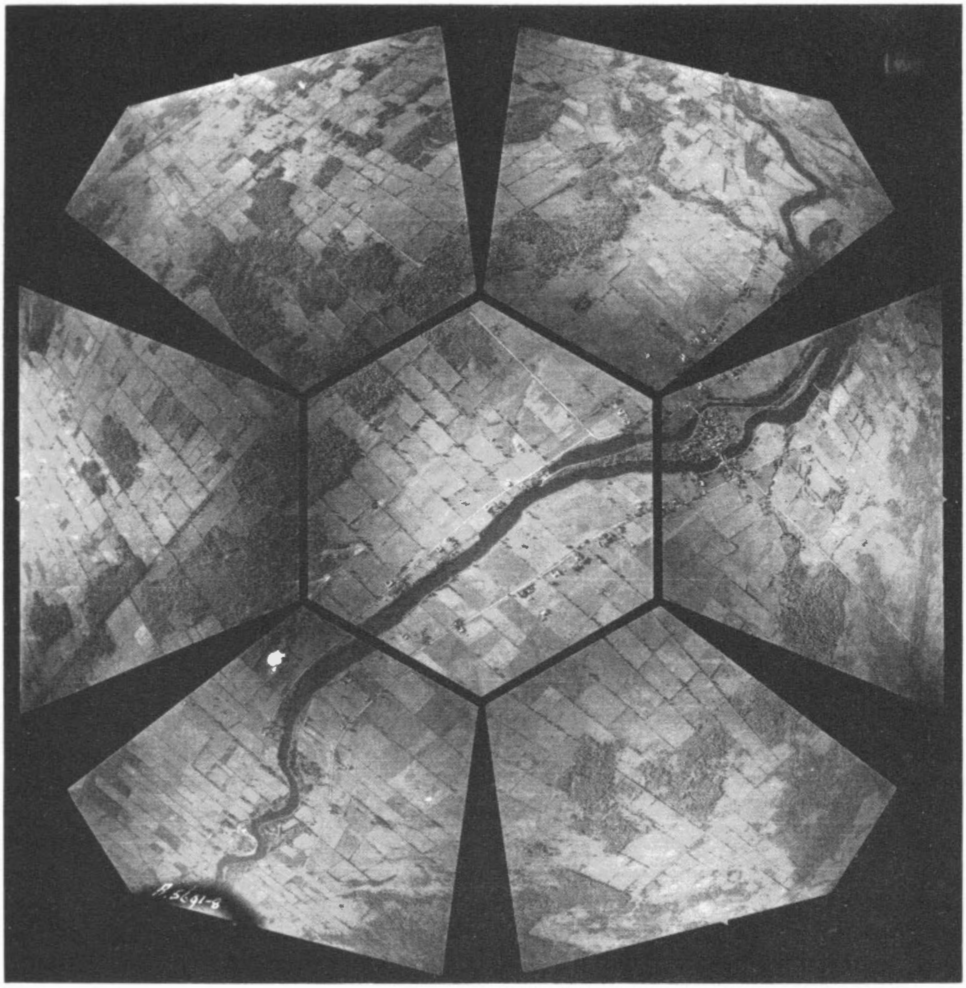

FIGURE 7. Air view of Burritts Rapids on the Rideau River, Ontario, taken by a seven-lens Barr-Stroud camera at 7,200 feet, 1937.

printing and developing of air photographs and the mounting of mosaics was performed by the staff of the Natural Resources Intelligence Branch, Department of the Interior.[14] The Library was formally established on February 7, 1925, but the need to provide for systematic filing and storage of negatives and prints was recognized at least five years previously when the first experimental photographic flights in Canada took place. Later on as the Air Force became more involved in this type of air surveying activity, the processing, printing and storage operations became functions of the Library staff. By the 1960s files of the Library were accommodating several millions of photographs, providing an aerial portrayal of all Canada, pictorial information vital not only to map makers but to all interested in the development of the nation's natural resources. Air survey photos, in fact, became a rich, varied and sometimes sole source of knowledge essential to the wise planning, construction and development of settlements and of engineering projects across the 1,800,000 square miles of northern Canada.

In time, then, the National Air Photo Library came to serve, not only as a central repository of all aerial photographs taken under the auspices of various federal government departments in full liaison with the provinces, but as well the most complete rapid reference service and most comprehensive storehouse of air photographs known to exist anywhere in the world for the benefit of all users.

In Deville's life span he had witnessed the steady development of Canada from a loose collection of seven provinces to a more unified political and economic entity extending from the Atlantic to the Pacific, on the verge of attaining full independent nationhood. The science of photography, during his lifetime, had progressed from the stage of daguerreotypes to the sophisticated, high-speed air camera using hyper-sensitized panchromatic film. Aeronautics had developed from the pioneering experimental flights of the Wright brothers and of McCurdy to planes capable of crossing the Atlantic non-stop. In the realm of transportation generally Deville had witnessed the institution of regular transcontinental service as well as the use of planes in place of the canoe and Red River cart. The whole field of long-distance communications had been so revolutionized as to make surveying and mapping of the vast, unoccupied areas of Canada immensely easier and more accurate.

Deville, married at the age of 32 to Josephine Ouimet, daughter of the second premier of Quebec, never shared her preoccupation with the unending round of social events in the nation's capital. In the closing years of a career completely dedicated to his work Deville was immensely saddened by the deaths of respected colleagues with whom he had close associations in the public service. As he commenced his 40th year as Surveyor General, Deville's legendary good health and sturdy powers of endurance began to decline noticeably. By the advent of summer he had become frail and bedridden.

The maples outside his Ottawa home blazed with vivid autumn colors as the mellow September days of 1924 drifted by. Downtown the film "Monsieur Beaucaire", starring Rudolph Valentino, played to capacity houses. Preparations were under way on Parliament Hill for the approaching visit of the Prince of Wales to Ottawa; Dr. Charles E. Saunders, discoverer of Marquis wheat, had just returned to the capital after a stay of several years in Europe. Daily papers were drawing public attention to the fifth anniversary of the League of Nations. At 60 Lisgar Street, Edouard Deville's life force ebbed steadily as his wasting illness took its inevitable toll of strength. On Sunday, September 21, the pace of decline became suddenly more rapid. Late that evening he died. Josephine and their only son, Gaston, were at his bedside at the end.

In the passing of Canada's Surveyor General the capital, the nation and the world lost the services of a man who stood for the highest standards in the application of scientific principles to problems of land measurement, as well as the loftiest ideals of reliability and accuracy in the discharge of public responsibilities. Thomas Shanks, who had been associated with Deville for a quarter-century in the strenuous work of the department, paid stirring tribute to Deville's personal integrity and his mastery of the tasks of administration. Shanks drew attention to the fact that although French was Deville's mother tongue, he succeeded in cultivating the qualities of terseness, fluency and clarity in his use of the English language.

J. J. McArthur, as president of the Dominion Land Surveyors' Association, had once described Deville as unflagging in his efforts to "raise the standard of Canada's surveying operations and to perfect the organization of Dominion Land Surveyors". The

Board of Examiners of the Dominion Land Surveyors observed that Deville had been responsible "in no small degree for the high position which Canada holds today in the world of sciences". Associated with the work of the Board as a member since 1879 Deville "may well be regarded as the founder of an important national profession. Through his initiative and masterly direction there had developed a system of survey almost unique in its extent, efficiency and accuracy. Throughout his career Dr. Deville brilliantly represented his country at scientific conferences abroad and became internationally known and recognized. Indeed, in several branches, such as photographic surveying and the science of optics, he was regarded as one of the greatest authorities of his time, and his influence extended to every country where advanced science was cultivated".[15]

This chapter would be incomplete without a tribute also to the energetic devotion to their challenging tasks of the personnel, flying and ground, of all air photographic services; federal, provincial and commercial. The outstanding record of gallantry, efficiency and dependability established by Canadians in the Air Force during the First World War was carried into the era of peace. No country was better served by aviators in post-war years than Canada. Much of their pioneer work was accomplished under arduous conditions, without adequate facilities, sometimes from remote bases, with small staffs and, on occasion, with obsolescent aircraft. But a new generation of pilots, navigators, air photographers and mechanics was being shaped in the crucible of experience. A stirring future awaited these young men, who felt, if they did not voice, a conviction well expressed in the prophecy:

> *"The air flows over both land and seas; more than either land or sea it is the place of vision, and of speed and freedom of movement. What we of this generation are witnessing is a process whereby the air shall come into its own. It will become a great highway for the traffic of peace."*

2

SURVEY INSTRUMENTS: ANCIENT AND MODERN

> *"A good instrument man, it may be said, has the sensitive touch of the surgeon, a sense and understanding of things mechanical, a sound comprehension of the principles of geometry, the language of a mule-skinner and the back of a pack-mule."*
>
> —Lester C. Higbee, W. and L. E. Gurley Company.[1]

Land surveyors in the earliest civilized communities in the Nile Valley left to posterity evidence, both direct and indirect, of the elementary instruments employed in the practice of their profession. There are sound reasons for the belief that in sighting, for example, and in meridian determination Egyptian practitioners of the surveying arts used a plumb bob, observed through a slit in a palm leaf. For levelling operations a plumb bob, suspended from a triangular frame, served their purposes. For right-angle measurements a carpenter's square and a type of surveyor's cross were used; for direct measurements, an ordinary rope. Much credit belongs, therefore, to these trail blazers of history whose observations and calculations, aided by primitive tools, made possible the construction of the pyramids, durable masterpiece of geometrical precision involving the application of technical skills and engineering abilities of a high order.

The earliest book in which first principles of surveying as well as descriptions of surveying methods and instruments were set forth was the *Treatise on the Dioptra*.[2] This was the work of Hero of Alexandria, a Greek scientist who wrote on various mechanical devices at the dawn of the Christian era. The *dioptra* was mounted on a Doric column with three small legs at the base. This support was made vertical by a plumb bob and, at the top, a toothed half-circle was turned by a worm-gear for the final levelling of the instrument. For angle work a horizontal circle was provided with an open sight and four right-angle graduations. For levelling, a water tube with proper sights was attached.

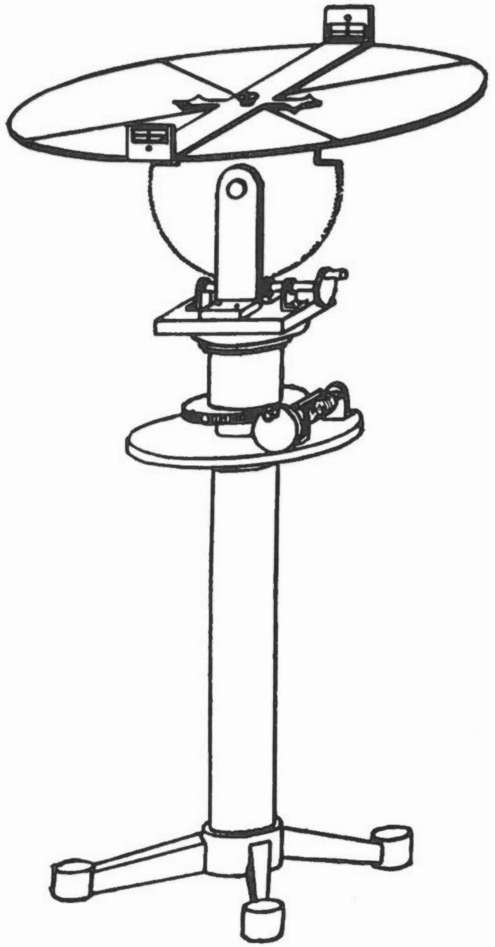

FIGURE 8
Dioptra of Hero of Alexandria, as reconstructed.

Among peoples of the Near East, long before the birth of Christ, the astrolabe was widely employed in certain occupations. It was a paramount instrument by which explorers, travellers and astronomers made observations of the altitude of the sun or stars and then rapidly computed the hour of the day or night. Because the astrolabe was portable and could be used on the deck of a moving ship it enjoyed considerable initial popularity among marine navigators. The magnetic compass and the astrolabe, in fact, were the principal navigational instruments at the time of Columbus.

Vitruvius, a Roman engineer, wrote about surveying instruments about 15 B.C., probably before Hero. He favored the use of the *chorobates* for levelling operations. These instruments, developed by the Romans, were based on the principle that the surface of a liquid in repose is level. Plumb bobs were used in the *chorobates* in place of the water tube employed in the *dioptra.* But a trough was cut in the top of the device and this could be filled with water when wind interfered with the bobs. Essentially this was a form of triangular frame with a plumb bob suspended from the apex, a type of level that can be traced back to ancient Egypt and even to Assyrian times.

FIGURE 9
Champlain's astrolabe, 1603.

Generally, however, the ancient surveyor lacked survey instruments of reliability and precision. For measurements of length he used ropes and rods, whose units had not been standardized. Records of surveys were also indifferently recorded, if at all.

It was in the Low Countries, in all probability, that the astrolabe was first employed on European land surveys. By its use the first triangulations were undertaken in the western world and the relative positions of towns fixed. The accuracy of such surveys depended upon the precision with which the instrument could be set up in the meridian, and upon the accuracy in those early days, of the division of the circle. The astrolabe and cross-staff, described in Volume One of this history, were forerunners of the sextant which enabled travellers and early navigators to measure the sun's altitude and thus determine the latitude of the observer. Instead of exposing the observer's eyes to the full glare of the sun and to remove the necessity of having a steady hand, John Davis invented what came to be known as the Davis quadrant. In time this instrument was displaced by Hadley's improved quadrant.

For some time after discovery of the New World, explorations were carried on with the aid of marine instruments. It is hardly surprising, therefore, that Samuel de Champlain made use of an astrolabe to guide him in his penetrations of the interior of New France. But in 16th Century Europe the practical surveyor in the field must have found that astrolabes were cluttered with appendages of little or no use to him. Artillery officers, seeking to get range of enemy positions as quickly as possible, could also dispense with facilities of the astrolabe for finding the place of the sun in the zodiac or for ascertaining the times of conjunction or opposition of the planets.[3]

Accomplishments in the development and construction of instruments were the primary contributions of continental Europe in the 14th and 15th centuries to the arts of surveying. Improvements in the magnetic compass, the invention of the holometer (which, in time, led to the adoption of the "plain table") and, in England, refinements of astronomical instruments as well as standardization of units of land measures featured this period. The method of surveying land by triangulation, as promoted by Frisius, was also an important step forward in those times. With this latter development came a steadily increasing demand for instruments by which the new practices could be advanced.

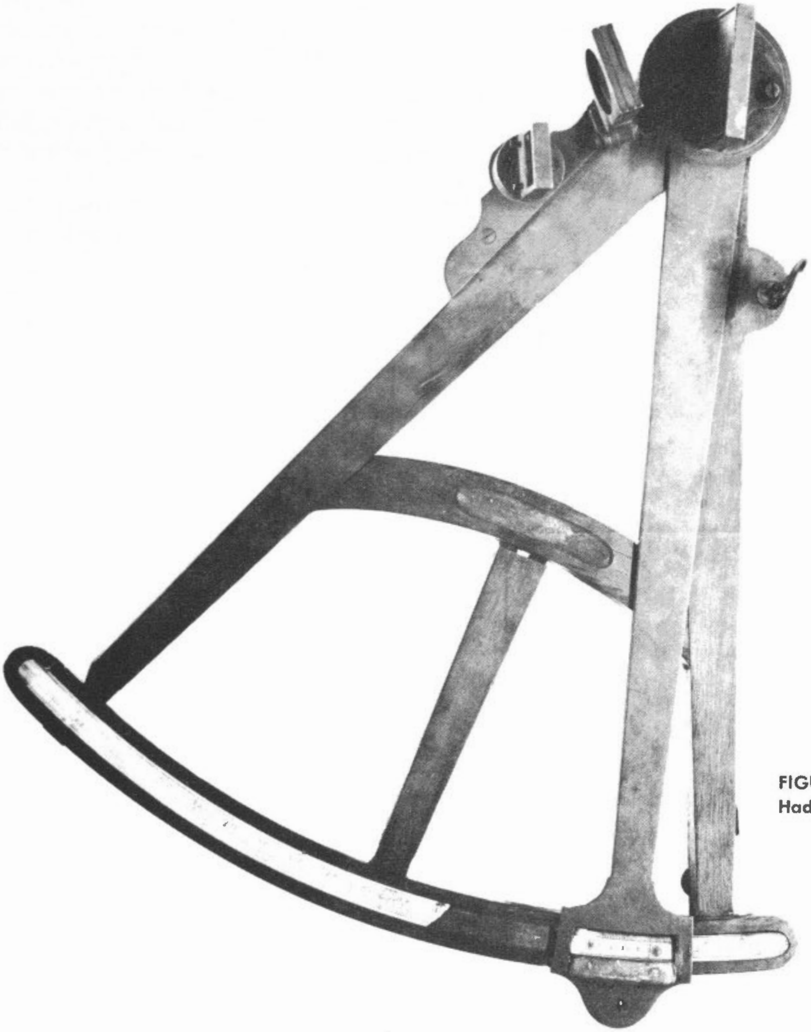

FIGURE 10
Hadley's quadrant.

The Englishman, Leonard Digges, wrote a book that was published in 1556 and in which three surveying instruments were mentioned, namely, the geometrical square on the side of a ruler, the carpenter's square, and the cross-staff. Digges failed to mention any instrument used for measuring direction but did refer to poles and cords for measuring distance. A second book of his, published by a son in 1571, mentions "the theodelitus" and "instrument topographicall". The latter device, combining the geographical square and theodelitus, provided a means by which angles in horizontal planes as well as angles of elevation could be determined. For almost two centuries the style or type of theodolite, as pictured in Aaron Rathborne's *The Surveyor*, 1616, retained the same general appearance. John Johnson, an American surveyor, used, for example, a theodolite of ancient model in his 1818 surveys of the New Brunswick-Maine boundary.[4]

An early improvement in distance-measuring instruments was Rathborne's "decimall chaine", made of round wire and curtain rings and with its 198 inches divided into ten equal parts or *Primes*. This chain was a distinct advance over cords and wooden poles previously used and a useful forerunner of the chain invented in 1620 by an English professor of astronomy, Edmund Gunter (1581-1626). Rathborne also mentioned an instrument representing a refinement of the astrolabe, namely, the circumferentor. As recently as the 1760s the circumferentor was employed by Mason and Dixon on their celebrated surveys in the New World.[5] In fact, early in the 19th century it formed part of the equipment of the Lewis and Clark expedition.

A relic recently uncovered in Oxford, England, ostensibly made in 1586 by the distinguished instrument maker, Humphrey Cole of London, is of special significance in the history of survey instrument construction. It is the earliest existing example of a combination of the pioneer topographical instrument and the primitive theodolite.[6] Its appearance marked the beginning of modern survey instrument design not only in England but in the civilized world. The search for a universal instrument for angle measurement was about to end in success.

Ralph Agas (1545-1621) was one of the first English land surveyors to make use of the plane table and a theodolite of the type described by Digges. Agas, in his field notes, also mentioned his use of a circumferentor. The improved surveying methods used by Agas and others suggested the need for scales by which distances and angular measurements could be read with greater ease, clarity and precision. It was then that instrument makers began to borrow ideas and methods from astronomers for the construction of scales for reading distances and angles with fair accuracy. In England, in the matter of survey instruments, the 17th century was, in fact, mainly important for the development of scales and for the appearance of the land measuring standard, Gunter's chain.

The family name of Dolland became synonymous in 18th century England with important advances in the science of optics. John Dolland, a silkweaver who had fled from his native France, although deprived of schooling at an early age, managed somehow to attain proficiency in optics and astronomy. His eldest son, Peter Dolland (1730-1820), founded the London firm that became world-renowned in the manufacture of instruments useful in surveying. In 1750 Peter established a shop near the Strand and concentrated on the manufacture of optical instruments. This enterprise proved to be highly successful. The elder Dolland forsook his silkweaving activities to join his son in the venture. In the course of time several Dollands made valuable contributions to the new science, inventing and improving a number of optical instruments. Their products were considered among the best made in England and were widely used in the British Isles and abroad.

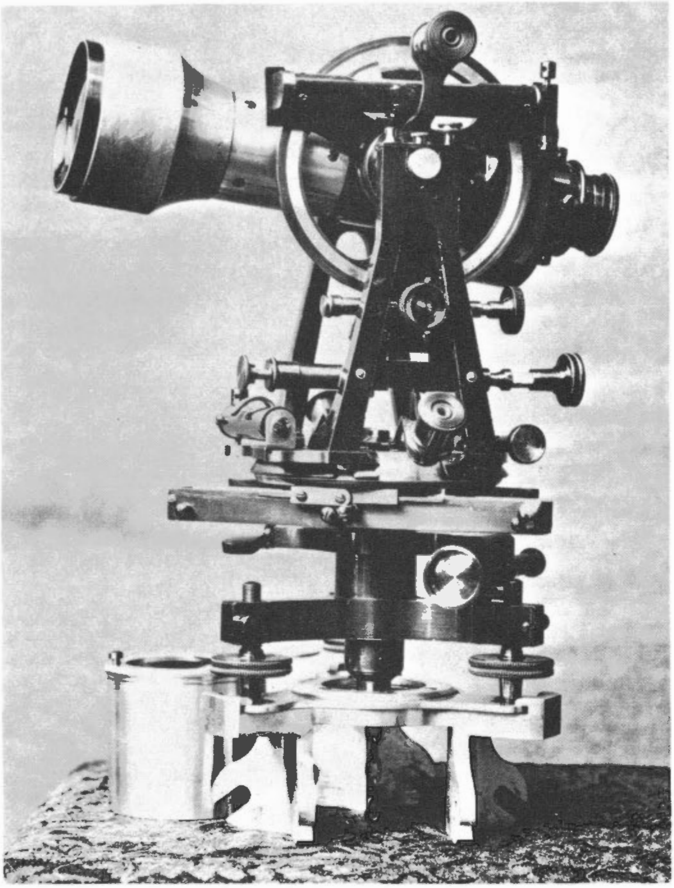

FIGURE 11
Early type of modern theodolite ("S.G." type).

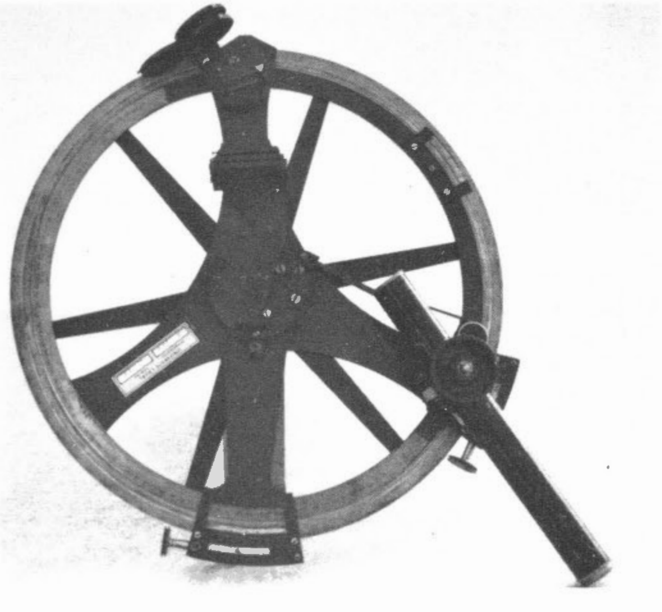

FIGURE 12
Sextant (undated) by Dolland of London.

During the same general period the Englishman Jesse Ramsden (1735-1800) became famous in another important branch of the instrument-making industry. He developed the first "dividing engine". Demand for his theodolites and other instruments became so great that he was impelled to devise a mechanical means of dividing the circle with precision. But it was not until 1775 that he produced a suitable working model. By the close of the 18th century the basic principles of instrument construction had been worked out and from that time forward it became more a matter of modifying instruments to meet special needs.

Ramsden, inspired by reports of an impending trigonometrical survey of Great Britain, took a long step forward toward the perfection of a portable, accurate transit theodolite. With the aid of a special lathe of his own contrivance Ramsden produced a hob for cutting the precision worm-wheel on a "dividing engine", as it came to be called. The latter machine consisted of a large, circular metal plate the circumference of which was very precisely marked off in degrees and half-degrees. The smaller circle of the instrument being constructed was placed in the centre of the machine. By the guidance of the marks on the circumference of the dividing engine, precise graduations of scale were then engraved, proportionately, on the smaller circle. This invention by Ramsden signalled the introduction in quantity of precision instruments designed for surveying work. Ramsden was awarded £615 by the Commissioners of Longitude for training men in the use of his device.

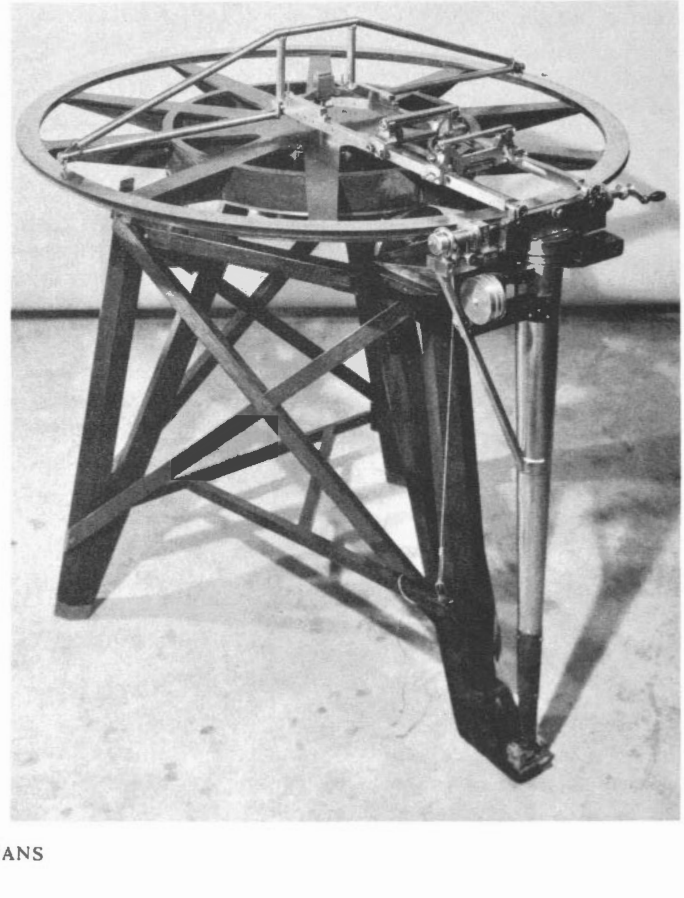

FIGURE 13
Ramsden dividing engine.

In the New World the art of graduation or calibration of instruments was further developed by a talented Philadelphian, William James Young, who built a "graduating engine" in the 1830s at a cost of $7,000 and many hours of exacting toil and tests by highly skilled workmen. This contrivance was a distinct improvement over the English apparatus in use in America up to that time. Another American instrument maker of importance during the same period was Richard Patten who described himself, with apparent justification, as the "only Manufacturer of Sextants and Quadrants in New York" (1813-1842) and who also claimed that all instruments of his making were "warranted, being divided on an engine after the Plan of Ramsdens."[7]

In 1826 William Simms in England invented the self-acting mechanism that made the dividing engine automatic in operation. The portable transit, designed especially for the use of land surveyors and civil engineers, was invented by W. J. Young in 1831 when he mounted a low-power telescope on standards over the dial of a surveyor's compass. In 1835 the first Solar Compass was made under Young's direction.[8]

In Canada, in February of 1791, John Collins, Deputy Surveyor General, advised the Land Committee of the colony that the government did not own any surveying instruments but that he and his deputy surveyors owned "good horizontal Theodolites". He listed his own instrument as being a product of Rowley. Six of these theodolites had been sent out from London in 1785 and were intended for surveyors at Gaspé, Chaleur Bay, St. Thomas, Detroit and Kingston. The sixth was retained for the son of John Collins. Four years later three more theodolites were acquired and an additional three instruments in 1791.

In 1794 a request was made to Governor Simcoe for a number of instruments for the use of the office of the Surveyor General of Upper Canada at Niagara. The list included a Gunter's chain, a theodolite, a "plain table", a perambulator, a pocket telescope, a circumferentor and a Hadley's sextant as well as compasses, spirit level, thermometers and barometers. In a letter from Elizabethtown dated June 22, 1814, deputy surveyor Robert McLean advised Surveyor General Ridout of Upper Canada that he had completed the construction of his own theodolite, a task commenced in 1812, as he could not purchase one that suited him. He found that its utility and accuracy exceeded his "utmost expectations". This theodolite may well have been the first such instrument built in what is now known as Ontario.

McLean also indicated that he was most anxious to obtain "a good magnet or loadstone" with the object of experimenting to determine longitude without reference to time or celestial observations. In asking that the Surveyor General try to supply such to him McLean expressed a profound truism, "You may perhaps consider me a visionary, and perhaps I am so, but important discoveries have been made by simple means, and sometimes by accident."[9]

Although the magnetic compass, as a land surveying instrument, was displaced in the course of time by the theodolite or transit in the interests of more precise measurements, it remained the mainstay of many land surveyors in Canada, particularly in the Atlantic provinces, for most of the 19th century. Its greatest usefulness was in original surveys on which accuracy was sacrificed to the need for speed and to the consideration of low cost. It was also useful in the resurvey of boundaries first laid out by reliance on the same instrument. One of its inherent weaknesses resulted from regional variations in magnetic declination. The need for checking the performance of compasses was widely recognized and laws were passed in many states of the American union, requiring each surveyor to test his compass periodically on some established meridian line.[10]

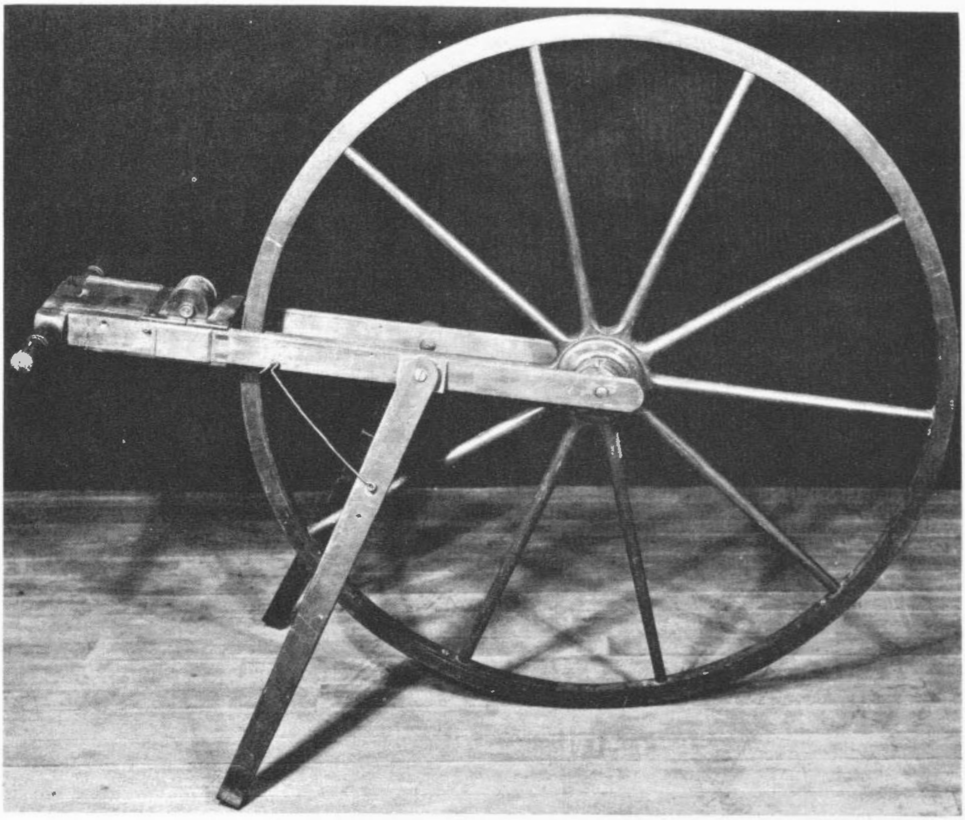

FIGURE 14. Odometer used by Sir William Logan.

For some years following Confederation there persisted among some surveyors and under certain conditions in this country the practice of roughly calculating distances by counting the number of paces, or number of wheel turns, required to cover same. A pedometer, a small instrument resembling a watch, could be worn on the person for the purpose of registering paces. A perambulator, attached to a wheel, served to record the number of wheel turns.

The historic surveyor's chain, less accurate in its functioning than the modern steel tape, was more easily damaged in the field and, when damaged, more difficult to repair. For historical review purposes two types of chains in common use should be kept in mind, namely, Surveyor's (or Gunter's) chain, and the Engineer's chain. Gunter's is 66 feet long and its use confined chiefly to land surveying on account of its simple relation to the acre and to the mile. The Engineer's chain was 100 feet long and divided into 100 links of one foot each. However, the link chain could not be used for highly refined measuring work. The 66-foot chain remains a definite measure of length, each of its 100 units being known as a link. Land surveyors, especially on township surveys in the West, generally preferred to use the link chain whereas in many modern surveying and engineering projects, such as highway and railway construction, a longer chain or tape, divided into feet, is preferred.

The use of steel tapes, because these are lighter, more compact and therefore more portable, produces savings in time and labor. Steel tapes also provide more accurate results in measurements made over rough ground, short of the use of special base-line equipment. Tapes, uniform in width and thickness, vary in length from 50 to 500 feet and are graduated in feet or links. In 1896 C. E. Guillaume discovered a nickel-steel alloy which was thereupon named "Invar". This substance had a very "low coefficient of thermal expansion" as scientists describe the response of metal to variations in temperature. When it was found possible to make long bands out of Invar the measurement of geodetic survey lines was revolutionized. Older forms of apparatus designed for the purpose became virtually obsolete.* The discovery of the new alloy was especially significant to Canadians carrying on basic or control measurements in this country where changes in temperature, sometimes both rapid and extensive, posed a problem through the expansion and contraction of instruments. In a 300-foot tape, for example, a drop from 120 degrees above zero to 20 degrees below zero, the total contraction would amount to 3 inches.

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*In 1883, Surveyor General Lindsay Russell reported, "The ordinary surveying chain was [being] replaced by a continuous steel band."

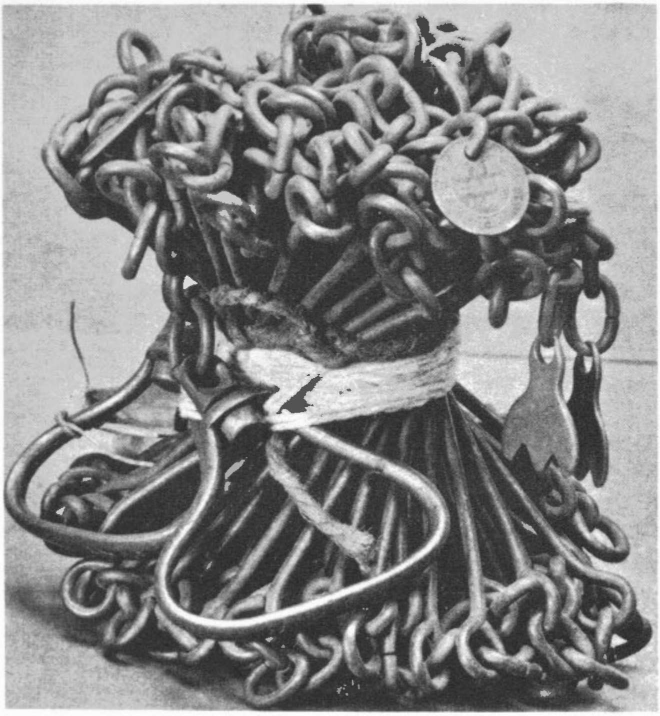


FIGURE 15
Gunter's chain.

The telescope, soon after its invention early in the 17th century, became one of the most important tools of the surveyor. By the employment of this instrument the properties of glass or lenses are used to obtain substantial magnification in the field of view of the telescope. The inclusion of cross hairs in this field of view and the mounting of the instrument on a circle were important steps forward in the practice of surveying. So far as most surveying work is concerned, light may be considered as travelling in a straight line, thus permitting the determination of directions in which the telescope is trained.[11] This is the basic principle of the transit theodolite and related instruments. The accuracy of the telescope is limited by the horizontal and vertical refraction of light. In precise surveying it is necessary to do angle work at night when refraction is at a minimum.

In the 17th century attachments for reading scales, for levelling, and for telescopic sighting gradually came into use in astronomy. The adaptation of these devices to surveying instruments was even slower.

FIGURE 16. Photo-alidade, used for measuring horizontal and vertical angles.

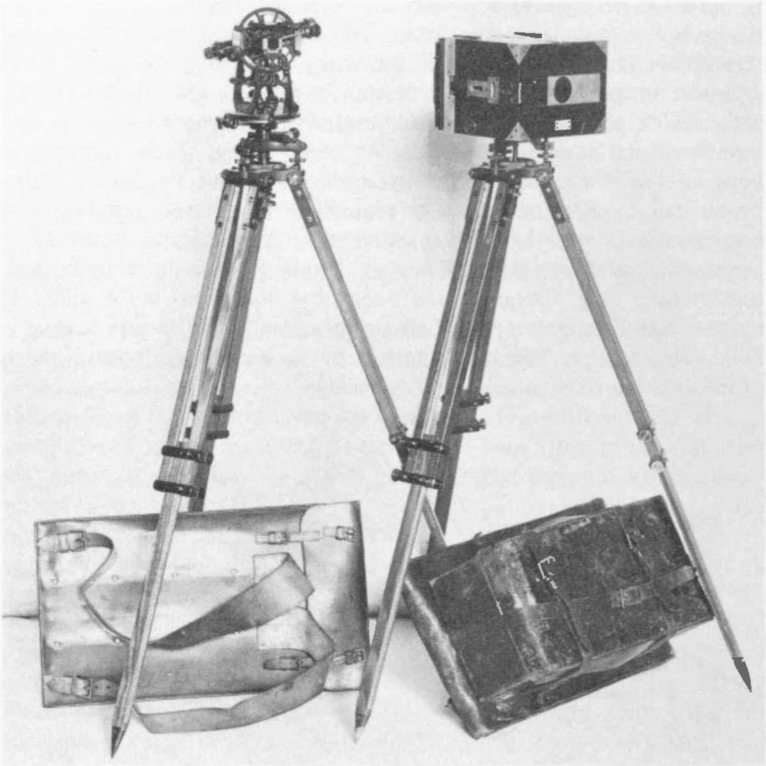
The instrument most commonly used by surveyors in the field is known alternatively as a transit or a theodolite. The perfectionist in linguistics would use the term "transit theodolite". In England, however, the term "theodolite" is favored in everyday parlance whereas "transit" is preferred in Canada and the United States. In any event a theodolite of the transit type is meant, the instrument being one on which a telescope can be turned or transited through a complete or nearly complete revolution about a horizontal axis attached to the telescope. With this instrument it becomes possible to project alignments, carry out triangulation operations, observe or lay out angles in horizontal or vertical planes, to estimate distances, establish grades, run levels and erect perpendiculars. Essentially the transit theodolite consists of three principal components: the levelling base, the graduated horizontal plate, and the alidade. The latter is essentially a telescope mounted on an upright standard and attached to a metal base used as a straight edge. The telescope can be rotated vertically and an arc permits reading of information from attached vernier scales.

In Canada, however, especially on government land surveys, English-made transits were more frequently used than those of American make. The Dominion land surveyor's Cooke instrument, manufactured by T. Cooke and Sons, Limited, was almost standard equipment for the field in Surveyor General Deville's organization. For the period between 1903 and 1910 the transits and other instruments manufactured by E. R. Watts and Son Limited of London, England were much favored by the Surveyor General. In fact, it was on Deville's suggestion that the Watts firm opened a branch office in Winnipeg about 1908. But in subsequent years departmental purchases from that firm dropped close to the vanishing point. The reasons for this decline were never clearly stated but much documentary evidence exists to justify the conclusion that the fall of the Watts firm from grace in Ottawa was due not so much to defects in their line of instruments as to influences of a personal nature affecting choices of equipment made by Deville.[12]

T. Cooke and Sons Limited, founded in 1840, and Troughton and Simms, both of London, England, were firms of prominence and excellent reputation in the instrument-making field. About 1922 these two rival companies merged to form Cooke, Troughton and Simms. In the mid-twenties of the present century there was a flurry of inventive activity in the world of scientific instruments, followed by the appearance of several new types of transits. In 1926 Cooke, Troughton and Simms produced the now well-known Tavistock theodolite, fitted with a glass circle, and by means of which optically meaned readings could be made to one second of accuracy. About the same time E. R. Watts and Son (Hilger and Watts) introduced the Microptic theodolite in several models, under licence from Zeiss to use their system. On the continent of Europe there were significant new developments also. Two types of improved transits appeared on the market. One was produced by Wild Heerbrugg Limited, Switzerland, the other by the Carl Zeiss firm of Jena, Germany. The introduction of the Wild and Zeiss transits provided the surveyor with brand new weapons with which to attack his field problems. No heavier than light mountain transits, their circles could be read to one second, a degree of exactness formerly associated only with large, heavy geodetic instruments.[13]

The story of the growth of the Wild firm is especially interesting. The principles governing the design of the Wild type of transit were conceived by Heinrich Wild (1877-1951) while he was serving with the Swiss Federal Survey. In 1908 he became associated with Carl Zeiss and in the following year devised a new, lighter and more

FIGURE 17
Mountain transit and camera.



stable type of tripod. It was this association of Wild with Zeiss that led to the appearance of the first Wild transit. This Zeiss-made instrument reached the market just prior to the outbreak of the First World War but was little known outside Germany until 1920. In the following year Wild, having established his own factory at Heerbrugg, Switzerland, began making the second model in the series of Wild transits.[14]

The Zeiss and Wild transits differed considerably in appearance from the then existing instruments in that category, as well as in the method of fineness of reading the horizontal and vertical circles. In the improved transits both circles could be read to the nearest second in a small micrometer microscope, placed slightly to one side of the eye-piece end of the telescope. The new Zeiss transit weighed only 7½ lb. and the Wild, 9½ lb., compared to the 13¼ lb. Dominion land surveyor's Cooke transit. The cost of the new instruments, laid down in Ottawa, was about $475 each. Although special efforts were directed to reducing weight, this advantage was achieved without lessening the strength or basic stability of the instrument.[15]

In Canada, John Leslie Rannie (1886-1954) Dominion topographical surveyor, of the Geodetic Survey of Canada became known as "the apostle of the optical theodolite". When Wild's new theodolite design first appeared on the market, Rannie supported it enthusiastically. At first only the T2 type of Wild transit was available and Rannie realized immediately that the small aperture of the telescope was the main reason why

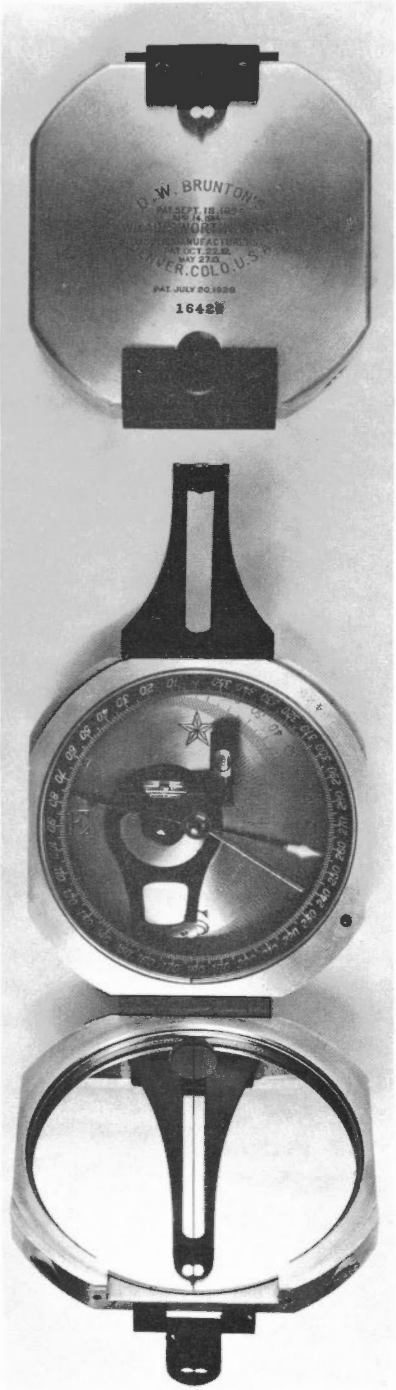


FIGURE 18
Brunton's pocket transit (compass), actual size. Above — closed; below — opened.

this lightweight transit could not replace the cumbersome first-order theodolites for very precise work. It was partly as a result of Rannie's suggestions that the T3 type was designed, incorporating a larger telescope. This precision theodolite for first-order triangulation came on the market in 1925. Other improvements were made later to this instrument as a result of investigations made by Rannie and his able co-worker W. Melbern Dennis. Curiously, the T1 model of theodolite did not come on the market until six years later.

Dr. Wild died on Christmas Eve, 1951. In his working lifetime he had played a critically important part in the development of three major precision instrument companies, Zeiss, Wild and Kern, a record unlikely ever to be equalled in this specialized field.

Some outstanding instrument-making firms in the United States were Young and Sons of Philadelphia, taken over in 1918 by Keuffel and Esser Company of Hoboken, New Jersey, and W. and L. E. Gurley of Troy, New York. W. F. Stanley and Company Limited of London, in addition to English firms already mentioned, was prominent in the instrument-making field in the period presently under review. At the time no firm in Canada was engaged in manufacturing transits but some well-known businesses in this country imported such instruments for surveyors, including James Foster of Toronto, Consolidated Optical Company Limited of the same city, and Hearn and Harrison of Montreal. With the approach of the Second World War experimental progress in the realm of survey instruments came to a temporary halt. But by then the modern transit had become firmly established as the paramount ally of all land surveyors. Its light weight, sturdiness, easy and rapid manipulation, convenience and simplicity combined to create an appeal unmatched by any other single item of surveying equipment.

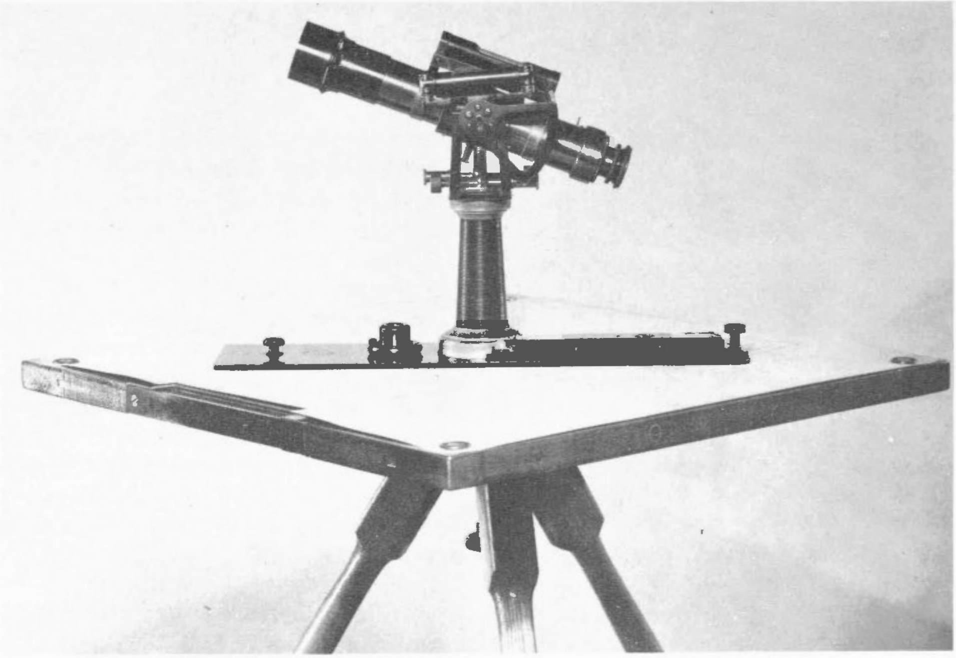


FIGURE 19. Boyd alidade and Johnston traverse plane table.

Levels of various types comprise another large and important area of instrumentation in the practice of surveying. Levels are employed to provide differences of elevation either directly, as in the case of the surveyor's level, or by utilizing differences in atmospheric pressures as in the case of the barometer or boiling point thermometer (hypsometer) or by slope measurements as in the case of clinometers and other types of vertical angulation, or where the distance in the stadia, slope or horizontal is determined.

In the earliest stages of the development of the level the plumb bob was enclosed in a wooden box to protect it from disturbance by wind. Also more accurate sights were constructed using the thread of a silkworm. Two important additional steps were required in order to form a basis for subsequent refinements of the level, namely the provision of a bubble tube and a telescopic sight. The former invention is attributed to two citizens of France, Thevenot and Chapotot, in the 1660s. Henry Wilson, in *Surveying Improved*, published in 1731, describes this instrument as a level tube filled with a liquid with open sights of equal height at each end and with proper screws for adjustment purposes. The use of the telescopic sight in this connection is attributed to Gascoign who, it is claimed, placed spider webs in the focus of the telescope attached to his surveying instruments as early as 1640. Picard, another French surveyor of distinction, applied the telescope to angle measuring and to levelling instruments in 1669. The wye level is said to have originated with Jonathan Sissons of London in 1740. In levelling operations work generally begins at a permanently fixed point whose elevation above some datum plane is known. Such a point is called a bench mark.

Barometers, including aneroids, and hypsometers are utilized for direct measurement of elevations above some standard such as mean sea level. Aneroid barometers (altimeters) are also used in aeroplanes for determination of the height at which they are flying and in the case of air survey work, recording the altitude at which photographic plates are exposed. Following the Second World War the statoscope, a new aviation instrument, came into wide use. By this device it became possible in flight to measure precisely differences in elevation between successive plate exposures. Generally barometers are used for topographical and reconnaissance work on a small scale, when precision in altitude determination is not essential. The hypsometer, a relatively coarse instrument, used mainly in exploratory survey work, has been displaced by the aneroid which has equal portability and accuracy, and dispenses with the need to boil water.

There are two types of surveyor's level in general use, the dumpy and the wye level. The functioning of all levels depends in essence on an ordinary level tube containing an air or vapour bubble in a suitable liquid. Under the influence of gravity the bubble will always rise to the highest part of the tube and come to rest, so that a plane, tangent to the inner surface of the tube at the highest point of the bubble, defines a horizontal plane. The basic difference between the dumpy and wye levels is that in the former the telescope and bubble tube are rigidly attached to the instrument, whereas in the wye these are independent of other parts of the instrument and may be lifted from their supports and turned end to end.

In this chapter consideration has been given to the progressive development from earliest times of instruments useful to the surveyor and mapper. The transformation over the centuries of primitive measuring tools into precision equipment has been gradual for the most part. But even the most impressive of the periods of advance prior to the Second World War was overshadowed by what took place in this field after that conflict. By combining photographic and electronic equipment with various types of

FIGURE 20. Tellurometer in use.

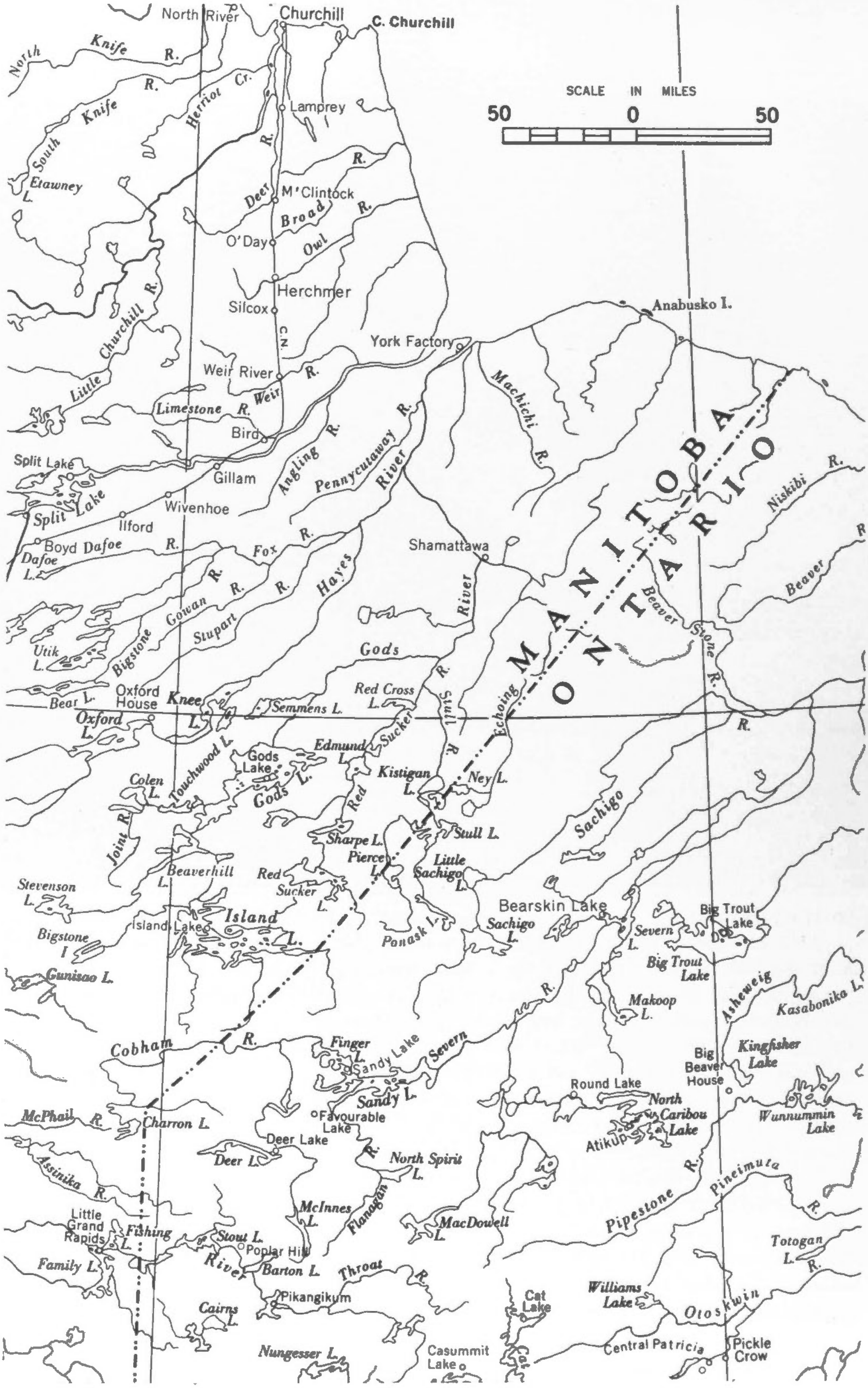
existing instrumentation, along with rapid and far-reaching developments in aviation, giant forward strides resulted in the surveying and mapping, efficiently and swiftly, of large geographical areas. Tellurometers, airborne profile recorders, the use of radar in electronic distance measurement, refinements in the airborne survey camera as well as surveys made from satellites in outer space orbits, are only some of the phenomenal new devices and systems that have brought about a profoundly absorbing revolution in the production of new surveying instruments and of special techniques involved in their uses.

3

THE ONTARIO-MANITOBA BOUNDARY: COMPLETION SURVEYS

In terms of historical background and physical achievement the establishment of the Ontario-Manitoba boundary on the ground, following its definition in law, provides one of the liveliest episodes in the annals of Canadian surveying. Indeed the narrowness of the closure on the Hudson Bay terminal point of the boundary, across 168 miles of largely unmapped wilderness, remains as a remarkable accomplishment in land surveys generally. Highlights of the extended and, at times, violent argument over the location of the border have been described in a chapter of Volume Two of this work, along with an account of the initial (Stewart-Saunders) survey, completed in 1897 and covering 58 miles.

No additional boundary surveys were made along the Ontario-Manitoba line until after the First World War but in the interval some significant statutory steps were taken, paving the way for new developments in the field. In 1912 Parliament at Ottawa passed two boundary extension acts, one applying to Manitoba (2 Geo. V, ch. 32), the other to Ontario (2 Geo. V, ch. 40). Under this legislation and with the consent of the two provinces concerned, large areas of Dominion lands were added to their respective territories. The boundary line separating these vast additions was defined as a due north extension of the existing boundary up to the 12th base line of the Dominion Lands Survey System, proceeding in a straight line to the most easterly point of Island Lake, from thence in a straight line to the intersection of the 89th meridian with the southern coast of Hudson Bay. Though defined definitely enough on paper, nothing existed in the form of markings on the ground, up to the end of the First World War, to indicate the location of this 550-mile-long border extension. Nor did there appear to be any pressing need for its physical demarcation until a post-war upsurge in mining activity took place in the vicinity of the boundary to the east of Lake Winnipeg.



MAP 1. Part of Ontario-Manitoba boundary, including portion from Island Lake to Hudson Bay.

Early in 1921 interprovincial boundary commissioners were appointed by the governments at Ottawa and Toronto respectively, Manitoba having declined to join in the survey project or to pay any part of its cost. Surveyor General E. Deville acted for Canada, and Director of Surveys Louis Valentine Rorke (1866-1943) for Ontario, each jurisdiction undertaking to absorb one-half of the total expenditure involved in the survey.[1] Incidentally, Rorke, a graduate of the School of Practical Science, University of Toronto, served his articles with Elihu Stewart who had been associated with Saunders on the initial survey of the boundary. By 1891 Rorke was a Dominion land surveyor and an Ontario land surveyor. He became Director of Surveys, Ontario, in 1917 and eleven years later, Surveyor General of the province, a position he held until his retirement in 1936. He served as president of the Ontario Land Surveyors Association in 1925.

The first step was to select a survey party chief. It was considered essential that the person to be placed in charge of operations on the ground should be qualified as a Dominion and provincial land surveyor. John Wesley Pierce (1885-1949) of Peterborough was named chief of party. Appointed with him as his assistants were Robert Douglas Davidson (1892-1960) and John Carroll (1888-   ) of Ottawa. The name of J. W. Pierce is an outstanding one in Canadian surveying and mapping. His high reputation is closely linked to the Ontario-Manitoba boundary surveys between 1921

FIGURE 21
Cedar post (1897) Monument 1. Initial point of Ontario-Manitoba boundary, marking North West Angle, Lake of the Woods.

and 1937, and to a point within 168 miles of Hudson Bay. A deep disappointment to him was his inability, due to ill-health, to assume charge of the final leg of this important survey, a section undertaken in 1947. His regrets were mitigated by the participation of his son John in this concluding survey operation. The ultimate highly successful closure with the shore of the Bay on the point established there by C. H. Ney in 1930, was due in large measure to Pierce's careful work and sound survey knowledge and mastery of its techniques. Born in Eaton Corner, Quebec, Pierce senior graduated from the University of Toronto in 1906 and three years later was commissioned both as a Dominion land surveyor and an Ontario land surveyor. His early practical training was with Ontario land surveyors J. W. Fitzgerald of Peterborough and Alexander Niven of Haliburton. In 1920 he was commissioned a Manitoba land surveyor, just one year after he had joined the federal Topographical Surveys Branch, Department of the Interior. From 1932 to 1949 he was engaged in private practice in Peterborough and became an ardent student of the history of that area. His son, John Gourlay Pierce, an Ontario land surveyor of distinction, has carried on in the fine professional tradition of the father, as senior member of the firm of Pierce and Pierce of that city.

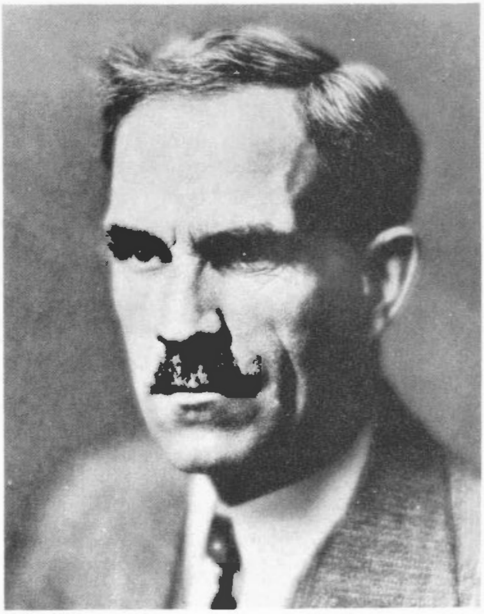


FIGURE 22. J. W. Pierce.

By 1929 Manitoba became a party to the interprovincial boundary survey and the continuance of J. W. Pierce as chief of party in the field was concurred in by that province. In 1932 the federal government transferred to Manitoba the control of that province's natural resources, and Pierce continued as field chief under the direction and authority of the Ontario and Manitoba governments. From 1924 he was closely associated with aerial mapping operations in Canada. Pierce trained and directed Ontario land survey parties which helped to map Muskoka and Lake Nipissing districts. This distinguished Canadian served as president of the Association of Dominion Land Surveyors in 1928 and of the Association of Ontario Land Surveyors in 1932.

Instructions authorizing the survey of what became known as the meridian section of the boundary, covering 180 miles due north of the Winnipeg River as far as the 12th base line, roughly parallel to the eastern coast of Lake Winnipeg, were issued on March 7, 1921. The need to forward supplies and equipment to bases in the field for use during the ensuing season was early realized and some ten tons of freight of this sort were hauled on snow-covered roads by horses, and by dog teams over trails to Gold Lake and Wallace Lake in mid-March. During afternoons snow became so soft that dogs could not work and so packing had to be done in early forenoons and late evenings while frost conditions prevailed.[2]

A survey party of twenty-four was engaged in Winnipeg and on June 2 proceeded by train to Pointe du Bois, Manitoba. In addition to the party chief and his two surveyor assistants the task force consisted of a chainman, instrument man, leveller, mounder, picketman, three rodmen, seven axemen, a head packer and three canoeman-packers as well as two cooks. The duties of the party members were interchanged a good deal as special conditions were encountered in the course of the survey.

Surveys in the field commenced on June 6, starting at the monument on the south side of Winnipeg River that marked the terminal point of the 1897 boundary survey. The marker was in such poor condition that it had to be replaced by a standard concrete monument later on. The original boundary line, although visible, had been so overgrown that it was necessary to clear it for some distance back from the river to obtain a direction by which the line could be produced northward.

The arduous physical labor involved in this type of field work demanded men of a type no longer readily available. They had to be adept in the use of the canoe and tump line; skilled in the use of an axe; willing to separate themselves from hearth and home for an entire season; content to live on summer provisions cached from the previous winter; and preferably possessed of survey experience. Natives of the area, with their more intimate knowledge of the region to be surveyed, were most suited to these requirements but seldom could be induced to remain on the project for the full season.

R. D. Davidson, senior assistant to Pierce, was responsible for line production, azimuth and magnetic observations, and triangulation work. John Carroll had responsibility for precise chaining operations, marking of monuments and the recording of topographical data. Later in these boundary surveys Richard Dore carried on with the supervision of chaining. J. W. Pierce wrote later in considerable detail on problems confronted during this phase of the work:

"The effect of changes in temperature results in appreciable differences in the length of any long course, when measured by a steel chain. The Invar tape has been designed to remedy this but it will not stand the usage to which the chain is ordinarily subjected in bush or northern surveys. On ordinary surveys it is now customary to determine the temperature with a pocket thermometer and a correction is applied to the measurement. As the chain is seldom of a constant temperature throughout, and is continually passing through the sun, over rocks, in the shade, or through water, the correction becomes a most uncertain quantity. The method used through the boundary survey was to determine the temperature of the chain at each successive measurement and to calculate the correction from the coefficient of steel tapes . . . Ordinary thermometers were used for this purpose the first season but it was found that the temperature corrections were not in keeping with the general accuracy of the other details of the chaining and that some different form of thermometer that would record more closely the temperature of the chain would be required.

"On Mr. Way of the Surveys Laboratory [Ottawa] being approached, he suggested a modification of the type used by the Geodetic Survey. This consisted of a trough thermometer with a broad flat bulb, so arranged that the thermometer was clipped on to the chain and the . . . bulb held in intimate contact with the chain . . . With the discontinuance of the use of the old link chain and its ever changing length, chains now in general use are not subject to appreciable variation between the absolute length and that of the official standard of measure. Where, however, the course is of great length, any discrepancy is multiplied with each measurement and is cumulative in effect. In order to counteract this result, a chain of the same size and weight, whose length had previously been determined at Ottawa, was taken to the field as a standard of measure. By comparing this at intervals with the field chain, a correction, that was found to alter somewhat through the season, was deduced and applied to all measurements."[3]

The means of transport in the field consisted of four freight canoes, three smaller canoes and an outboard motor. The summer season was chosen for field work in preference to the winter for reasons peculiar to Canada. The summer season is customarily a month longer, the amount of equipment needed is much less in warm weather. Sand, gravel, and stone for monuments and mounds are, as a rule, readily available in summer.

October 14, 1921, was the last day in the field before the survey party returned to Winnipeg. During the season a stadia tie line connection was made between the line where it crossed Garner Lake and a marked post in a stone mound on an island near the south end of Beresford Lake. This monument had been erected in 1919 by the Dominion land surveyor Bruce W. Waugh. The most serious accident that happened during the season occurred when a tree near the survey line was dislodged by wind and fell suddenly on the surveyor in charge. He did not recover consciousness for twenty hours. When he reached the city three weeks later it was discovered that his collar bone had been fractured and two ribs splintered. So effective, however, had been the rude but prompt attention accorded the patient in the field that no additional medical treatment was required.[4]

Unused provisions of flour, meat, sugar, tobacco and a full line of groceries were cached in a cabin built for the purpose at the north end of Carroll Lake and left under guard for use in the following field season. Tangible results of 1921 operations included the surveying of a total of 69 miles of boundary line running from Winnipeg River to headwaters of Bloodvein River; the erection of 752 permanent monuments and a traverse of 385 miles of shoreline of water areas.

For the 1922 field season some ten tons of provisions and of outfitting were forwarded in mid-winter to the mouth of the Berens River by way of frozen Lake Winnipeg. Continual winds commonly pack snow so firmly that the surface of lake ice becomes almost impassable to traffic. Accordingly a snow plough was propelled by horses operating behind it. The plough was closely trailed by the freighting teams. As a rule the laboriously opened roadway was completely filled in within a half an hour after passage of the loads. Near the end of February, R. D. Davidson, assisted by three men and using a dog team, reached Little Grand Rapids, slightly north of 52 degrees north latitude, on his probe of investigation. All this advance organization and exploration was designed to permit the expenditure on effective survey tasks of every hour of working time available during the short summer season. It was necessary, in fact, to maintain progress at the rate of at least one mile per day every working day, regardless

FIGURE 23. J. W. Pierce's survey party, Berens River, autumn of 1922.

of weather, in order to reach the 12th base line by the latest date in October that would permit return to civilization by open water.

Arrangements were made with the Canadian Air Force for their cooperation during the 1922 season so that the line and the areas adjoining it would be photographed from the air and so that mail might be delivered occasionally to field camps. It was shortly after completion of the evening meal in camp on July 3, 1922, at Clayton Lake, Manitoba, that a hydroplane was heard and seen approaching from the south. Dense columns of smoke were produced at the camp site to attract the pilot's attention. The plane landed on the nearby lake carrying Controller of Surveys A. M. Narraway of Ottawa and a load of mail on board. Narraway remained with the survey party for four days.

The 12th base line was reached on October 6. Members of the survey returned to Selkirk and were discharged there on October 23. The 111 miles of boundary line surveyed during the 1922 season, added to the 69 miles of the previous season, brought the total mileage surveyed to 180. This total, of course, was in addition to the initial 58 miles surveyed in 1897 by Stewart and Saunders. A total of 86 monuments was erected in the 1922 season and more than 100 magnetic and astronomic observations made.

The third leg of the resumed surveys of the boundary was not undertaken until the field season of 1929. The program consisted of surveying a trial line from the 12th base line to Island Lake. J. W. Pierce was again in charge. The direction of this line depended upon a precise astronomic observation at the most easterly point of the lake. By this time, in addition to Surveyor General Rorke for Ontario, the commissioners for this boundary survey were G. A. Warrington for Manitoba and Surveyor General Frederic Hatheway Peters for Canada. In view of the impending transfer to Manitoba of its natural resources the government of that province had decided to join the Dominion and Ontario in authorizing the boundary line survey.

On June 4, 1929, J. W. Pierce and Cecil Herman 'Marsh' Ney (1889-) left Selkirk on the first boat of the season bound for Norway House at the north end of Lake Winnipeg and a point slightly north of 54 degrees north latitude. Ney, after leaving Pierce to proceed separately, reached Island Lake on June 11 in a Royal Canadian Air Force Vickers Viking plane.

FIGURE 24. Boundary surveyors, Palsen River, 1929.

Ney, born at Bradford, north of Toronto, received his early education in Aurora, graduating in civil engineering from the University of Toronto in 1916. At university, where L. B. Stewart was one of his professors, Ney specialized in geodesy and astronomy because of a natural flair for precision measurements. In summer seasons, between university terms, he went on federal survey parties as an articled student, serving with Dominion land surveyors Wilbert Henry Norrish and Guy Houghton Blanchet (1884-1966) in Saskatchewan and Manitoba respectively. Following his graduation from university Ney enlisted in the Royal Flying Corps and went overseas. Within five days of his demobilization in 1919 Ney was on staff with the Geodetic Survey of Canada. In 1946 he was awarded the Order of the British Empire (Civil Division).

FIGURE 25. C. H. "Marsh" Ney.

Ney's own account of his procedure in establishing Point "A" at Island Lake is of special interest. After carefully making a trial selection of the point he built a concrete pier on a rocky outcrop about 300 feet away as a base for his astronomic telescope.

"A value of the longitude was made on each of three nights, taking time sets of about 12 or 14 stars observed both direct and reversed by means of the travelling transit micrometer. Radio time signals for Greenwich time were received . . . from the Washington Naval Observatory, Arlington, using the vernier clock system of reception . . . The latitude was determined by Talcott's method, taking pairs of stars transitting north and south of the zenith . . ."[5] The observation pier was connected to a post planted at Point "A" the target at which Pierce, nearly 90 miles away, was to aim.

Pierce had a much less comfortable and expeditious journey than Ney from Lake Winnipeg to Island Lake. It took him 17 days to cover about 120 miles, made difficult by 44 portages. It was a route which, up to that time, had been travelled only by Indians. The survey from just south of Elliot Lake began on June 26. Transportation along this section of the line was aided by reliance on an air map of the district, a rarity in those days. As a result very little exploration for routes was required and the movement of men and materials could be planned well in advance of the event. On September 6, 1929, the trial survey line across 87½ miles closed within 5.1 feet of Ney's post at Point "A".[6]

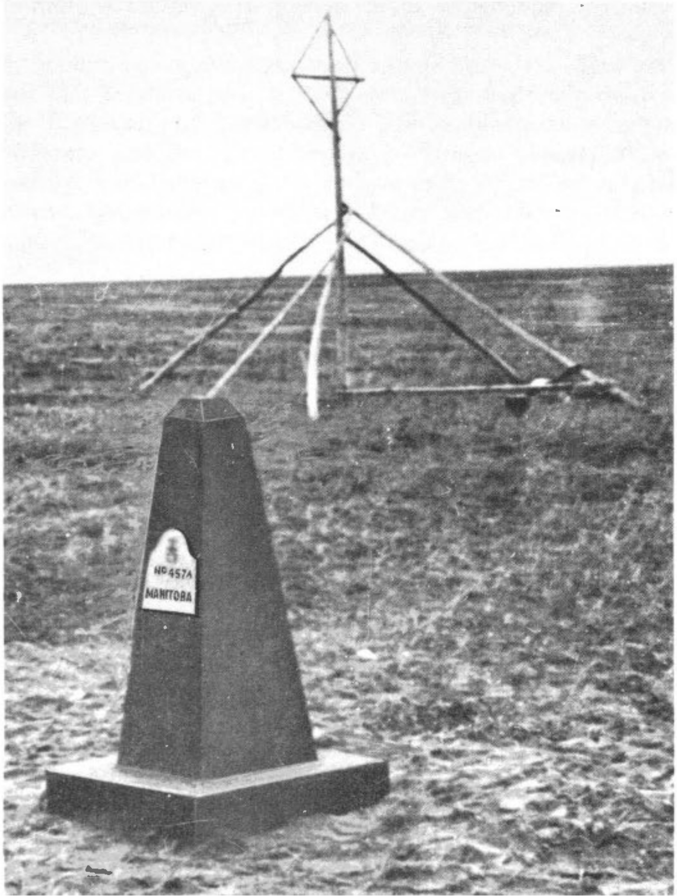


FIGURE 26
Boundary monument at Hudson Bay terminus; 1948 trial line with wooden target marking Ney's 1930 monument.

Chief of party Pierce has provided an illuminating comment on the survey work of that season:

"After computations we found that Island Lake was about 13 miles north of where it was shown on the map . . . and as a result of that error the area of Manitoba was 3,000 to 4,000 square miles less than shown on maps and the province of Ontario was correspondingly greater . . . Very soon there were [newspaper] headlines about "Ontario steals three or four thousand square miles from Manitoba" . . . The premier of Manitoba wanted to know what it was all about. When I came into his office the Surveyor General left the explanation to me. I was worried about what I would say, but after a little consideration it appeared that this was one of the finest examples of the need of accurate maps in Canada. . . ."[7]

As a preliminary step in the surveying of the Ontario-Manitoba boundary line from Island Lake to Hudson Bay, the last leg of the project, it was necessary first to determine the terminal point of survey on the southern shore of the Bay. This involved the establishment of two intermediate points along the proposed line of survey. Ney began his search by air for the first intermediate point on June 16, 1930. With the pilot, J. C. Uhlman, accompanied by an air mechanic and with Ney acting as navigator, the plane ventured over the unmapped territory of northeastern Manitoba. The first intermediate point was established near Black Duck Lake and the second, in mid-July, was established just north of Sturgeon Lake, Ontario.

To reach his destination on Hudson Bay in the absence of air transportation, Ney canoed down Nelson River to Port Nelson where he was storm-bound for several days. He did not reach York Factory until August 1. Ney has recounted that "in trying to make an entrance to York Factory we became stranded in the mud flats, three or four miles from shore. Not being able to go on for another 8 or 10 hours [waiting for the incoming tide] we set up our cots and had a good sleep on the bottom of Hudson Bay . . ."[8]

On August 2, 1930, very early in the morning, a start was made in two canoes on a hazardous 160-mile trip down the coast. Five days later it was estimated that the objective, the 89th meridian of west longitude, had been reached. Ney reported "we tried again that night and a preliminary observation showed us that we were one mile from the boundary terminal position." Difficulties of such a trip impelled Ney to comment that "travel on the west coast of Hudson Bay is a strenuous undertaking even in good weather . . . Due to the low elevation of the immediate coast, it is often impossible in hazy weather to see the shore at this distance. Consequently when travelling with outboard motors it is advisable to run entirely on compass bearings. A day's journey . . . cannot be ended at will. Until the tide comes in about eleven and a half hours from the time of high water, the traveller must stick to his ship in fair weather or foul. It is for this reason that travel in small craft is not considered extremely safe along this coast. Should a sudden storm blow up, so bad as to threaten disaster, a landing can usually be made through the surf, although boats and cargoes are generally sacrificed."[9]

On landing Ney made numerous observations for latitude and longitude and a concrete monument was built to mark the meridian intersection with the shore of the Bay. As an aid in locating the monument a 15-foot beacon was erected. The position of the monument was calculated to be 56°50′26″.73 latitude and 88°59′59″.10 longitude. The final legally-established terminal, based on a survey of the trial line 18 years later, was only 15.8 feet away, so close that the commissioners recommended that the line be adopted as the true boundary.

FIGURE 27. Ney's party stranded on Hudson Bay flats awaiting tide, 1930.

Work in 1930 on the leg to Island Lake, commenced the year before, was confined to final monumenting and levelling of the trial line, it having been accepted as the true boundary. A total of 76 intervisible monuments were erected in this connection. In 1932 there was a retracement survey of the 1897 line, carried out by J. W. Pierce (Canada), L. V. Rorke (Ontario) and Samuel Ebenezer McColl (Manitoba). The original line had been clearly enough marked to permit the restoration of all but two of the 82 monuments placed along its 58 miles, thirty-five years previously. Survey work on the most northerly leg of the boundary was not resumed until the 1937 field season, carrying the line from Island Lake to Echoing River, a distance of 114 miles. Pierce was accompanied on this stage of the work by Manitoba (and Dominion) land surveyor Edward Gauer, functioning as first assistant.

In the eight years following the survey of the Ontario-Manitoba boundary line to Island Lake the use of planes for the transport of men and supplies on field surveys had greatly increased. The decision to use aircraft on the 1937 survey was based on the strong recommendation of the commissioner S. E. McColl, at the time Director of

FIGURE 28
Monument 82, on south bank of Winnipeg River, erected at point of beginning of 1932 retracement survey.

Surveys for Manitoba. Under his direction base and meridian lines in the Island Lake and Gods Lake regions had been surveyed in winter. Through the employment of planes the camps had been made more comfortable and diets more normal.

The initial group of field-party members was flown to Island Lake on January 4, 1937, and four days later the survey operation commenced. By March 20 all work had been completed. On that day the party ate lunch in camp and dinner in Winnipeg, 350 miles distant. During that season a total of 61 monuments was erected.

Ten years later work on the final 168 miles of boundary line was undertaken and completed in a single season. According to one experienced Manitoba surveyor, March has always been an outstanding month for progress on northern surveys in that province. Some measure of credit for this performance record has been given to the lowly muskrat. It appears that the willingness of axemen to put their maximum effort into each day's cutting was linked to the availability of this small creature of the wilds. The open season for muskrat in Manitoba was usually the month of April and the men were invariably anxious to complete the survey work in time to permit them to go trapping.[10]

The work during the 1947-48 season was carried on under Gauer's direction. His first assistant was John G. Pierce, son of the man who had been prominently identified for so many years with this boundary survey project. Since no suitable landing places existed between Echoing River and Sturgeon Lake dog teams were used for haulage instead of planes, at least for a time. H. E. Beresford, Director of Surveys (Manitoba) and Surveyor General F. W. Beatty (Ontario) visited the field party in March in their capacity as commissioners. Henry Edward Maskew Beresford, who had succeeded S. E. McColl as Director of Surveys, Manitoba, was a younger brother of Herbert Graham Beresford, whose warnings of 1920 led to a resumption of boundary surveys in the following year. H. G. Beresford, who was both a Dominion and Manitoba land surveyor, served for a term in the Manitoba legislature as member for Rupert's Land. He died in 1938.

FIGURE 29. H. E. Beresford.

FIGURE 30
Edward Gauer at Monument 327, Manitoba-Ontario boundary survey, 1937.

FIGURE 31
John G. Pierce at boundary terminal monument, Hudson Bay, 1948.

Line cutting on the last leg began on December 24, 1947, and was completed at Hudson Bay, Mile 282, on April 6, 1948. In this concluding stage of the boundary survey Bruce W. Waugh, as Surveyor General, Ottawa, served as federal commissioner on the project.

John G. Pierce has described his sensations on participating in the highly precise closure on Ney's monument at the terminal point.

"Ney had erected a substantial wooden beacon," Pierce reported afterward, "over a concrete monument on the shores of Hudson Bay and it was indeed a thrill to see that beacon through the telescope of my transit while still about four miles inland."

Although dog teams proved most useful under special conditions, aircraft continued to play a key part in the final stage of field operations. A total of 34,070 miles were flown on 468 flights in connection with the project and 157,045 pounds of freight were hauled at a total estimated cost for all these air services of $16,775.00.

FIGURE 32. Transportation by dog team and aircraft, Ontario-Manitoba boundary survey, 1947-48.

Thus ended a 607½-mile-long survey that had spanned half a century, beginning in the era of toll gates and ending in the age of the aeroplane. The work of surveyors had served to substitute certainty for vagueness and doubt, had established clear fields for the provincial jurisdictions involved, and had thereby helped in an important way to promote interprovincial amity and cooperation. But again it should be pointed out that one of the most gratifying features of the entire undertaking, from a technical point of view, was the closure to within less than 16 feet on the terminal point, a feat achieved by surveyors who had commenced their line 282 miles away. Early in 1950 the three government entities concerned, having formally agreed upon the surveyed line as the true boundary, authorized the monumenting of the last span of the project and this task was carried out and completed during the summer of that year.[11]

4

MAP PRODUCTION AND REPRODUCTION

> *"He does smile his face into more lines than in the new map . . ."*
>
> —*Twelfth Night;* Act 3, Sc. 2.

The caveman's first awkward efforts to portray the locality in which he lived by carving on the walls of his abode or on clay tablets led step by faltering step through the ages to the colorful, complex, mass-produced paper maps of the mid-20th century. The achievement of map portability marked the first important forward stride in the art of cartography. This improvement was accomplished by the production of drawings on animal skins and, in ancient Egypt, by the discovery that the papyrus plant, found along the banks of the Nile, could be processed into sheets capable of carrying cartographic and other inscriptions. By 500 B.C. parchments were being produced from the skins of sheep and calves. Calf skin produced the better writing surface and became known as *vellum*. This material was much more durable than papyrus and became widely used as a medium for map making in the Middle Ages. Juan de Cosa's chart of the world, produced about 1500, was drawn on oxhide. Its appearance marked the beginning of a long series of maps illustrating discoveries made in the New World.

Improvements in map-making materials and in map-multiplying processes were inevitable in the face of increasing needs for the extension of man's knowledge of the earth. Long before the availability of such materials in the western world, paper (a word probably derived from papyrus) was in use in China. It appeared in the central part of that country about the end of the first century following the birth of Christ and by the fifth century paper had become the general medium for written documents in that part of the world. The introduction of paper making to Italy in the 13th century, followed by the advent of the printing press and the invention of moveable type in the 15th century, provided a tremendous impetus to the production of books, including elaborate folio editions of Ptolemy's *Geographia.*

The discovery of paper making heralded the approach of a solution of the materials problem, and the subsequent appearance of the printing press revolutionized methods of map reproduction. From the genesis of the printing process until fairly recent times maps required in quantity were reproduced from copper engravings. The acceptance of this engraving process and the production of impressions on paper marked the beginnings of a cartographic renaissance. This skilful art was developed by Italian goldsmiths, trained in engraving designs on goblets and tableware. In their work they used a greasy ink. By rubbing this substance into incisions they were able to press an image to paper. It was a natural step for them to begin engraving maps on flat sheets of copper and then to produce impressions on paper. The combined dexterity of hand and eye as well as the infinite patience required to engrave a map in this manner represent attainments almost beyond our comprehension today. All work on the engraved plate was reverse reading and all colors had to be added by hand on each printed copy. Two centuries were to elapse before the application of coloring in this laborious manner was abandoned in favor of an improved process. In the meanwhile the coloring of maps had become an independent trade within the map-making industry. By the middle of the 16th century this trade was recognized by artist's guilds and it was one followed, in his earlier years, by Ortelius.[1] Despite the advantageous introduction of metal in map making many maps were still being drawn on paper, others appeared on skins and yet others, such as the Waldseemüller map of 1507, were produced from wood engravings.

By the end of the 16th century conventional map symbols began to appear. These signs included church steeples representing villages, double lines signifying roads, and crossed swords marking battlefields of special importance. It is believed by many scholars that the coloring of map features originated with the Romans. In the early centuries of the Christian era topical maps were designed for specific purposes such as illustrating estates and depicting routes of pilgrims, and various locations with place names provided. These maps were beautifully drawn on parchment in many instances and often adorned by illuminated text. At any rate the coloring of geographical features "according to the nature of it" may be found in mediaeval maps of all sorts. Water appears in blue, roofs of dwellings in tile red, trees in green, and roads in brown. Vertical shading and the representation of mountains in plan came into practice about 1680. This new trend marked an advance of historic importance, enabling cartographers to show for the first time the length and breadth of a mountain range as well as to give indications of gradients.[2]

W. J. Blaeu (1571-1638), the noted Amsterdam printer and map maker of the 17th century, constructed a press that eliminated much of the back-breaking toil required to print a copperplate impression. Nearly two centuries later the German, Alois Senefelder (1771-1834), provided the map maker with a greatly improved method of reproducing his product. Senefelder began to experiment with copper etching in an effort to reduce the costs of printing. This process involved lettering in reverse with a scribing point which cut through a waxy acid coating on the copper. Because Senefelder made numerous errors in etching he concocted a correcting ink or medium composed of wax, soap and lampblack. This composition was formed by him into sticks and, when required, he rubbed the sticks in water and made a mixture which he applied by brush.

Senefelder also found it too expensive to practice reverse lettering in copper and, seeking a substitute surface, he discovered a highly polished floor tile of Kellheimer sandstone produced in nearby Bavarian mines. By chance he wrote a laundry list for his mother on a clean stone, using his correcting ink stick. Before cleaning the stone he poured acid over the surface and the result was a raised image of the lettering, capable of being printed. Employing a thin, gum-coated paper he lettered right reading with his correcting ink stick, wetting the finished work and rubbing its face down onto a new stone, thus transferring it to a greasy reverse image that could be etched. He observed, when wetting the work, that water adhered only to inked letters. This observation marked the birth of lithography. The next step was to transfer an image to a new stone and treat it with a mild acidulated gum solution that would not lower the non-image surface. He found that, if the stone were kept moist, greasy ink applied with a roller would adhere only to the image area and from this a reproduction on paper could be made.[3]

This new technique, based on the principle that generally grease and water will not mix effectively, developed rapidly and by 1845 lithographic prints in color had appeared in many countries. Lithography provided map makers with many advantages and, in fact, brought about a technical revolution that profoundly influenced map production and reproduction. It placed at the printer's disposal a mechanical process for reproducing flat or even transparent colors and eliminated an immense amount of manual labor involved in applying colors separately to each map sheet. Quantity printing of maps in color with good registration became speedier and less expensive. Uniformity of product was also assured. The benefits of this historic advance transformed the representation of relief in cartography, increasing flexibility and the power of visual suggestion. Colored hill-shading in brown was first added in 1858 to the Ordnance Survey (United Kingdom) one-inch map.[4] Soon after, line engravings were being color separated.

Although maps and charts continued to be engraved on copper these plates were transferred to lithographic stones for printing. The new technique gave rise to a different breed of map makers. At the beginning of the 20th century these were mainly lithographic draughtsmen who drew maps directly on stone, pulling transfers from one stone to another to provide color keys. Copper engraving work for map reproduction purposes continued in use well into the first quarter of the 20th century but by the 1920s the pen and ink drawing method had become standard practice in this field. The introduction of typography in the realm of map nomenclature was a natural forward step and by 1925 preprinted lettering was being used in most maps.

During the period when lithography was coming into wider use a new art, photography, began to exert an increasingly important influence upon cartography. Photography, in fact, may well be regarded as the handmaiden of modern cartography for it provided many benefits in the processes of map reproduction. As photographic coatings and chemical processes improved, glass became more widely accepted as a supporting medium for the production of negatives. In 1851 Frederick Scott Archer described a method in use in London in which a wet collodion was employed on glass sensitized by immersion in a silver nitrate bath. While wet the plate was exposed and this process became known as the *wet plate method*. This accomplishment marked the birth of photo-mechanical methods of map making and led to the development of photo-zincography, a process perfected by Captain A. de Courcy Scott in 1860. Grained zinc was first used in place of stone about 1889, with the introduction of rotary lithographic presses. By 1904 the first offset press made it possible to use right reading images on zinc printing plates, but stone flat bed presses continued to be employed well into the first quarter of the 20th century.

In the Europe of the Middle Ages, and especially in the Netherlands, as crafts or guilds of artisans associated with map engraving and map printing continued to flourish, special manual and other skills were passed from father to son and from brother to brother in succeeding generations. These family dynasties continued to be an accepted feature of the industry's growth over a period of several centuries. The practice spread to the British Isles and so it is not surprising that a respected and representative Scottish unit of the system, the Cunningham family, was destined to play a significant part in the progress of map making in Canada.

In concentrating upon the career of this family it is realized that undue emphasis on the place and importance of the copper-engraving method of map reproduction in Canada will result. But it must be kept in mind constantly that maps were being drawn in large numbers by hand on paper and on lithographic stones by Canadians during most of the period under review and that these activities required the services of highly skilled map makers.

Edinburgh-born Walter Charles Cunningham (1872-1941) began his six-year period of apprenticeship in copperplate engraving in his native city in 1886. Soon after the completion of his training he became foreman in the Ordnance Survey organization at Southampton. Toward the end of the century Canadian map-making firms were struggling with a steadily increasing volume of business. Efforts were made to attract to this country from the British Isles engravers skilled in copperplate work. As a result, W. C. Cunningham, responding to the lure of opportunities for betterment in a new land, came in 1898 to the Stone Company Limited, Toronto, to help build up a unit of copperplate engravers for that firm. At that time the company (later to form part of Rolph-Clark-Stone Limited) was performing a considerable amount of map reproduction work for the federal government. By 1900 W. C. Cunningham had induced a group of former associates in the craft in England to join him on the staff of the Toronto firm. This group included Walter J. Watts, George C. Silver, Alex Stewart, Dick Arnold, Robert Walker and George Sheirlaw.

In 1910 W. C. Cunningham was approached by officials of the Government Printing Bureau, Ottawa, in a successful effort to persuade him to leave Toronto in order to organize a copperplate engraving unit of that federal organization. The motives underlying Cunningham's move and, later, that of his Stone Company colleagues remain obscure but, in all probability, the desire for individual economic security played a large part in what, in those days, must have been a momentous decision to make. As a rule engravers lived rather insecurely, never certain of long-term employment in their craft. An opportunity, therefore, to enter govenment service would seem to offer the relatively rosy prospect of assured, continuous work. In any event the engravers who followed Cunningham from the British Isles to Canada did not hesitate long in joining their leader in Ottawa. Soon after this exodus of its most skilled craftsmen the Toronto firm ceased its copperplate engraving activities.

Another important factor in bringing about the recruitment of trained copperplate engravers by the federal government agency at this time may well have been the grave administrative difficulties experienced by the Government Printing Bureau in the first decade of the 20th century. The Bureau's malfunctioning was first exposed to the public in a report in 1910 by the Secretary of State, Hon. Charles Murphy. Mr. Borden (later Sir Robert), Leader of the Opposition, made reference to this statement in his address in the House of Commons on November 21, 1910, when he observed that ". . . the affairs of the Printing Bureau were hardly touched at all and surely my right honourable friend [Sir Wilfrid Laurier] in the light of the revelations that have been made before this session and at the beginning of the session in the report of the Secretary of State, will hardly deny that there ought to be some investigation into the affairs of the Printing Bureau in recent years . . ." The opposition leader used unusually strong terms in describing the situation that had developed in the Department of Public Printing and Stationery. "I do not purpose this afternoon," he said, "to enter into a discussion of recent scandals . . . The fact that there is an enormous admitted loss in this country in regard to the administration [of the Department of Public Printing and Stationery] . . . charges of inefficiency, maladministration . . . stealing, looting, grafting . . ."[5]

The committee inquiry that followed upon these startling disclosures was highlighted by the flight from Ottawa, before the investigation began, of the Superintendent of Stationery and the subsequent discovery of his body in the Detroit River.

Although during the first decade of the 20th century map drafting with pen and ink was well established in federal government mapping services, a considerable part of Ottawa's map production requirements was filled by private firms on the basis of competitive bids. Because of lack of administrative experience in the outside work allotment section of the Bureau staff unrealistic price lists were established in this area with the result that in some instances the federal government was virtually held to ransom through the instrumentality of exorbitant bids for map-making contracts by outside firms. With the rapid expansion of the economy then taking place in the western interior of Canada came heavy and increasing demands upon the Printing Bureau to perform

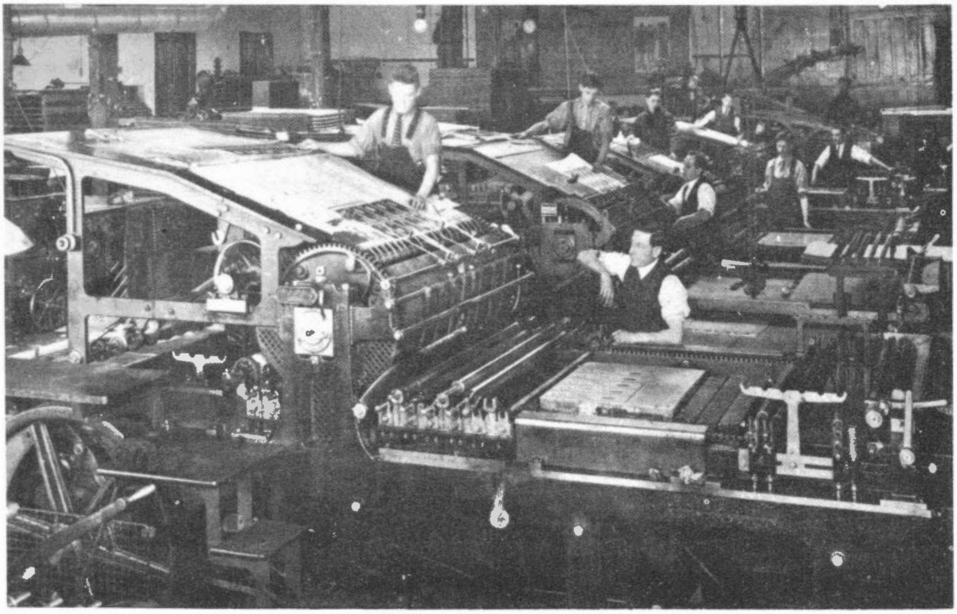


FIGURE 33. Pressroom of Mortimer Co., Ottawa in 1918. Hand-fed press and stones used in the lithographic process were still in use in the late 1930s.

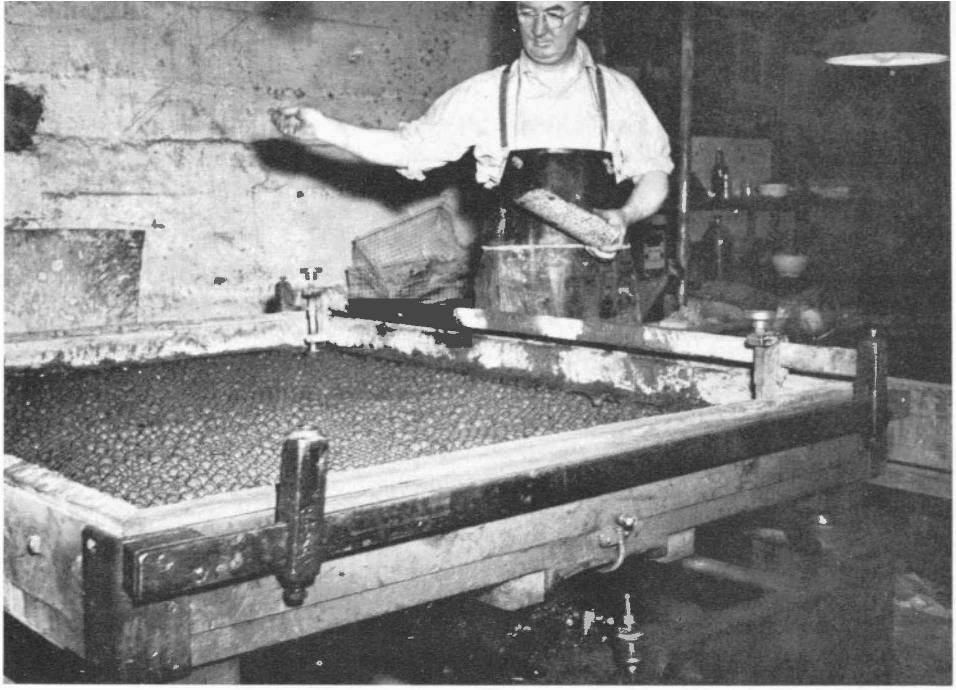


FIGURE 34. A lithographic plate is "grained" using metal balls and abrasives on a shaker platform. This abrades the surface evenly, helps the plates to carry moisture and makes the image areas more receptive to ink.

a class of work it was not equipped to handle. This steadily mounting pressure, in turn, compelled the government to rely more and more on the services of non-government establishments.[6] As reports and rumors of abuses in the system filtered out to the public the Undersecretary of State suggested to Bureau officials that requisitions for printing work and for map making should be checked carefully with a view to preventing the extraction of undue profits by private firms.

At the time of the inquiry into the affairs of the Printing Bureau a decision had been made by federal authorities to have their best and most important maps engraved in copper rather than on stone. This new departure in policy proved helpful in controlling the upward limits of competitive bids. When stone was being used for the purpose there was constant friction between government officials and contractors over the right to ownership and custody of the stones. With the advent of copperplate engraving for federal government purposes, and because of the much greater portability of the metal, there was no longer any necessity for plates to remain in the possession of the printer. With little risk and with relative ease the plates could be shipped from shop to shop and from city to city. Engraving firms, cognizant of the new circumstances, were no longer tempted, in making bids for government map reproduction work, to charge excessive rates on other processes involved simply because custody of the engravings remained with them.

Undoubtedly the Printing Bureau in Ottawa, to some extent, was a scapegoat for some politicians and a victim of certain civil servants in positions of responsibility whose work was habitually in arrears. Often, it seems, requisitions for maps as well as for other categories of printing work were delayed until the last possible moment, then marked 'Rush' and sent to the Bureau. But, in the main, the parliamentary inquiry proved timely and salutary. Administrative reforms were introduced in the Bureau that have since served to increase the efficiency and lower the costs of meeting government requirements. The inquiry also paved the way for the establishment in Ottawa, under the Bureau, of one of the ablest and most productive units of copperplate map engravers on the North American continent.

Another spur to the formation of the new unit in Ottawa was the trend, instituted by the federal government, toward the production in Canada of hydrographic charts of Canadian waters. Until the first years of the 20th century there had been a continuing reliance by Canadian authorities on the map-making and map-multiplying facilities of the British Admiralty in England. The first truly Canadian hydrographic chart, engraved and reproduced in this country in 1903, was that of Lake Winnipeg (Red River to Berens River), based on a geological survey map of the area with soundings resulting from Stewart's hydrographic survey of 1901.[7] It is probable that Mortimer Company, Ottawa, active at the time in performing mapwork for the federal government, printed this historic chart.

Earlier in this chapter reference has been made to the part played in the development of European map making by artisans whose skills had been exercised within close-knit family groupings. By bringing his son Walter to this country, W. C. Cunningham was soon able to demonstrate to Canadians how the special skills of the engraver's craft could be handed down from father to son and how this succession might remain unbroken over many years. It was in 1913, after his father had moved from Toronto to Ottawa, that Walter Alfred Cunningham (1895-1965) embarked upon half a century of work in the employ of the federal government in the capital city, interrupted by two periods of service in the Canadian army overseas in the First and Second World Wars. He began his apprenticeship as a copperplate engraver in the Government Printing Bureau on November 8, 1913, the first to serve such articles in this country. His salary during this training period was $85.00 a month. Seven years later he became a Junior Engraver and by 1928, when he was promoted to the rank of Senior Engraver, his monthly rate of pay had risen to $190.00.[8]

FIGURE 35. Walter A. Cunningham.

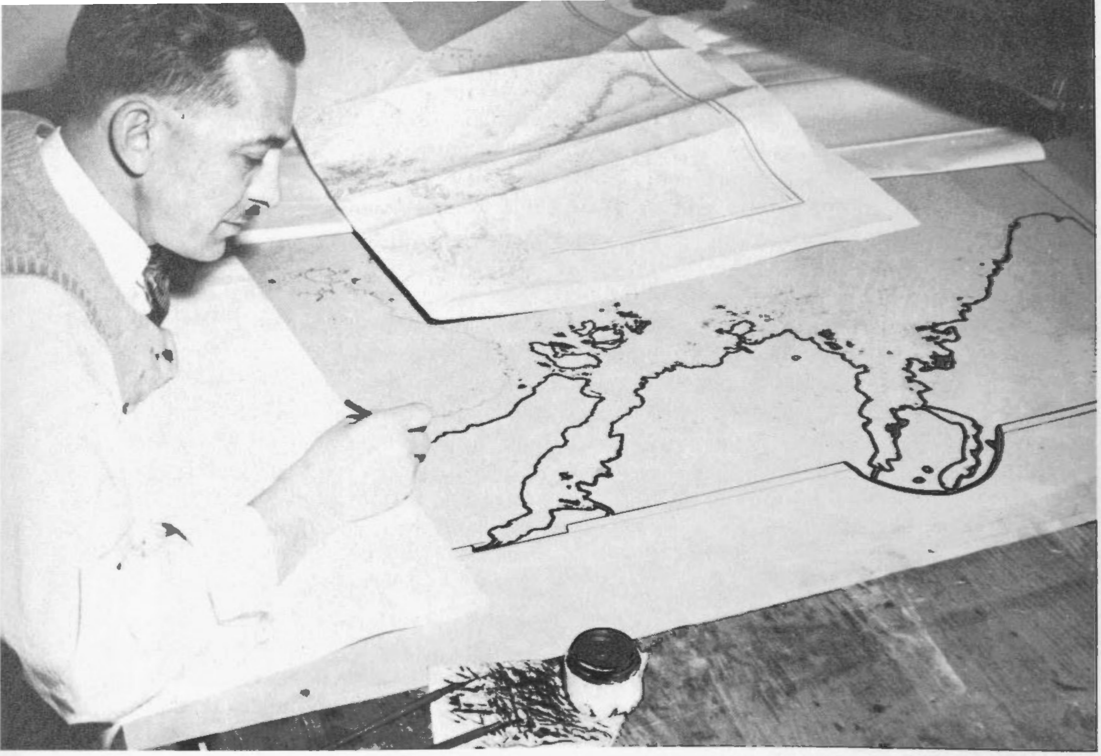


FIGURE 36. Engraver inking on zinc printing plate for water blue for hydrographic chart.

In 1921 the copperplate map engravers on the staff of the Printing Bureau were allotted among four federal government agencies in the capital city. Each of the four, namely, the Department of the Interior, the Geological Survey of Canada, the Militia Department, and the Naval Service were engaged in some aspect or other of map or chart making. This move marked the end of the copperplate engraving unit at the Bureau. Technically 'on loan' from the Printing Bureau to the Canadian Hydrographic Survey staff of the Naval Service, Walter Cunningham, along with his father and several other engravers moved to the Hunter Building and then, after about five years, to the Confederation Building in central Ottawa. Walter's uncle, Thomas Cunningham, came to Ottawa from the Old Land in 1921 and, after a term with Mortimer Company, became chief of the lithographic plant of the Department of the Interior, serving in that capacity until 1946. When Walter Cunningham returned to Canada after the Second World War he rejoined the Hydrographic organization. He found, however, that most of his fellow engravers of former days had either retired from service or had been transferred to the Mines and Resources Department to become lithographic artists or to join the photographic section in the Labelle Building.

Instruments used in copperplate engraving included at least a dozen steel points of various sizes, also a number of gauges such as double-line gravers employed in cutting highway routes among other purposes. In addition there was a special cutting instrument known as a 'lozenge' and also a dotter for making dotted lines or to indicate deposits of sand, especially along shorelines. No one at the time could have surmised that instruments such as these, after becoming relatively obsolete in Canadian map making for several decades, would return to use in a modified form of engraving, namely, scribing on plastic.

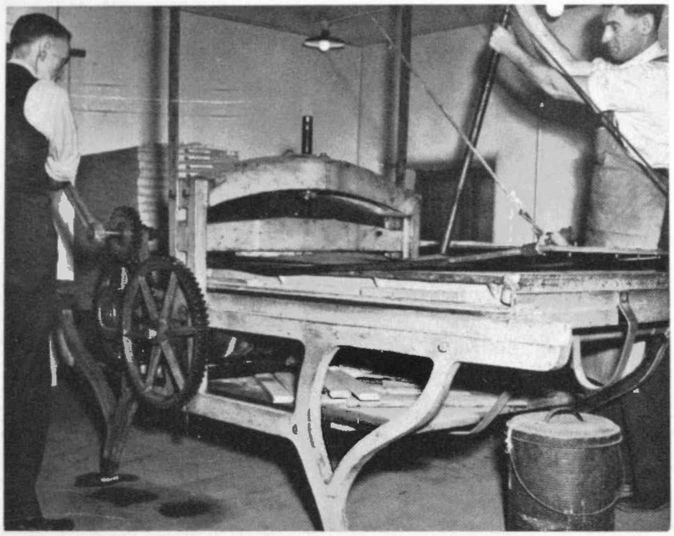


FIGURE 37
Transfer press in use. Pressure is being applied to effect transfer of image from stone or metal base to paper. Used until the 1950s in the Labelle Bldg., Ottawa.

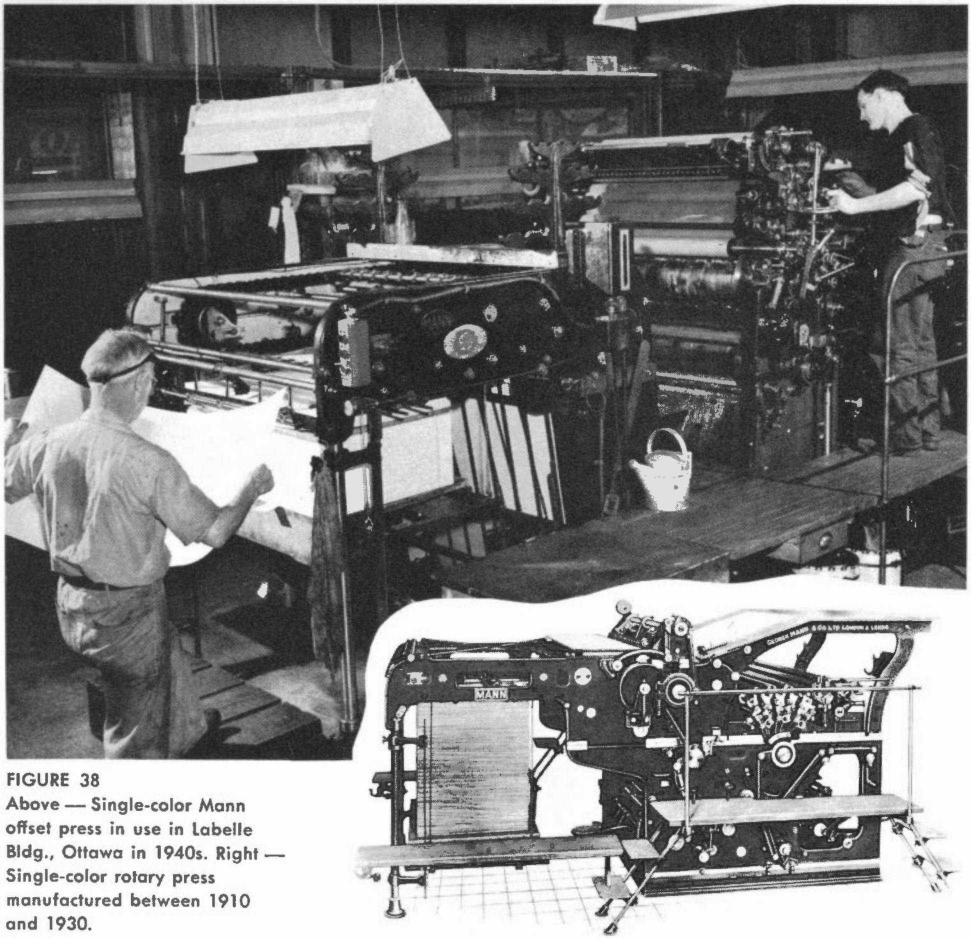


FIGURE 38
Above — Single-color Mann offset press in use in Labelle Bldg., Ottawa in 1940s. Right — Single-color rotary press manufactured between 1910 and 1930.

FIGURE 39. Operator compiling a map manuscript on a stereoscopic plotting instrument, aided by overhead projection of color images.

An event of considerable magnitude in the general progress of cartography in Walter Cunningham's time was the introduction of the rotary printing press. The direct result of this development was the significant speeding up of map-multiplying processes. As early as 1926 a rotary press was in operation in the Surveyor General's section of the Labelle Building and by 1932 three such presses were in operation in that organization. With the advent of the lithographic rotary offset press it became possible to print several thousand maps per hour, which compared with only about 100 map copies per day by means of the tedious copperplate process. This new press also permitted the printing of colors in exact register, and the cartographer was able to produce a greater variety of color combinations with fewer press runs.

By the 1940s the world of cartography was poised at the beginning of a great new advance in map-making techniques. That decade witnessed exciting experiments in the art of negative engraving, the key to which was the discovery of a plastic medium that would be suitable for map scribing.[9] Such a method of map reproduction offered a combination of solid advantages, provided the draughtsman could actually scribe a negative at printing scale and the result could be exposed to a lithographic printing plate. With success along these lines photography could be eliminated in the final reproduction stage and the original scribed line reproduced exactly. By 1940 basic instruments for use on a plastic material in the process of map making had been perfected by the United States Coast and Geodetic Survey, which had been entrusted with the production of a series of topographic maps for the Tennessee Valley Authority and was searching for a quicker method of reproducing maps.[10]

FIGURE 40
Map technician using stereoscope to assist identification of features on aerial photographs.

With the much wider use of airborne survey cameras following the Second World War and the accompanying demand for accurate, reliable maps, came increasing demands upon map makers to speed up their production processes. Prior to the war the map maker invariably kept well ahead of the surveyor and seldom, if ever, experienced pressure on his time from the weight of accumulated map data gathered in the field. But with new developments enabling the surveyor to rapidly obtain mapping information over vast areas, the map draughtsman began to lose his historical advantage in terms of working time. Leisurely progress, at the rate of two or three sheets per year, constituted a luxury in map production that no longer could be afforded.

The technique of negative engraving was a totally new process requiring a new material and new instruments. The wartime chemical industry of the United States had produced vinyl plastic and research was under way in Washington, D.C., following the war's end, to discover a suitable base for scribing material. Canadian government cartographic officials became aware of the American experiments in the early stages of these investigations. In particular, Edgar Douglas Baldock (1905-) clearly envisioned the immense possibilities inherent in the new approach. In 1946 vinyl was first used to produce artificial negatives. At the same time it was discovered that this type of plastic offered the most stable base for engraving work on negatives, in respect to durability and size. It was also capable of being easily cut without cracking. The development of thin, stable plastic sheets imparted fresh impetus to studies in faster map reproduction

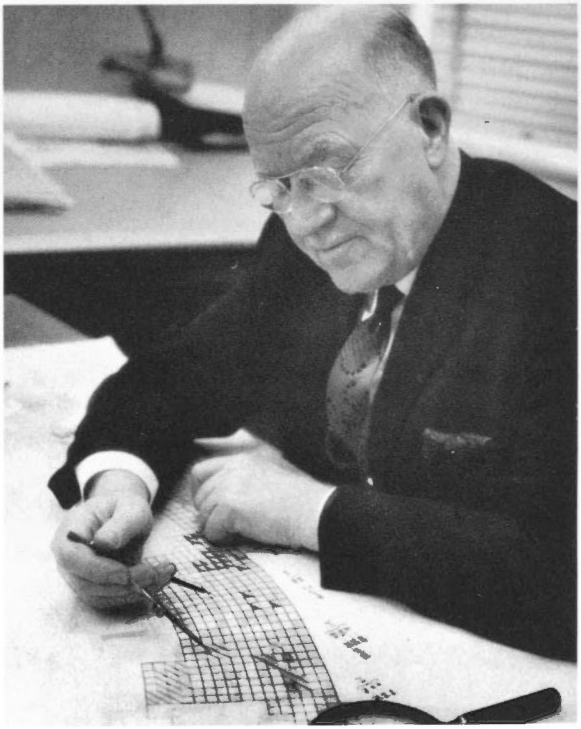


FIGURE 41. E. D. Baldock.

methods being conducted in Canada and the United States. The discovery of a suitable solution for the all-important coating substance continued to elude researchers. On Baldock's instructions Montreal-born Joseph Paul Emile Antonio Metivier (1900-   ), Assistant to the Chief of the Photo-Mechanical Section, Surveys and Mapping Branch, Ottawa, made a number of visits to Washington in order to keep abreast of developments in this new technique. It was Metivier who, in the final analysis, produced in 1951 a workable coating that could be cut cleanly. The decks were now clear for wide-ranging action.

FIGURE 42. Paul Metivier.

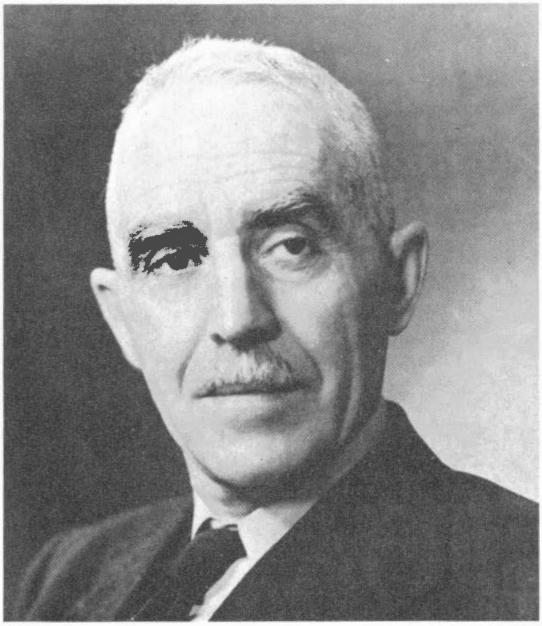


FIGURE 43. W. H. (Bill) Miller.

The Canadian operation in this new field of endeavor moved along swiftly. Deputy Minister Marc Boyer and Branch Director W. H. Miller quickly perceived the advantages of the new method on viewing a demonstration of the process arranged by Baldock, and authorized its adoption in departmental work. The transition from pen and ink drawing of manuscript maps to negative, and positive, scribing in plastic was accomplished almost overnight. The speed with which this radical change took place is all the more astonishing in the light of the long-standing, rigidly-observed traditions and practices of the copperplate engraving craft, extending over centuries. The smoothness and effectiveness of the changeover was mainly due to the excellent teamwork of men such as Douglas Baldock, Paul Metivier, W. J. Clark, D. Howard Bagguley and Walter A. Cunningham.

Paul Metivier came to Ottawa in 1920 and entered the federal civil service as an apprentice metal printer, Topographical Survey of Canada, Department of the Interior. At the time he could speak little English but soon acquired fluency in the language.

In the slow-moving system of promotion of those times Metivier was not awarded a journeyman printer's salary until a quarter-century later. During those 25 years he was officially classified as an apprentice. In 1948 Metivier became assistant to C. Warner Besserer, Chief of the Photo-Mechanical Section. In 1961 he was appointed Chief of Reproduction.

After Deville's passing and as long as the Photo-Mechanical Section remained under the Surveyor General it was regarded as a "poor cousin" and endured considerable administrative neglect. When Maxwell George Cameron (1888-1951) became Chief Cartographer matters improved somewhat in this regard. Cameron, born jn Peterborough and educated in public and high schools in that Ontario city, graduated in 1910 from the University of Toronto in applied science. In 1913 he was commissioned a Dominion land surveyor and he subsequently performed considerable field work in the western interior and in northern Ontario. From 1927 until 1936 Cameron was in charge of the newly-formed oblique photograph section of Topographical Survey, Ottawa. He developed the technique of plotting from oblique photographs and generally was prominent in pioneer work in mapping in Canada from aerial photographs. During the Second World War Cameron played a leading role in the production of the 8-mile-to-the-inch aeronautical chart series required in connection with the Commonwealth Air Training Plan. From 1948 until his death in 1951 he was Chief Cartographer, Department of Mines and Technical Surveys.

Baldock succeeded Cameron and became Chief of the Map Compilation and Reproduction Division of that department. "For the first time", Metivier later observed, "we of the staff were authorized to travel within and outside Canada and to see how others dealt with problems in this field . . . Our views on map making broadened accordingly and we adopted and improved upon ideas inspired by these contacts." Metivier has recounted how Baldock, in the early 1950s, approached him and asked whether his men could turn out a job by using plastic as an engraving medium. "Let's take this gradually" was the basic admonition but the outcome proved so satisfactory that glass plates and all that were quickly abandoned and the tedious, often dirty work, hallowed by long usage and tradition, suddenly became obsolete. The volume of production mounted impressively and reached several times the amount of work formerly produced. One notable loss in the transition from one practice to the other was that of the draughtsman's individuality in craftsmanship. In earlier days it would be possible to tell, at a glance, what artisan had drawn a particular map. On the other hand large gains were made in obtaining a desirable uniformity of product as well as greater variety in the use of color and, above all, a far greater speed of output.

One of the formidable problems of the transition stage was that of the insertion of place names in the scribing process. This was brought about eventually by the use of the type-overlay system.

Baldock realized that rather than attempt to convert the old hands of the staff, steeped in the traditional but slower practices, to the new system it would be wiser to select ten or twelve newcomers to the expanded staff and to teach them how to scribe from the outset of their training. But it was first necessary to find a man able to teach, conversant with long-established methods, yet adaptable to the new order of things. Baldock found such an instructor in the person of Walter A. Cunningham. Early in 1953 he asked Cunningham to visit Washington and to acquaint himself with advances made there in the plastic scribing method. On his return to Ottawa Cunningham began to impart the benefit of this new technique to the young draughtsmen in a series of

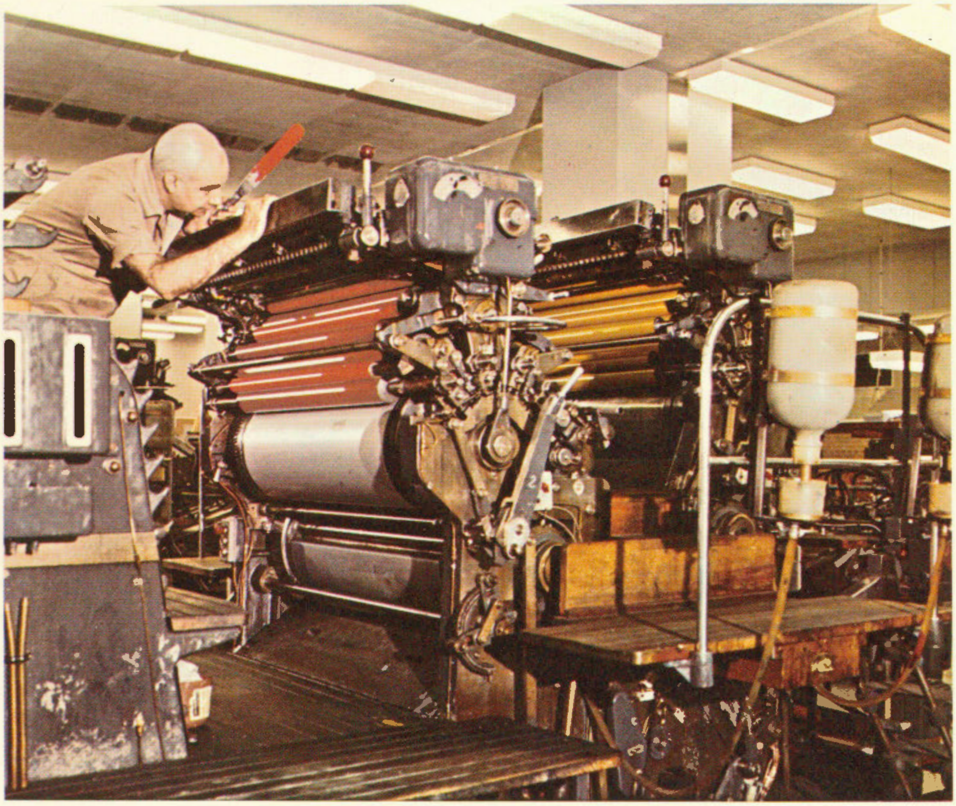


FIGURE 44. Two-color Mann offset press (25 x 38″) used by Map Compilation and Reproduction Division, Ottawa (now the Directorate of Map Production) for printing multi-color maps and charts. Installed in 1957.

lectures. The system was soon launched and the first experimental map was the Gambo sheet, Newfoundland. The highly satisfactory results obtained convinced federal authorities that a change to the new system was advisable.

In Canada plastic sheets were first used in map production, in 1952, in that stage of the map-making process where the areas (as distinct from the lines) of a map that will be printed in a given color are placed on the printing plate. Formerly this had been done on the plate itself by laborious and delicate handwork. But with the introduction of plastic sheets, a system was developed whereby the *outlines* of the color areas were printed on the plastic in a nonphotographic blue line. Using this blue line as a guide, the color areas were filled in with water-soluble opaque. The whole sheet was then dyed, but the color areas that had been protected by the opaque could be washed clean, leaving an "open-window" negative. Map makers could thus provide reproduction material* for both line and area colors. This eliminated the long delays that formerly occurred when an area color printing plate broke down during the printing processes, because with this system a new plate could be made in a matter of minutes.

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*"Reproduction Material" is the term used to refer to the various draughted sheets of plastic which are used to make lithographic printing plates.

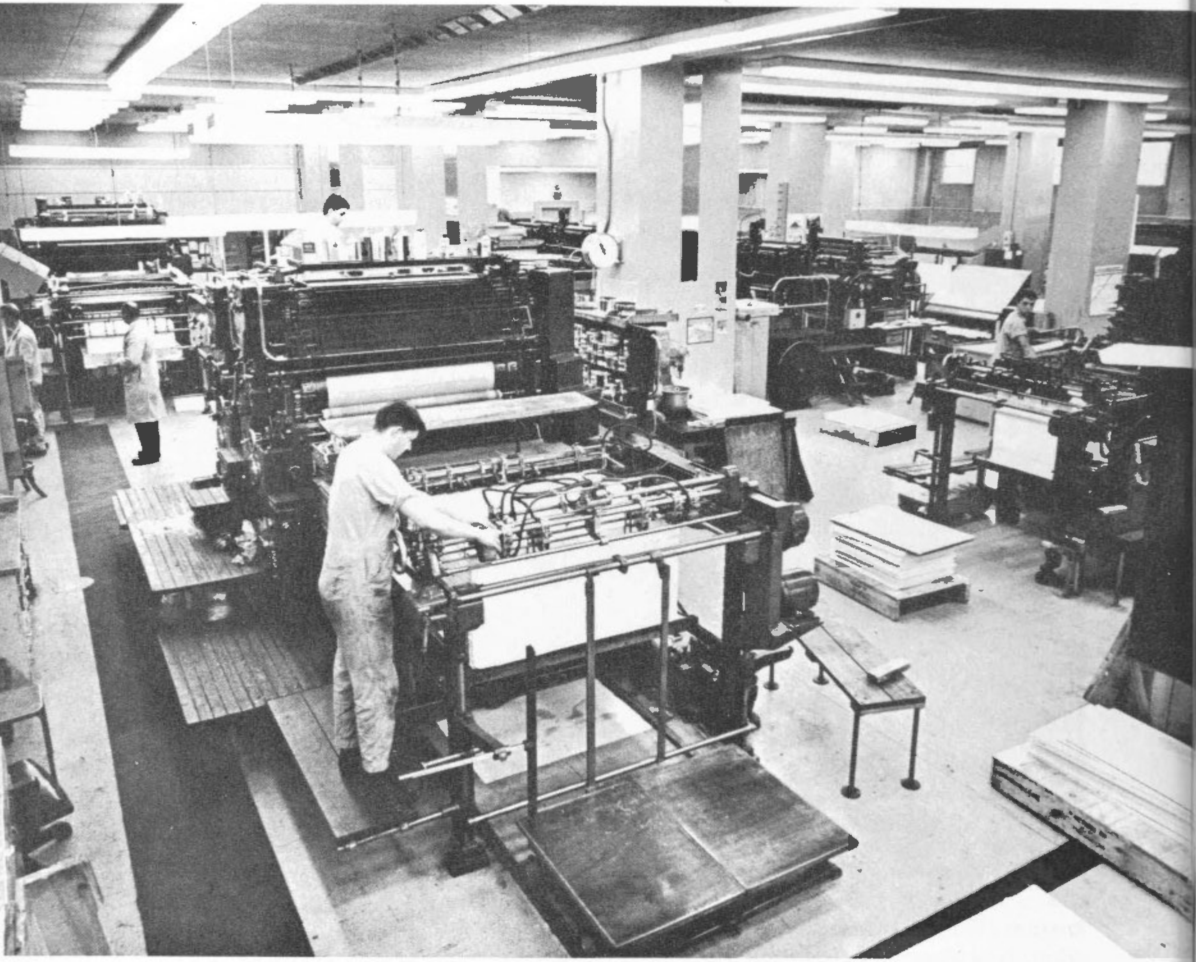
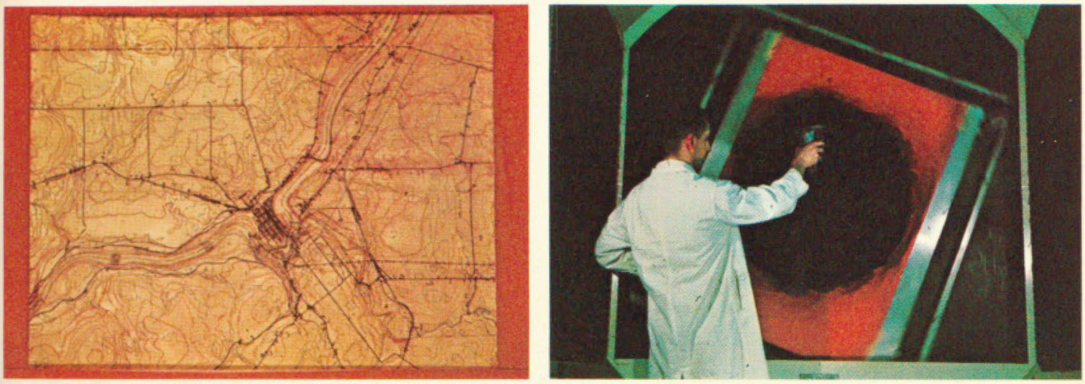


FIGURE 45. Two-color Mann Master offset press (36¼ x 50"), installed March 1961 in Map Compilation and Reproduction Division, Ottawa.

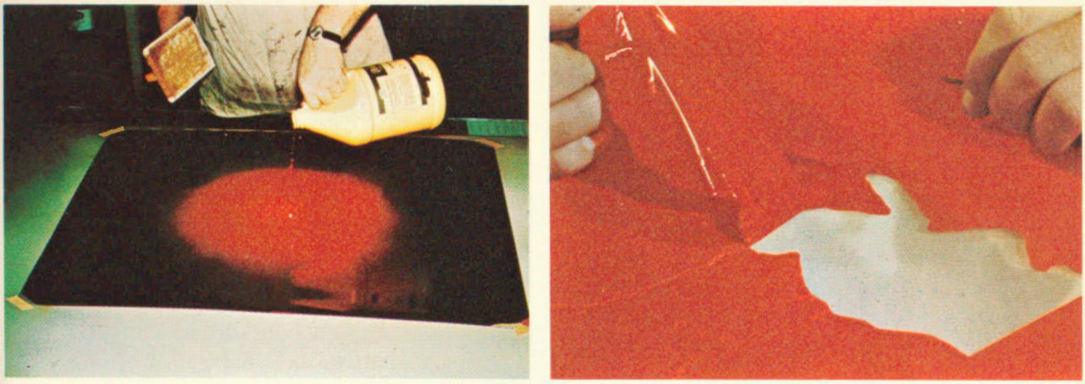
In 1953, as mentioned above, map scribing on plastic sheets was introduced. This is a process for producing the cartographic line work (in contrast to the area work described above) and involves the removal of the surface coating on a coated sheet of plastic with a sharp-pointed tool. Basic tools included the rigid scriber, swivel scriber and scribing cutters in single and double lines. Under the new system the average draughtsman greatly increased his annual output of finished maps and, almost incredibly, draughtsmen could be trained to perform acceptable work under supervision in less than one year. The instruments were simple, line weights could be well maintained and difficult symbols could be drawn with relative ease. In addition the idiosyncracies of individual penmanship were eliminated, permitting more than one person to work on a specific map.

FIGURE 46. Modern processes in map making.



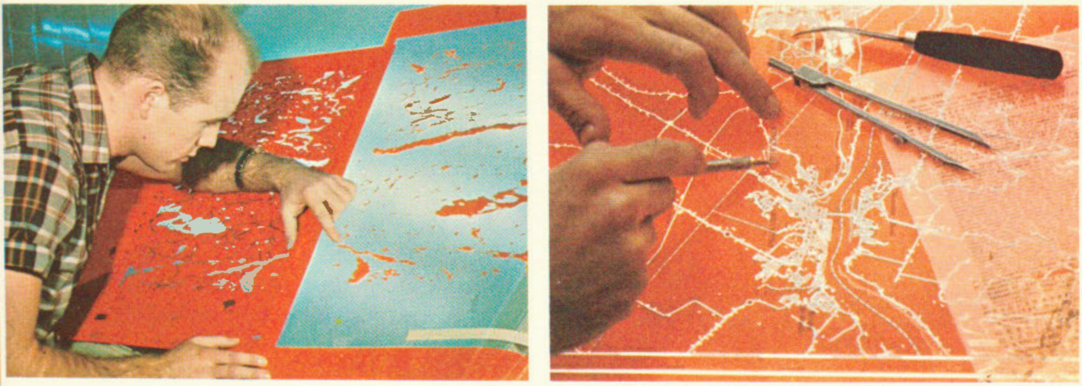
Manuscript map.

Applying light-sensitive coating to peelcoat.



Developing the peelcoat by use of solvent.

The peeling process.



Checking open-window negative.

Type (place-name) affixment.

This successful venture with the new system marked the beginning of a profound revolution in the realm of map making in Canada. It was a process first developed and used in this country by far-seeing and resourceful map makers of the Map Compilation and Reproduction Division of the Surveys and Mapping Branch, Ottawa. The changes in methods brought about by these craftsmen and others gave to the Canadian cartographer the greatest flexibility he has ever enjoyed in map design and map production as well as map reproduction work.

5

THE ROLE OF SURVEYS IN THE STORY OF MONTREAL

Central Montreal is situated on the largest island of an archipelago in the St. Lawrence River near the mouth of the Ottawa River. By the time Cartier had arrived on his first visit to the place a palisaded Indian village had been constructed on a hillside and called by the natives, Hochelaga. There is evidence that this settlement existed before the year 1400. For a time, after the epochal voyage of Columbus, Hochelaga served as a mother community of the North American continent. Today the same island, along with companion islands and nearby mainland areas, together comprise a metropolitan region inhabited by upwards of three million persons. Montreal has become not only Canada's largest city but, next to Paris, the largest of all French-speaking cities in the world.

More than four centuries ago, on the summit of the hill that for so long dominated this principal island, Indians of the Iroquois nation used forest cover as they hid from enemies, or waited to descend upon them. Today their descendants are employed as specialist workers on the 'high steel' framework of skyscrapers that, from street level, appear to dominate the once-impressive Mount Royal, from which this urban colossus has derived its name. Ste. Catherine Street, an important shopping promenade, now extends across the central business section of the city along the third of five hillside terraces that mark the community's gradual climb through recent centuries from the river up the mountainside. The terraces are the remains of ancient beaches and testify to the spasmodic recession of the seawaters in this locality during the long reaches of geological time.

Before the white man arrived in what is now central Canada the Indians used the gully cleaving Mount Royal as a portage route, carrying their canoes from the St. Lawrence River to Rivière des Prairies. The latter stream formed the beginning of a water highway leading up the Ottawa River, down the French River into Georgian Bay and, by way of Lakes Huron and Superior, to the western interior of the continent.

Champlain bestowed the name 'Place Royale' on a riverside trading post located about a mile from Hochelaga settlement and this site continues to be the pivotal position of Montreal's present-day, 8-mile-long port development. In 1642 Paul de Chomedey de Maisonneuve arrived in this locality with about 60 persons, people brought from France to serve as soldiers and settlers. As the first executive officer of Compagnie de Montréal, Maisonneuve selected Place Royale as the site of the new European community and named it Ville Marie. In that vicinity farmland concessions were granted and surveyed. Land surveyors known to have been active in the settlement or near it during the latter part of the 17th century were Bénigne Basset, Jean Lerouge, Gilbert Barbier, Robert de Villeneuve and Louis-Marie Boucher *dit* Boisbuisson.

The 18th century was only a few years old when the name Ville Marie, now a settlement of 1,500 persons, was discontinued in favor of the appellation, Montreal. The settlers soon wearied of the restricting stockades and by 1660 a village had grown up outside the fort, its forty or so dwellings extended in two straggling rows facing each other across a rough trail.

The beginnings of Westmount have been traced to this early period. By a deed in Maisonneuve's handwriting, and over his signature, a grant of land on Côte St. Antoine was made to Jean Leduc in 1662, the first of a number of land grants made in that locality during the 1660s. Pierre Hurtubise received a grant of land in that vicinity in 1687 with the stipulation that a house should be erected on the property within three years. About this time the Sulpicians founded a mission for Indians, the boundaries of which extended into what is now known as Westmount. The name Priest's Farm, in fact, was long in use locally to denote the area between present-day Wood and Atwater avenues.[1]

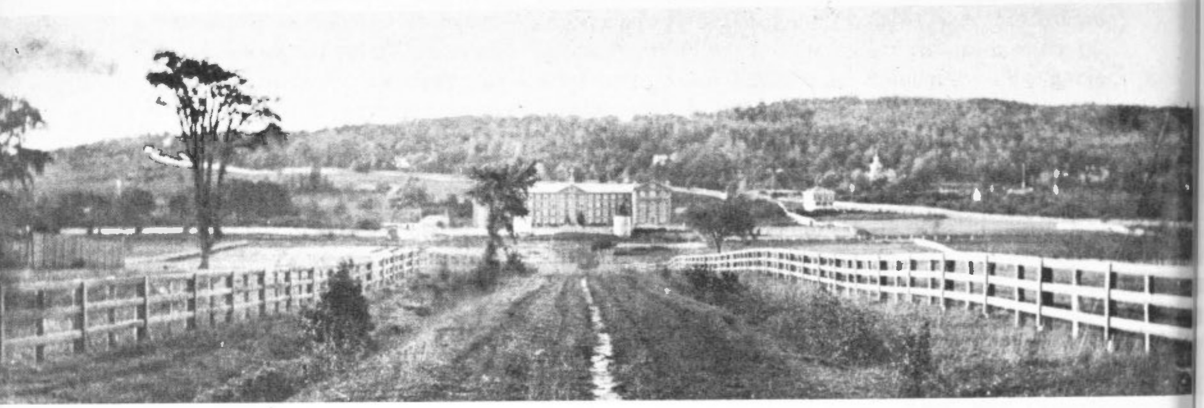


FIGURE 47. Priest's Farm, Côte des Neiges Road.

The first streets of the embryo town were planned in 1672. In March of that year the Sulpician Superior, Dollier de Càsson, with the aid of the surveyor Basset, laid out these pioneer thoroughfares within the present limits of central Montreal. They marked the courses with great care, using posts bearing the leaden seal of the Sulpician Seminary. In some instances the trails already in use were transformed into streets. In other cases entirely new roadways were required. Notre Dame Street, then the principal thoroughfare, was made 30 feet wide. Saint-François Street, later Saint François Xavier Street, was named after de Casson himself; Saint-Paul Street, initially a pathway from the old fort to Hôtel-Dieu Hospital, after Paul de Chomedey de Maisonneuve; Saint-Jacques (St. James) Street after the founder of the Seminary of Saint-Sulpice, curé Jean-Jacques Olier de Verneuil (1608-1657); Saint-Pierre (St. Peter) Street after the great apostle "and also out of respect to M. de Fancamp, one of the founders of Montreal who bore that name."[2]

During the decade after 1672 the tiny community was not precisely a beauty spot. The condition of streets was a constant source of complaint. Some property owners completely ignored their existence, cultivating across rights-of-way. This led to a prohibition of all crop-raising activities on roadways. Each proprietor was permitted to enclose his lot with stakes or hedges. Nevertheless streets remained in uneven condition as efforts by the authorities to induce each property owner to pave the street to the centre line in front of his dwelling met with indifferent success.[3]

In addition to its importance as a fur-trading centre the early town was the natural outfitting point for the inland explorations of La Salle, Jolliet, Marquette, Duluth, Cadillac, LeMoyne, La Vérendrye and others. Two of the many sons of Charles LeMoyne, Baron of Longueuil, in fact contributed much to early explorations of the Mississippi River and to the founding of Louisiana. In 1723 the town's fortifications were strengthened by the erection of stone walls for the wooden stockades surrounding the settlement. The enclosed area embraced 110 arpents, or about 93 acres, and the walls remained intact for almost one hundred years. By 1761 the population of Montreal

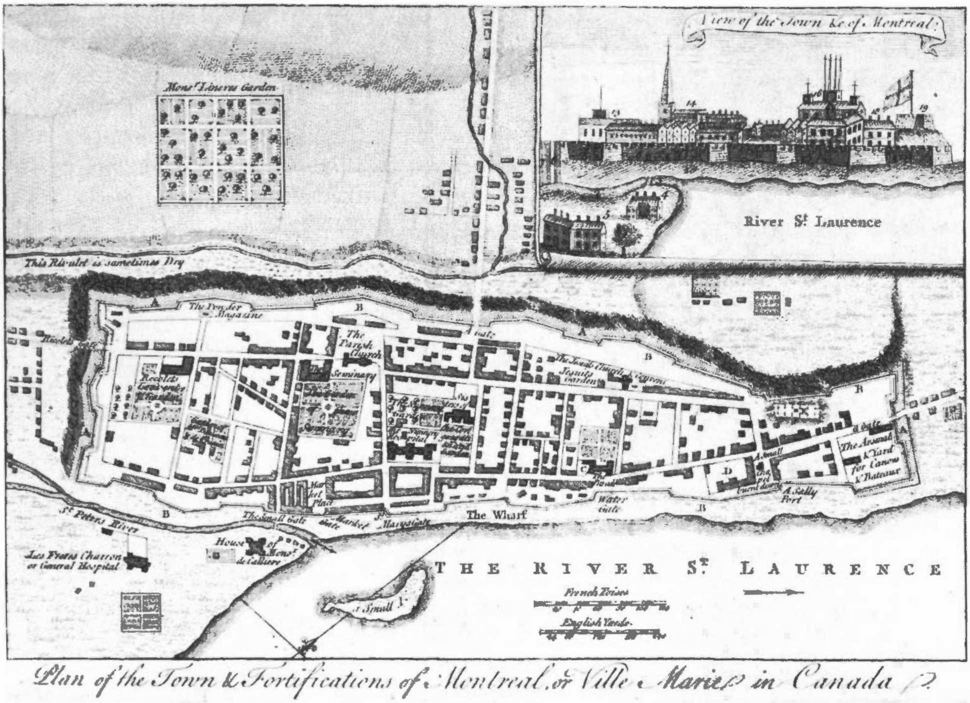


FIGURE 48. Engraving based on 1758 plan by Jeffrys.

exceeded 5,000. Land surveyors prominent in Montreal and vicinity during the 18th century included Jean Boutin, Jean-Baptiste Belisle, Gabriel Boudreau *dit* Graveline, Louis Charland, Toussaint Beaudry, Joseph Papineau, Jesse Pennoyer, Charles Basset, François Papineau, Joseph Perrault, Amable Dezery, François-Enouville Lenoix, Pierre Arsenault, Jean-Baptiste Grenier, and René de Couagne.

The American Revolutionary War brought in its wake some highly significant changes in the development of the island community. Its population increased and became more varied. Men trained in the British civil service and in British forces augmented the flow of other emigrants from the Old World. In the streets officers and soldiers mingled with black-robed priests as well as with students wearing brightly colored sashes, nuns in black and grey, farmers, lumbermen, Indians and laborers, the latter clad in serviceable homespun. The peopling of empty lands, especially in the Eastern Townships, by United Empire Loyalists and others, heralded the approach of a dramatic change in function for the burgeoning community on the island of Montreal. The core of the original settlement had been located on a hillock near what is now St. James Street. As business enterprises gradually advanced up the escarpment to Ste. Catherine Street, the local world of commerce tended to gravitate about Phillips and Dominion squares. This intrusion into what had been a district of residences only, resulted in a retreat of home owners up the south side of Mount Royal to the Sherbrooke Street plateau.

At numerous points in Upper and Lower Canada the forests and the frontier receded as land was cleared and crops raised. When grain was produced in excess of strictly local needs this product began to reach Montreal for shipment overseas. In return the British Isles began to send manufactured goods to Canada to help meet the requirements of the steadily growing population. The merchants of Montreal responded vigorously to the unfolding prospects and the city took its first steps towards becoming a national seaport.

Up to this stage in Canada's growth, Quebec City, as the administrative and military centre of Lower Canada, had been a more populous, more thriving, and generally more important community than Montreal. A principal factor was the tendency of vessels, bound upstream between the two places, to be delayed in the approaches to Montreal by adverse winds and currents. But with the appearance in the St. Lawrence River of steam-powered, ocean-going ships, navigation problems eased. As Montreal's port activities expanded the island city rapidly forged ahead of Quebec City. Young people began to move from the latter to take advantage of the improved economic opportunities in Montreal. Important discoveries of natural resources multiplied in the province and these developments along with better transportation combined to widen the disparity in growth between the two ports.

The increase in traffic in Montreal harbor emphasized limitations imposed by hazardous river approaches and by primitive dockside arrangements. But directly opposite the town there was a deep-water channel enabling ships of several hundred tons to approach close to shore. The sharp declivity of the riverbank at the waterfront formed a natural wharf over which cargoes could be loaded or discharged. During the closing years of the 18th century, although a plank-faced dock had been constructed at the riverbank, goods for the most part continued to be boarded or unloaded directly from or on to the beach.

Attempts were made at this time to improve navigation west of Montreal wherever a series of river rapids dictated arduous and costly portages. By order of the Governor,

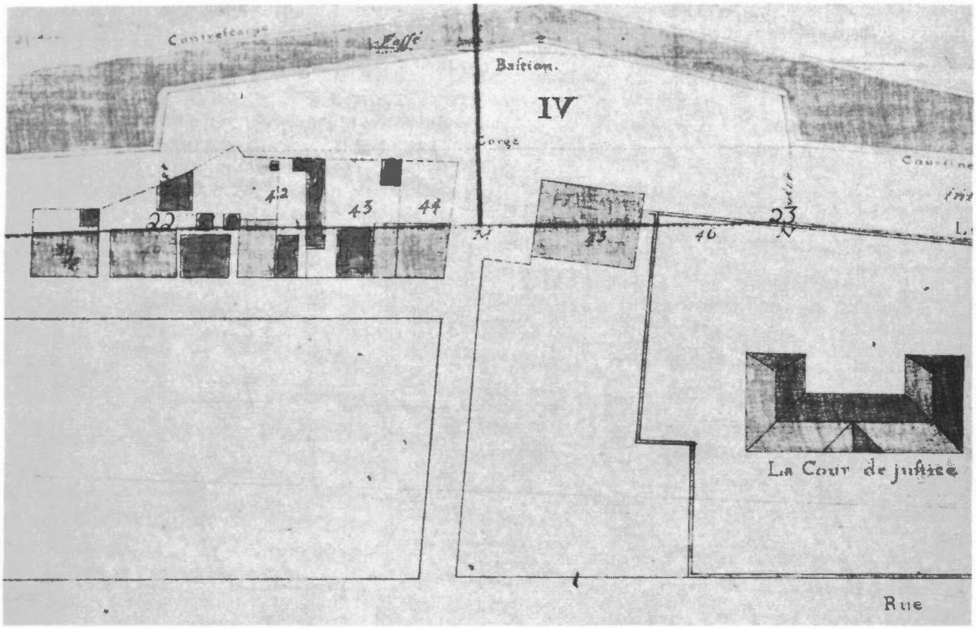


FIGURE 49. Part of plan of fortifications of Montreal, drawn by Louis Charland, 1803. From copy by J. Rielle, P.L.S. Today's Rue St. Jacques runs horizontally from the left margin to meet Rue St. Gabriel at about the centre of the diagram. Rue Notre Dame extends horizontally along the lower margin.

and under the supervision of Lieut. William Twiss, R.E., work began in 1779 on the construction of six-foot-wide canals and tiny locks at Coteau du Lac, Cedars, and Cascades. These projects included enlargement of Lachine Canal. Its length was extended to 8½ miles and four new locks were provided to overcome the 42-foot height differential.

As early as 1815 town-planning projects were under study by a civic commission, one of whose members was James McGill, Scottish founder of McGill University. The pattern of urban growth was considerably influenced by immovable physical barriers in the form of the mountain and the watercourses in its vicinity. These natural features tended to confine development of downtown Montreal to some 1,300 acres wedged between the base of Mount Royal and the St. Lawrence River. Local geography also compelled the spreading city to flow around Mount Royal to form suburbs such as Outremont, Mount Royal, Ville St. Laurent and, in recent years, to complete the encircling movement, Côte Saint-Luc and Hampstead. By 1840 the population of the city had grown to 40,000.

Towards the eastern end of the island of Montreal other municipalities were developing such as Pointe-aux-Trembles, Montreal-Est, Anjou, Saint-Leonard-de-Port Maurice, and Montreal-Nord. Along the south shore of the main island from its western tip towards its centre, other communities eventually began to take shape, places such as Baie d'Urfé, Beaconsfield, Pointe-Claire, Dorval, Lachine, La Salle, and Verdun.

Directly across the St. Lawrence from central Montreal, on the southern mainland, other communities such as Longueuil, Saint-Lambert, and Montreal-Sud sprang into prominence.

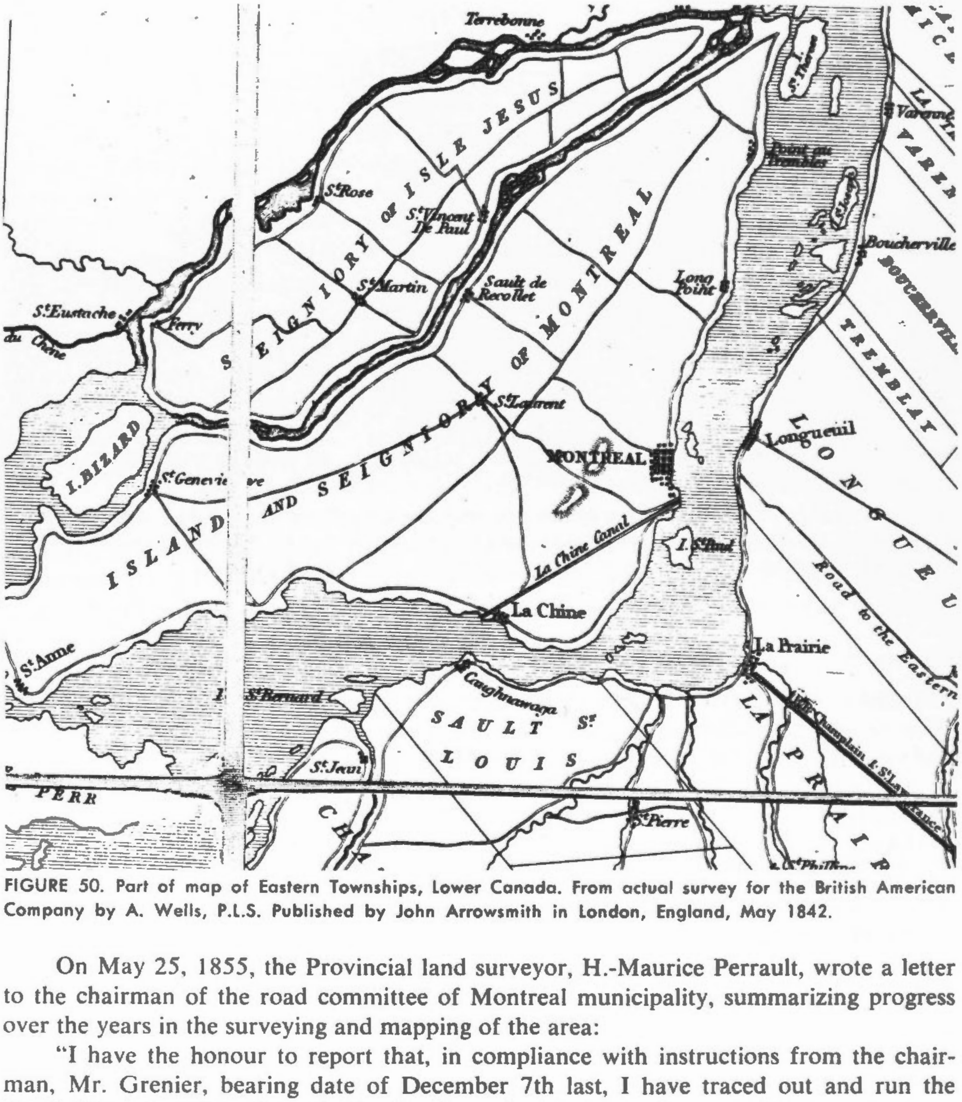


FIGURE 50. Part of map of Eastern Townships, Lower Canada. From actual survey for the British American Company by A. Wells, P.L.S. Published by John Arrowsmith in London, England, May 1842.

On May 25, 1855, the Provincial land surveyor, H.-Maurice Perrault, wrote a letter to the chairman of the road committee of Montreal municipality, summarizing progress over the years in the surveying and mapping of the area:

"I have the honour to report that, in compliance with instructions from the chairman, Mr. Grenier, bearing date of December 7th last, I have traced out and run the North West boundary line of this city from the North Angle to the Western Angle.

"In the course of this operation I have found that the intermediate boundary stones. such as those planted at Papineau, or Victoria Road, and at the Main Street of St. Lawrence suburb, were not in a straight line with the two terminal stones although represented as such in sundry old and new maps.

"It appears from various records that these limits were originally laid down by William Sax, Deputy Provincial Surveyor, under a Proclamation from His Excellency the Governor General, bearing date of May, 1792; and that on the 16th day of August, 1798, the said William Sax planted three hewn stone bornes to define the said limits; the one was planted on the bank of the River St. Lawrence near the present Ste. Mary Street toll gate; another was planted on Mr. Clarke's land at Main Street, St. Lawrence suburb, a short distance east of the present toll gate; and the third opposite Cantin's shipyard, also a short distance from the present St. Joseph Street toll gate.

"Subsequently the outlines and boundaries of the city were drawn and extended from the above three old bornes in June, 1826, by the late Theodore Davis, duly commissioned land surveyor, at which time he planted 10 additional stone boundary markers and seven cedar posts to define and establish the said limits. This operation was performed at the request of the magistrates for the city and district of Montreal.

"I have prepared the accompanying plan from an actual survey of the whole of the extent of the aforesaid Northwestern boundary line and have laid down the said line as running from boundary stone to boundary stone . . . Should it be found necessary, or advisable, to make a more minute survey in order to ascertain where deficiencies may exist, I shall be ready at any time, on receiving your instructions, to do so immediately."[4]

Some ten years later a plan of the city was made from a trigonometrical survey and for a number of years this was the only official map available in Montreal. In 1881 an atlas of the City of Montreal, the work of Charles E. Goad, C.E., was published, based on special surveys and official plans. These maps showed all buildings, their numbers, and the names of their owners. In 1890 Goad published a second edition of this atlas, including a map of the city that was widely regarded as the best and most comprehensive of its kind up to that time. Goad began his career in engineering with the Toronto, Grey and Bruce Railway. By 1876 he was Chief Engineer of the Halifax and Cape Breton Railway. He left railroading to inaugurate and promote a system in Montreal of insurance surveys and plans of the city, later extending this type of work to large cities and towns of Great Britain.[5]

During the 19th century a number of other surveyors were busily occupied in the Montreal area. In the early years of the century these included Eugène Guy, Pierre Guy, John Adams, Richard Hay and Alexander Gibbs. The notable mapper of the Canadian North-West, David Thompson (1770-1857), who had retired from exploratory and international boundary work, performed surveys in the vicinity of Montreal in the early 1840s. His remains rest in Mount Royal Cemetery.

In 1850, at the age of 16 years, Joseph Rielle (1834-1915) was articled to the Montreal firm of surveyors, Ostell and Perrault. After four years with that partnership Rielle served as assistant engineer with the Montreal Harbour Commission, then entered general surveying practice. In 1904 he was presented by his fellow land surveyors of the Montreal district with a testimonial marking the fiftieth anniversary of his commissioning as a qualified surveyor.[6] His records, plans, and field notes are in possession of the surveying firm of C. C. Lindsay and R. J. Lindsay of Westmount. The transfer of survey records from one qualified surveyor to another by sale, gift or bequest is authorized under Quebec laws.[7]

Joseph-Emile Vanier, born in Terrebonne, was another who contributed in an important way to the surveying of Montreal properties. He began his professional career

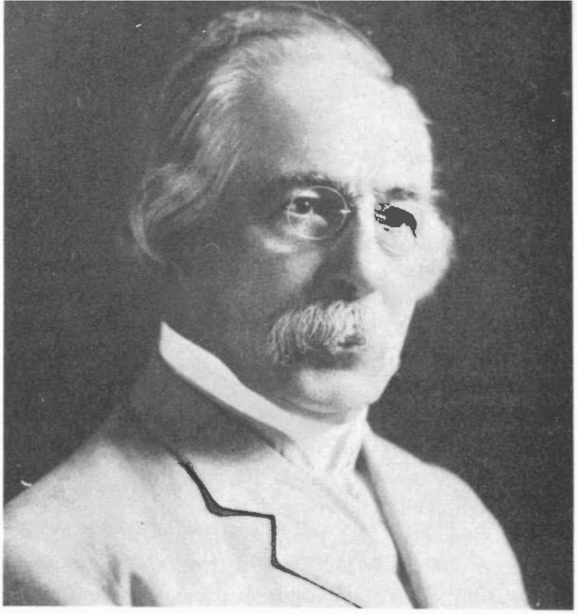


FIGURE 51. Joseph Rielle.

FIGURE 52. F. W. Blaiklock.

FIGURE 53. Honourable J. P. B. Casgrain.

in Montreal in 1879. For many years his firm of engineers was considered widely to be one of the most eminent in its field in Canada.[8]

A name synonymous with the advancement of the profession in Quebec province is that of Joseph Philippe Baby Casgrain (1856-1939) who was commissioned a Provincial land surveyor in 1877 and a Dominion land surveyor in 1881. Born in Quebec City, Casgrain belonged to one of the first French families of New France. He was named to the Senate at Ottawa in 1900. Although Senator Casgrain had a distinguished career in the field as a surveyor his most enduring contribution as a Canadian was made in promoting the best interests of his fellow surveyors through the agency of their professional organizations. He was a member of the board of directors of the Corporation of Quebec Land Surveyors for fifty consecutive years and in 1938 was made permanent Honorary President of that association.

Brian Douglas McConnell (1836-1930) was also prominent in the making of surveys in and around Montreal during the latter part of the 19th century. Born in the Gaspé and educated there as well as in Quebec City and Montreal, McConnell began to practise in 1869. He was on the party that made the initial surveys for the Canadian Pacific Railway along the north shore of Lake Superior. Later he became City Engineer of Westmount. J.-Louis Michaud (1851-1915), born in Rimouski, became a Provincial land surveyor and, in 1882, a Dominion land surveyor. After many years in the field in the Canadian North-West, Michaud entered private practice in Montreal.

Other names of surveyors active in the 19th century in Montreal and vicinity include Marius Dufresne, F.-T.-V. Regnaud, N.-C. Mathieu, Clement H. McLeod, Ernest Bélanger, Henry Irwin, John Ostell, J.-Hermyle Leclair, W. McL. Walbank, Thomas Guérin, Clovis Leduc, Thomas Kirk, J. P. Mullarkey, Frederick William Blaiklock (1820-1901), commissioned in 1843, and Percival Walter St. George, a civil engineer, who became City Surveyor of Montreal in 1883.[9]

In 1875 a three-man Commission of Engineers was appointed to investigate methods for improving the harbor at Montreal. Robert Bruce Bell of Glasgow, Major-General Newton of New York, and Sandford Fleming of Ottawa were its members. Among those submitting views to this commission was City Surveyor MacQuisten of Montreal, who testified on the subject of flood levels. MacQuisten, in the great flood of 1861, claimed that he had sailed in a boat through St. Ann's Ward when that part of the city was under three feet of water.[10]

Two years after their appointment the commissioners reported that some serious discrepancies had been found in existing charts of the St. Lawrence River at Montreal. New surveys and soundings were recommended. Results of these new measurements, as laid down on a large-scale plan, embraced the stretch of river between Victoria Bridge and Longueuil. Soundings were numerous enough to permit the drawing of contour lines, revealing at a glance depths at all points.[11]

Again in the spring of 1897 a resurvey of the river began "to meet the general demand for perfected charts and to keep pace with the deepening and general improvements to the ship channel." The field work on this survey was completed in 1907. The survey consisted of triangulation and topographical work from Montreal and Quebec City, and hydrographic surveys from Montreal to Pointe Platon. From the latter place to Quebec City extensive soundings had been made a few years previously and it was not considered necessary to repeat this work.[12]

On the island of Montreal other developments of significance to surveyors and to the general public were taking place. The Municipal Council of Montreal, by a resolution on October 2nd, 1905, divided the area within city limits into two parts by designating Boulevard St. Lawrence, now St. Lawrence Main, as the north-south line of division. This important thoroughfare extended from the St. Lawrence River to Rivière des Prairies. All avenues cut by this traffic artery would henceforth be described as east and west respectively and street numbering, accordingly, would begin on each side of this dividing line and mount in orderly sequence in each direction.[13]

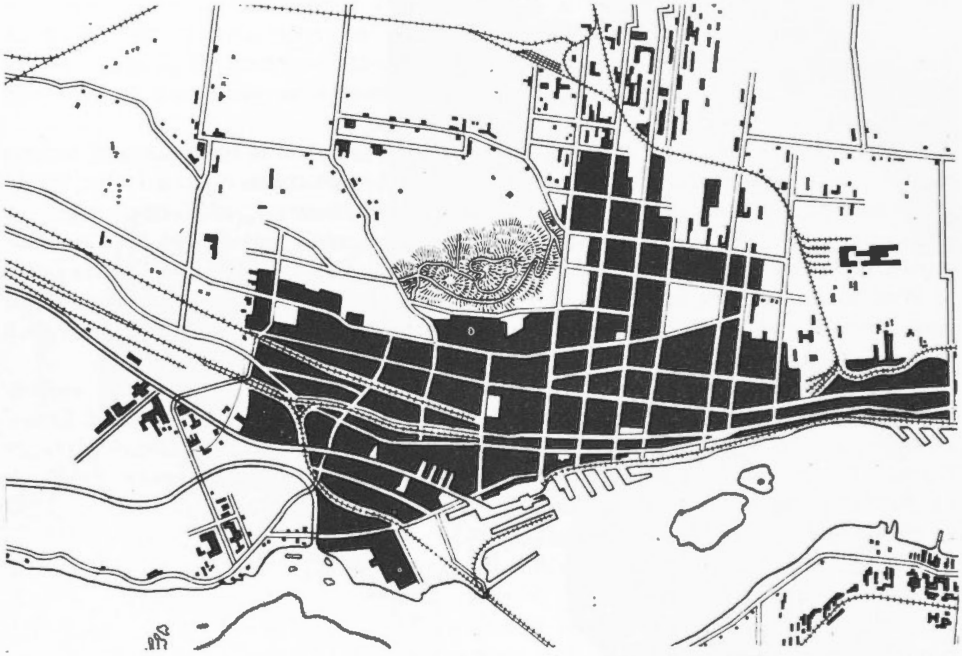


FIGURE 54. Built-up area, Montreal, 1907. Montreal Metropolitan Commission map.

A number of aspects of law and practices applicable to land surveying in Quebec are distinctive to the province. For example, the provincial cadastral system (le cadastre) was ratified in 1864 under authority of articles 2174 and 2175 of the Civil Code.* A prime objective of this system was to provide simplified descriptions of properties. Another principal aim was to facilitate registration of various rights related to ownership of any particular parcel of land. Application of the cadastral system began in November, 1866, and was extended to the Montreal district in the following year. Under the Quebec Surveys Act only a duly licensed surveyor can make valid surveys in the province and prepare plans of properties for public record such as cadastral lots, Crown lands, surveys of power sites, transmission lines and railway right-of-ways.

In the matter of surveying boundary lines of private and public properties the practices followed in the province can best be understood in the light of developments in France at the time of Louis XIV. In that era officials described as Arpenteurs Jurés (Sworn Surveyors) formed a privileged professional body and when a boundary dispute arose between owners of adjoining lands it was mandatory that a Sworn Surveyor be

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*Articles 2166 to 2176c (Civil Code). See ch. 320, R.S.Q., 1941.

appointed by the disputants or by a court in order that the boundary line might be established with finality. This method and procedure is followed in Quebec.

Property laws in Quebec are based on the Civil Law of France (Napoleonic Code). One of the more important features of that system of law is that concerned with the establishment of boundary lines or *bornage*. Under the Civil Code of Quebec any land owner can oblige his neighbor to participate in a *bornage*. This is mandatory and a

FIGURE 55. Association of Quebec Land Surveyors in convention on 50th anniversary of incorporation, Quebec City, 1932.

FIGURE 56. Downtown Montreal and waterfront (Jacques Cartier Bridge in background), about 1962.

neighbor may not refuse to cooperate. When accomplished on a friendly basis this survey operation is known as a *"bornage à l'amiable"*. When achieved through the intervention of a court of law it is described as a *"bornage judiciare"*.

When a deed to real estate is drawn up and properly authenticated it remains a documented description of the property. The surveyor is the interpreter of that description, the link between the deed of land and the fixing of the property outlines on the ground. In establishing the *bornage,* all deeds, plans, and other documents bearing upon the history of transactions affecting the properties involved, are assembled and listed by the surveyors concerned. On an appointed day, and at a previously arranged hour and place, the surveyor attends in order to meet both parties to the *bornage* and any other surveyor participating in the proceedings. The documents are duly examined and chainmen are sworn in. After a careful survey of the adjoining properties is completed the survey is tied in to existing landmarks or reference points. A plan of survey is then made for the purpose of easy identification of the lots and this plan is compared with the cadastral plan of the district. If the survey is accepted by both owners, markers are duly placed at each corner of the surveyed property. Then the surveyors draw up a *procès-verbal* of *bornage,* a joint document. By this legal document the *bornage* becomes an official proceeding. It declares the good professional standing of the surveyor and recites the list of deeds examined, plans studied, and details of any survey made in the matter. Finally there is a statement that the document has been duly read by the parties thereto and the accompanying plan or plans approved. Signatures are then attached and the document duly registered.[14]

In the event of a refusal by one or both of the parties to accept the recommended boundary line, it becomes necessary to proceed with a judicial *bornage.* The procedure then followed, requiring the participation of lawyers and of an expert surveyor appointed by the court, is a fairly rigid ritual and rather costly. The expert surveyor makes his own survey independently of the previous one, and prepares his own plan of the line. This plan as well as his report and recommendation are placed in a sealed envelope and forwarded to the custody of the court. The amount of the expert surveyor's fees and expenses are marked on the envelope which is not opened until the indicated amounts have been paid. In most cases the two parties to the dispute agree to half the expense.

Two systems of measurement exist in the province, namely, the French or Paris foot (arpent) and the Standard English foot (acre) and their respective multiples. The French foot is the standard measure of length in Quebec for measuring all land and lots sold prior to 1759 or since granted or sold by the arpent or foot where no special contract to the contrary has been concluded. The English foot is the standard measure of length in the province used in measuring all lands granted by the British Crown where a special contract has been made for that purpose.[15]

French and English Measures

Lineal

1 pied français	=	1.0657 Eng. feet
18 pieds français	=	1 perche 19.183 Eng. feet
10 perches	=	1 arpent
1 arpent	=	180 pieds français 191.835 Eng. feet

Square

1 pied carré	=	1.136 sq. Eng. feet
324 pieds carrés	=	1 perche carrée 368.017 sq. Eng. feet
100 perches carrées	=	1 arpent carré
1 arpent	=	32,400 pieds carrés 36,801.7 sq. Eng. feet

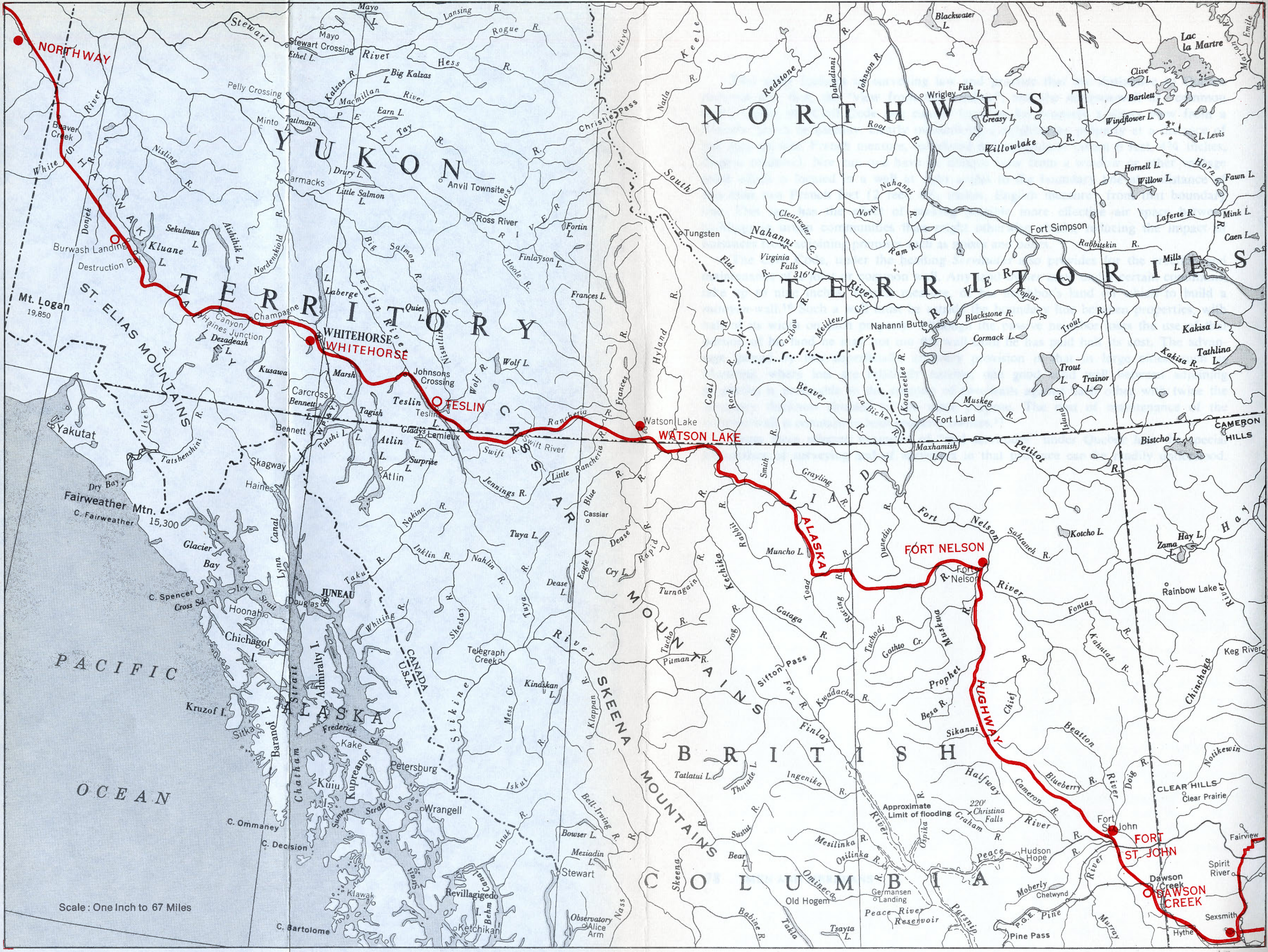
1 acre	=	43,560 Eng. feet
Side of an acre	=	208.71 Eng. feet
1 acre	=	1.184 arpent
1 arpent	=	0.845 acre
1 mile	=	27.52 arpents
1 link	=	7.92 inches
100 links .. 1 chain	=	66 Eng. feet
80 chains .. 1 mile	=	5,280 Eng. feet

10 sq. chains = 43,560 sq. feet = 1 acre

Two other features of surveying law and practice that are distinctive to Quebec province are, first, the "view from the window", and the *mitoyen*-wall or "common wall". Under the Civil Code one cannot have on his property a direct view from a window, porch or balcony, clearly overlooking a neighboring property at a distance of less than six feet, French measure, calculated perpendicularly (about 6 feet, 4¾ inches, English measure). Nor can one have an oblique view from a window or other vantage point which is located in a wall at right angles to the boundary line at a distance of less than two French feet (2 feet, $1\frac{9}{16}$ inches, English measure) from that boundary line. This law has the effect of making possible more effective air space between buildings in urban communities than might otherwise obtain, reducing the impact of nuisances from adjoining premises such as noises and odors.

The Civil Code, under the heading *Servitudes* also provides for the erection and maintenance of a joint or common wall. Any land owner may, under certain conditions, take up to nine inches, French measure, of his neighbor's land on which to build a *mitoyen*-wall.[16] Such a wall must be astride the boundary line between properties, with half of its width on each property. Although the passive neighbor loses the use of that portion of his land he may not use the wall until he has paid half its cost. The advantage gained by this superficially arbitrary provision is that in large cities, such as Montreal, where lots are relatively narrow, one good solid wall between adjoining properties is preferable to the erection of two walls against each other with twice the necessary thickness devoted to the same purpose. The cost of maintenance of the *mitoyen*-wall is common to both property owners.[17]

From these selected examples of "real servitudes" under Quebec law, the special importance of surveying and of surveyors in that province can be readily understood.



MAP 2. Route of the Alaska Highway from Dawson Creek, British Columbia, to Yukon-Alaska boundary

6

ALCAN AND CANOL: THE SURVEYS STORY

The Alaska Highway, the pilot road of which was undertaken and completed wholly in 1942, must be counted among the truly superlative feats of engineering performed on the continent of North America. The pioneer road, 1,523 miles in length, linked Fairbanks, Alaska, with the British Columbia community of Dawson Creek, some 500 miles northwest of Edmonton, Alberta. This unique highway project, the concept of which was described by one early critic as "an engineering monstrosity impossible of completion" was built in little more than eight months of arduous, unceasing labor and at a cost estimated at about $135,000,000.[1] Most of the road, some 1,221 miles, lies in Canadian territory. Although much of the credit for the location and construction work belongs to units of the United States Army Engineers and to contractors and workers employed by and through the United States Public Roads Administration, nevertheless individual Canadians, including surveyors and mappers, made vitally important contributions to the advancement of the project in preliminary stages of its construction. In addition, Canadian government military and civilian organizations became wholly responsible for post-war maintenance and improvements of the right-of-way, tasks calling for extensive surveying activity.

At the outset this road project was officially described as the Alaska-Canada Highway, conveniently shortened on occasions to Alcan Highway, then commonly and finally known as the Alaska Highway. The Canadian portion of the highway cuts across the northeastern corner of British Columbia and, in a general way, follows the British Columbia-Yukon boundary as far as Teslin Lake. From there it heads into Whitehorse, Yukon Territory, and, after skirting the west shore of Kluane Lake, reaches Snag on the Yukon-Alaska border. If a highway of similar mileage had been built from, say, east Florida in the same general direction as the northern road, it would have reached into Kansas. Seven engineer regiments of the U.S. Army, comprising nearly 400 officers and upwards of 11,000 enlisted men, worked on the Alcan project, aided by about 50 contracting firms employing more than 7,500 men. At least 130 bridges, several of them of major proportions, were built in addition to thousands of culverts.

The idea of an overland road link between the continental United States and Alaska was first conceived during a period of peace. In 1928 a location engineer, Donald MacDonald of Fairbanks, enthusiastically campaigned on behalf of this plan. As early as 1930 recognition of the desirability of such an undertaking was expressed in official actions by the governments of the United States and of Canada.[2] In that year, under the terms of Bill H.R. 8368, the President of the United States was authorized to designate three special commissioners to cooperate with representatives of Canada in a feasibility study of a highway to Alaska. Three Canadian representatives, headed by Hon. George Black, were named but, owing to depressed economic conditions in both countries, no action to implement these studies was taken. The idea of such a highway was revived in 1938 when the Alaskan International Highway Commission was appointed by the President. This was a five-man body and, later in the same year, its counterpart was established in Canada, headed by Hon. Charles Stewart. These two commissions jointly and severally carried out investigations of various proposed routes up to and shortly after the United States' entry into the Second World War. In the meanwhile the United States House Committee on Roads studied and reported on various bills proposing highway links with Alaska in 1930, 1935, 1938 and 1940.[3] The Canadian commissioners flew over much of northern British Columbia and recommended alternative routes, one through Prince George to Whitehorse and Dawson City, another through Prince George to Watson Lake by way of Pelly Crossing.[4]

During the relatively unhurried pre-war days of cautious probing and careful deliberation it was assumed that the location of such a highway would be determined, in the final analysis, by balancing its advantages against initial costs and subsequent maintenance charges. Its principal benefits would include usefulness as a defence measure as well as a developer of mineral resources and of tourist traffic. It was conceded that elevations, and depth of snowfall, would be factors having an important bearing upon the final decision on location. It was felt that consideration ought to be given to the availability of possible airfield sites along the route. The government of British Columbia had arranged

FIGURE 57. View of the Alaska Highway near Koidern River, Yukon. Kluane Range is in background.

for the scouting of three likely routes but it favored the Rocky Mountain Trench route by way of Prince George.[5] This route, of the three examined, had the lightest average snowfall, the longest open season, the shortest total distance to destination and, since it possessed the best grades and alignment, consequently the lowest construction and maintenance costs.

In the meantime, under civilian auspices, an unpublicized but portentous air probe had taken place in northwestern Canada. The findings of this investigation resulted, in time, in the rejection of all routes to Alaska previously under serious consideration. In the summer of 1935 the then Acting Superintendent of Airways and Airports, Alexander Daniel McLean (1896-1969), along with the enterprising Canadian bush pilot, C. H. "Punch" Dickens, D.F.C., flew on an aerial reconnaissance survey across northern Alberta, the Northwest Territories, Yukon Territory, and northern British Columbia. At that time air transport officials at Ottawa were planning for the long future in the realm of international airlines and had decided to seek out the shortest and best airway across northwestern Canada to Siberia and thence to China. In the latter stages of this far-ranging investigation McLean and his pilot were accompanied by Dr. Charles Camsell, Deputy Minister of Mines and Resources, whose knowledge of the Canadian North was intimate, extensive and highly respected. W. Sunderland, a flight engineer on this reconnaissance mission, served also as a cameraman and, in this latter capacity, had the responsibility of providing a pictorial record of the trip. In effect McLean's findings transformed the Edmonton-to-Dawson Creek-to-Fairbanks route into a road of destiny.

FIGURE 58. A. D. McLean.

Before his epochal flight McLean had consulted a large map of North America. Using Chicago as his principal cartographic base he had drawn lines on the map indicative of great-circle routes eastward to Europe and westward to Asia. His great-circle route to the west was a line running through Winnipeg, Manitoba, Fort Smith, N.W.T., and Fairbanks, Alaska, a point close to the Arctic Circle.

McLean's final report to Ottawa was succinct and conclusive. He pointed out the defects, as he saw them, in the Winnipeg-Fort Smith route. "In comparison", he stated, "the route from Peace River to Whitehorse by way of the valley of the Liard closely approximates the true great-circle route and greatly shortens the distance through which it would be necessary to develop an airway through virgin territory." McLean expressed the view that this latter venture was feasible and that, in his judgment, "there would be no section which, after development, would be inaccessible at any time of the year."[6] Sorties by air into the Liard country had been confined, up to that time, to occasional transportation of prospectors and trappers. Stan McMillan of Edmonton was a noted bush pilot who made a number of flights of this nature into that largely unknown part of Canada.

In the course of the year preceding the McLean probe and report, the possibility of establishing an airmail service on a regular basis between Edmonton and the Yukon had been scouted by two other Canadian bush pilots, Ted Field and Grant McConachie. The latter flier, years later, became president of Canadian Pacific Airlines. These two trailblazers of the air, flying Fokker Universal aircraft, carried out this reconnaissance at the request of the government at Ottawa. They promptly organized a company, United Air Transport, later the Yukon Southern Air Transport and, in 1937, the Post Office Department awarded them the mail-carrying contract between Edmonton and Whitehorse on a weekly basis. The frequency of this service gradually increased until, in 1940, it was on a daily basis.

These regular mail flights were carried on, in the absence of intermediate airfields, by means of pontoons in summer months and skis in the winter period. Both McLean and his Ottawa chief, J. A. Wilson, Controller of Civil Aviation, made trips with McConachie over the airmail route during this period. Its suitability as an airway to Alaska and, eventually, Asia, was amply demonstrated to Wilson, and approved by him at that time. It should be borne in mind that at this stage in the history of aviation generally, there were no high-altitude aircraft in use; very little, if any, flying by instruments and, apart from Lindbergh's epochal Atlantic crossing and several other extraordinary individual or dual exploits, no trans-ocean flights. Thus, even across the land mass of northwestern Canada the need for a system of intermediate airfields between Edmonton and Fairbanks was obvious if that route was to be, in fact as well as in fancy, a "Northwest Passage" by air to Asia. In the spring of 1939 a survey of the proposed airway was authorized by the government at Ottawa. The precise location of airfield sites and related detailed contour surveys were carried out by W. L. Lawson and R. Crossley. Landing strips suitable for extension and each served by a radio range station were installed.[7] The knowledge that these landing fields had been planned and surveyed, and were in varying degrees of readiness for full use, undoubtedly weighed the balance in favor of the Northwest Staging Route when the final decision for the location of the Alcan Highway had to be taken.

On the ground between the airfields there had been other helpful developments. As early as 1922 parties of the Topographical Survey of Canada had cut a pioneer sleigh trail from Fort St. John to a winter station called Horsetrack on the Sikanni Chief

River, a point from which trade goods were customarily scowed downstream in the springtime to Fort Nelson.[8] Philip H. Godsell, explorer in the Canadian northland, has claimed that he blazed a trail between these same two points in 1925.[9] In any event the Department of Transport, early in 1941, widened the trail by using bulldozers and extended it to the site of the newly-established Fort Nelson airfield as a winter road. The only other important roadway along the entire Northwest Staging Route in Canada was a 160-mile wagon road that had been opened from Whitehorse to Kluane Lake. This latter facility proved highly useful as an access road in preliminary stages of Alaska Highway construction.

In the depression period of the early 1930s, when surveying activity throughout Canada was generally at low ebb, the Dominion land surveyor, Knox Freeman McCusker (1890-1955) and a companion, Glen Minaker, acted as guides in northern British Columbia for hunting parties organized by wealthy Americans. In 1935 such a venture took them from Fort St. John to the Pacific Ocean by way of McDame Creek. When they returned to their winter camp that autumn the Canadians read newspaper references to a proposed highway serving to connect Alaska with the continental United States. Stimulated by these reports the two men busied themselves during the off-season by locating on paper a more or less feasible route extending in part as far as Lower Post, B.C., just across the boundary from Watson Lake in the Yukon. McCusker, over the years, had gathered considerable information from Indians of the region concerning the nature of the country between Lower Post and Whitehorse. All this knowledge, which he had accumulated as a guide in the northland, was incorporated in the rough-drawn map. McCusker and his friend little realized that, seven years later, this map would prove to be exceedingly useful in promoting an important strategic enterprise of the free world in a deadly conflict of global scope.

It was during this period of economic depression that one of the strangest overland expeditions ever to venture into the Canadian North West originated in Edmonton in July, 1934. The highly implausible cavalcade that was organized and financed that year by the French multimillionaire, Charles Eugene Bedaux, was formed ostensibly for exploration purposes. It consisted, in transport equipment, of two shiny new limousines, five Citroen tractors and some 130 horses loaded with gasoline tins. The core group of the expedition was composed of Bedaux and his valet; two refined ladies from the gracious, elegant salons of Western Europe; Madame Bedaux and her friend, Madame Chiesa, along with a maid-in-waiting and, on the more practical side, two British Columbians well-versed in the lore of the northern wilds, the Dominion land surveyors Frank Cyril Swannell (1880-   ) and Ernest Charles William Lamarque. The announced destination of the Bedaux expedition was Telegraph Creek, B.C., on the upper Stikine River.[10] The expedition left Edmonton on July 6, 1934.

Although Swannell was expected to render services to the expedition as a mapper, it soon became obvious that Bedaux's interest in cartography was, to say the least, desultory. When Swannell was ordered at one point on the route to abandon nearly 100 pounds of surveying equipment, he felt confirmed in his earlier suspicions that the expedition was more in the nature of a publicity stunt than a serious scientific probe into an unchartered wilderness. With the sudden dismissal of the expedition's radio operator, Swannell was deprived of the use of Greenwich time signals for position-fixing purposes. The forward advance of the party was constantly hampered by wastage of time, stores and equipment as well as the loss of many horses. The Muskwa River was reached on the last day of August but, with colder weather rapidly approaching, Bedaux gave

FIGURE 59
F. C. Swannell.

instructions to turn back at Sifton Pass, some 200 miles short of their announced goal. By the end of October, 1934, the expedition had come to an inglorious end. It had cost its wealthy sponsor about a quarter of a million dollars and, in the process, provided a stream of sensational news despatches that had regaled the reading public in many nations at a time when extravagant distractions were at a minimum.

The bizarre venture, however, was not a complete loss from a practical standpoint. Experience in the use of tractors in the hinterland of northern British Columbia revealed the severity of conditions under which modern roadbuilding machinery could be expected to operate should the construction of a major highway be attempted in that part of Canada. The cross-country progress of the Bedaux expedition also added somewhat to general knowledge of the region it traversed. It is significant to the theme of this chapter that Bedaux remarked on the dispersal of his cavalcade, "a start has been made on a highway to Alaska."

During 1940, as diplomatic relations between Japan and the United States deteriorated, tension between the two great powers began to mount in the Pacific area. The fact that Alaska, in all North America, offered the mainland target most vulnerable to attack from Asia, caused increasing concern in Washington, D.C. In August, 1940, under the Ogdensburg Agreement, the United States-Canada Permanent Joint Board of Defence was established. Provision for the movement of American warplanes across western Canada to Alaska, and possibly to the Soviet Union, was considered imperative. In November of that year, in Victoria, B.C., the board recommended construction of a line of airfields from Fort St. John to Fairbanks, soon to become generally known as the Northwest Staging Route.

Meanwhile, in 1939, Canadian authorities had authorized, as has been noted, a more detailed survey of this airway project, including location of airfields at Grande Prairie, Fort St. John, Fort Nelson, Watson Lake and Whitehorse. Later, intermediate fields were to be added at Beatton River (between Fort St. John and Fort Nelson), Smith River (between Fort Nelson and Watson Lake) and Snag Creek (between Whitehorse and Fairbanks). An Edmonton construction firm awarded the airport-building contract at Fort Nelson, ingeniously put together a diesel trailbuilder train that chugged out of Dawson Creek and headed northward on February 9, 1941, over the existing rough winter trail. In April and May surveyors were busily engaged at Fort Nelson laying out runways and setting grade stakes. One year later United States forces were to travel over this same winter trail during the first stages in the building of the Alaska Highway.

FIGURE 60. Typical scene on the pioneer winter trail between Fort St. John and Fort Nelson.

During the spring and summer of 1941 McCusker and his associates in the packing business aided the Department of Transport in the freighting of heavy equipment and supplies to the Fort Nelson airfield by employing scows on the Sikanni Chief River. In the following winter nearly 1,500,000 gallons of aeroplane gas and motor fuel in drums were conveyed to that field. The primitive road was so bumpy in places that occasionally a barrel would jump clear of a truck. A missing drum lay for weeks beside a rivulet known as Buck Creek. One day a plane, operated by a construction official, left Whitehorse for Fort Nelson. Unable to land at its destination because of poor visibility, it continued in flight. With fuel running low and perceiving a fairly level strip of ground the pilot decided that this was the most suitable available place in the wilderness on which to make an emergency landing. Safely down, the official left his plane to take stock of his surroundings and noticed a small patch of red on the snow a short distance away. Upon closer investigation the object proved to be a drum of aeroplane gas, the same barrel that had been bounced out of the supply truck. In the whole of that vast, unpeopled region this pilot had selected, by sheer coincidence, the only landing place equipped with fuel for his plane!

A Vancouver construction firm was awarded the Watson Lake airfield-building contract and began freighting loads upstream on the Stikine River after the spring break-up, the first loads arriving on site on July 9, 1941. Thus, by December, 1941, on the entry of the United States into the Second World War, an airway remote from enemy attacks, equipped with what was then up-to-date air navigation aids and at least rudimentary lighting facilities, had been established by Canadians between Edmonton and the Yukon-Alaska boundary. In 1942 the United States was to spend many millions of dollars improving the airfields along the staging route and installing more than a dozen intermediate landing strips.

The highly destructive Japanese attack on Pearl Harbor, Hawaii, in December, 1941, and the crippling loss to the British fleet soon afterwards through the sinking of two of its major battleships, *Prince of Wales* and *Repulse*, in Far Eastern waters, drastically altered the balance of naval power in the Pacific Ocean. The entire situation in that vast area, from the standpoint of the free world, was enveloped in an atmosphere of extreme urgency. Often wars act as catalysts, bringing into being immense projects which, in peacetime, appeared to be far beyond early realization. Thus, in regard to the Alaska Highway proposal, political and bureaucratic wheels began to turn with increasing rapidity. On January 16, 1942, immediately following a strong appeal in Congress by Delegate Dimond of Alaska for action on the road, a committee of three members of the American cabinet was appointed by President Roosevelt to meet the War Plans Division of the Army General Staff and to discuss the ways in which Alaska could best be defended. This committee was soon convinced that a highway linking the continental United States with Alaska, along a route reasonably remote from enemy onslaughts yet capable of ferrying planes, troops and supplies on a large scale, was vitally essential. The water route along the Pacific Coast, exposed to activities of Japanese submarines, had become hazardous. Late in February, 1942, the joint board on defence authorized the undertaking, and formal agreement of the two national governments directly concerned was embodied in an exchange of notes between Ottawa and Washington in mid-March. The agreement provided for the construction of a major highway from Dawson Creek, British Columbia, to connect existing airfields between that point and Fairbanks. There had been strong arguments, vigorously advanced, in favor of other possible routes and had a decision on the various choices been made during peacetime it is quite likely that one of the alternative routes would have been selected. But investment in existing airfield construction together with the expert opinion of United States army engineers that such a connecting highway could be built over the Northwest Staging Route within the time limit set for its completion, outweighed all other factors. Speed of construction and considerations of a completely military character had become suddenly paramount.

A trail investigation group from the United States arrived at Sikanni Chief River early in 1942 and consulted with McCusker and others whose first-hand knowledge of that part of Canada's northland was both well-known and widely respected. McCusker assured the group that if advance units of roadbuilders could be in position at Fort St. John by mid-March he would guide them in location work for a pilot road across some 500 miles of hinterland before the spring break-up. Within three weeks of this preliminary discussion McCusker's offer was accepted officially and the Canadian land surveyor was soon fully occupied in organizing outfits able to guide American engineers across country from Fort St. John to Toad River for the purpose of confirming on the ground the findings of aerial surveys of the region, involving the stereoscopic examination of air

FIGURE 61
Typical temporary bridge on pioneer trail of the Alaska Highway.

photographs. By the employment of several dog teams on separate missions, reconnaissance was accomplished of some 450 miles of possible route within a month.[11] In the main, the scouted line followed closely the route sketched by McCusker for his own satisfaction seven years previously.

The awesome vistas and ancient ways of life of the north country had seemed unchangeable. High over the mountain peaks, planes shuttled over dark forests and deep canyons where the roar of mountain streams and wolf howls echoed weirdly. Moose still came to lake's edge to drink at dusk. Trappers continued to set snares for the wary fox. Bears ambled forth after a long winter's sleep and in the late springtime fattened on wild berries and fish. Canoes slipped noiselessly along watercourses, summer highways in the wilderness. In winter, dog trains followed trails which ran straight as an arrow's flight over hill and dale. But a startling change was near. Silent forests would soon resound to the snarl of the power saw and the mechanical snorts of bulldozers and caterpillar tractors. The end of the quiet hinterland was at hand; myriads of men were on the march and this scarcely trodden wilderness was their battleground.

By mid-March soldiers, machinery, and supplies began to arrive at Dawson Creek, the end of steel. Engineers commenced to travel up the trail toward Fort Nelson. Astonishing roadbuilding developments followed in rapid succession. A highway survey between Dawson Creek and Fort St. John was completed for the purpose of improving the existing road to accommodate the anticipated heavy traffic. Word went through the northland by 'moccasin telegraph' calling all pack-horse train operators (packers) into action. From the hills and valleys came the Napoleons, Calahoos, Beattons, Belcourts, Letendres, Campbells and Camerons, along with Cree and Beaver Indians and a total of about 400 horses. The age of the packers had suddenly returned to the northland.

McCusker, in his unpublished memoirs, described the customary highway construction procedure followed in conquering the hinterland. Two men, guided by McCusker, blazed the initial trail. The Canadian, who plodded ahead on foot, kept waving the pair onward. After them came the stadia survey party who ran the preliminary line and cut a pack trail of sorts for the use of advance transport. The surveyors were closely followed by a single bulldozer, busily opening a narrow swath through tree growth along the stadia or centre line so that other bulldozers, in squads of six, could operate on a larger scale. Three large bulldozers felled big trees and three smaller machines cleaned up resulting debris. This clearing operation made way for rough as well as finished grading work, installation of culverts and of small bridges. During this stage an Indian, travelling along the old packhorse trail from the direction opposite to that of the advancing Americans, remained blissfully unaware of the brutal, crashing advent of 'civilization' into his placid, lonely domain. Suddenly he came upon a caterpillar tractor, operated by a negro soldier, at a moment when the cat had casually tossed several sizable trees high into the air. The Indian, it is related, left the scene and tarried not in the leaving. When at last he reached a trading post the native gasped out the obscure but somehow terrifying message, "Big black devil him come!"[12]

FIGURE 62. Army truck fording a stream in flood during survey reconnaissance along the Alaska Highway.

After the cats had levelled the roadway for grading, subsequent parties located the final route, building corduroy road and culverts when required. Pack trains threaded their way gingerly through tangles of tractors, graders and toiling men. Radio equipment enabled workers to keep in close, constant touch with developments all along the regional line of construction. In this manner the pilot road of the Alaska Highway was pushed through forests of stately evergreens, across swift-flowing rivers and streams, over mountain passes, and alongside shimmering lakes and brooding glaciers, old as time.

The story of hardships and discomforts endured cheerfully, if cussingly, by these indefatigable roadbuilders, spurred on by inter-regimental rivalry, will never be fully told. "We were soon to find out," wryly commented one engineer, "that each of us had muscles we had not previously known about." Again, "Mushers ahead left a piece of bannock and a can of grapefruit juice at the side of the trail. The bannock was cold and the grapefruit was frozen."[13] This was hardly the sort of fare to revive hungry, cold and tired men laboring through the unfriendly bush. Voracious mosquitoes and flies, dust in billowing clouds, sub-zero temperatures and bone-chilling, sleety rains frequently

FIGURE 63. The original Peace River bridge. Erected 1942, partly collapsed in 1957 and replaced in 1960.

made life miserable for human beings and animals alike. In addition, the baffling problems of deep-penetrating permafrost, jelly-like muskeg, and swampy lowlands had to be faced and solved in a hurry.

The initial drive to reach Fort Nelson with vehicles and supplies proved to be a stamina-testing race against the advent of the spring break-up. Men worked in extremely long shifts and motor engines were seldom turned off. A false thaw set in at one stage of the work. Men and machinery floundered in a sea of soft mud. River ice began to heave. Suddenly, Fort Nelson seemed unattainable. But just as hope was fading 'General Frost' came to the rescue of the toiling troops. Muskeg again froze over, cracks in river ice filled in. During those few days of grace, extending almost to mid-April, hundreds of trucks freighted in to the airfield mammoth loads of supplies required for its improvement. The trucks were kept moving night and day during this critical period. A pilot who flew over the busy scene one night reported, "the stretch of road into Fort Nelson looked like Broadway. It seemed to be lit up all the way with the headlights of trucks."[14] Often the ubiquitous jeep, that tireless workhorse with its narrow wheelbase, powerful engine and four-wheel drive, covered with ease ground that was so difficult to cross that heavier, less versatile vehicles bogged down completely.

Official assistance to the American roadbuilders was not entirely provided, on behalf of Canada, through the good offices of the federal government. Prior to the entry of the United States in the Second World War Ontario had developed, through its provincial government services, a system employing air photographs by which it was possible to locate on the ground lines of proposed new highways. After selection of the most acceptable route on the basis of planimetric data, topography along the projected line was checked for grades and surface conditions through examination of stereoscopic photo pairs. This procedure entailed the services of an examiner experienced in photo-interpretation. Information produced by orienting and scaling the photographs into mosaic form often resulted in major revisions of the line first chosen.

The Alaska Highway construction authorities, aware of Ontario's progress in this special field, asked for the services of Ontario government officials directly involved. R. N. Johnston, in charge of aerial surveys for the Department of Lands and Forests, and K. H. Siddall, chief location engineer for the Department of Highways, arrived at Fort St. John in June, 1942, and were at once attached to the Southern Sector Task Force.[15]

By the use of air photographs much faster progress was made on the establishment of a line of highway than would have been possible without them. By the use of air transport, survey parties had moved rapidly and easily to points along the entire line of proposed road. Location work, accordingly, was greatly simplified and accelerated. Without any doubt the highway could not have been built so swiftly without the facilities provided by the airway system already established through the foresight and wise action of Canadian leaders. As it was, all road construction records were surpassed when the highway between Dawson Creek and Fairbanks was completed.

On November 20, 1942, in 30-below zero weather, the official road-opening ceremony took place at Soldiers' Summit overlooking Kluane Lake. After the red, white and blue ribbon was cut, a convoy of trucks left for Fairbanks, the first vehicles to travel over the highway from Dawson Creek to the Alaska terminal. Ten thousand soldiers divided into seven army engineer regiments, aided by 8,000 civilian workmen had completed their task in record time. They had pushed forward at the rate of eight miles a day, bridged 200 streams and rivers, laying a roadway 24 feet between ditches. The highest point on the highway, 4,212 feet above sea level, occurred between Fort Nelson and Watson Lake.

With the completion of the Alaska Highway the long isolation of northwestern Canada from the rest of the world was brought to an abrupt end. Although the immediate purpose of the road was to serve urgent military needs, its potentialities for promoting peacetime development of Canada's renewable and non-renewable natural resources as well as tourist traffic in that part of the nation, were implicit in the project. Moreover the Northwest Passage to the doorstep of Asia, for several centuries the dream of men of enterprise and vision, had become a reality by air and by highway in the 1940s in Canada.

The Canol Project

At about the time that the Alaska Highway was launched to follow along the line of the Northwest Staging Route, another northern engineering enterprise of major proportions began to take shape in the minds of American military authorities. They became convinced, as Japanese aggression continued in the Pacific area, that a reliable supply of oil for aircraft and mechanized ground units engaged in defence operations in Alaska was urgently required. In the light of all factors obtained at the time the sensible solution to this problem appeared to be the construction of a pipeline from the modest but still active oil field discovered and developed in the early 1920s by Imperial Oil Company of Canada in the vicinity of Fort Norman. This field was located on the banks of the Mackenzie River near the 65th parallel of north latitude. The plan called for the transportation by pipeline of the crude oil to a refinery to be constructed at Whitehorse, from which point the gasoline could then be shipped to points in Alaska.

The direct airline distance from Whitehorse to Norman Wells is about 425 miles but a pipeline overland between these two places would extend to nearly 550 miles. In addition an all-season highway would have to be constructed along the entire route of the pipeline in order to expedite its construction and any servicing involved in its use. The roadway would govern grades along the course of the project, not the pipeline. Pipe could be laid on the surface of the ground except at river or stream crossings where pipe could be either buried or suspended.

Late in April, 1942, Canadian officials of Imperial Oil Limited were invited to Washington in order to discuss with army authorities there the proposal that came to be known as the Canol (Canadian Oil) Project. In June of that year official notes were exchanged between Ottawa and Washington embodying agreement of the two governments on principal features of the proposal. Again the need arose to achieve maximum results during the relatively short construction season in the Canadian North; a race of men and machines against the hostile elements. One of the first steps to be taken was the establishment of a line of airfields between Edmonton and Norman Wells in order to speed the movement northward of Canol personnel, supplies, and equipment. Most Canadian flying in the northland, down the Mackenzie, had until this time been accomplished in planes using skis in winter and pontoons in summer.

In the region between Whitehorse and Norman Wells careful reconnaissance survey work was essential. This was a largely untravelled wilderness, formidable and even forbidding to all but the most zealous explorers. On the horizon west of Fort Norman and nearby Norman Wells were the peaks of the Mackenzie range, described in Père Pettitot's

FIGURE 64
Surveys on the Alaska Highway at junction of pilot road and the permanent highway.

map of 1875 as "the backbone of the earth."[16] But a certain amount of authoritative information on the country between this range and Whitehorse was available as a result of a pioneer reconnaissance made in the region by Joseph Keele (1863-1923) of the field staff of the Geological Survey of Canada in the seasons of 1907 and 1908.[17] Keele investigated with characteristic care the areas drained by the Pelly, Ross, and Gravel rivers and his 54-page report on a variety of aspects of the region, was issued in 1910 as a government publication separate from references on the same subject in annual summary reports of the Geological Survey of Canada. A map of the country he had explored formed a supplement to his report.

As Keele was no longer alive the American authorities, in this time of special need, turned to a man possessing extensive, first-hand experience of the Canadian North West, the Ottawa-born Dominion land surveyor, Guy Houghton Blanchet (1884-1966). In early discussions of problems involved in the Canol Project the decision had been reached to resort to a rapid air reconnaissance. The initial selection of a route would be made on the basis of information supplied by such flights. Ground surveys would then be undertaken. Construction work on the road and the pipeline would follow, just as soon as contractors could establish their organizations in the field. Accordingly a number of flights were made over the area situated between Norman Wells and Whitehorse. The terrain was studied from altitudes ranging up to 12,000 feet. As a result of these air surveys the Mountain River valley appeared to be preferable to the Gravel River route. Efforts to carry out ground surveys in the case of the former proved futile, however, because heavy vehicles employed by the surveyors bogged down in the soft soil of the Mackenzie River valley.

A decision to abandon the tentative location line was soon made. But time was fast running out and a feasible route had to be projected so that construction could commence in the spring of 1943. Indians at Fort Norman spoke about an obscure trail that they regarded as an improvement on any of the routes already considered. This trail, the natives claimed, by means of an almost concealed break in the mountainous barrier, entered the range that flanks the Mackenzie River to the west. Blanchet thereupon resolved to make an overland reconnaissance, using a train of dog teams. Early in October, 1942, he set out from Teslin River with five dog teams. After travelling one hundred miles he sent back two of these units to the starting point. His examination of the country between Johnsons Crossing (at Teslin River where it leaves Teslin Lake) and Pelly River produced a satisfactory location for the Canol Highway over that part of its total length. In the same season and covering that same distance a survey party followed Blanchet in tractors and carried out a stadia traverse. Air photographs helped to establish line location as far as Christie Pass. This latter feature crosses the continental divide on the border between Yukon Territory and the Northwest Territories.[18]

Blanchet, with his three dog teams, travelled light and in company with several Indians familiar with the region and adept at living off the land. Only track survey methods were employed by Blanchet, including compass bearings, estimated distances and barometer elevations. The Indian trail proved to be a remarkably good one, established by natives who knew every mountain, valley, and pass. The trail followed the deep canyon of Sheep Nest's River, a tributary of the Carcajou. This route involved a climb to a point nearly 5,000 feet above sea level. One of Blanchet's Indian guides had to draw frequently on his faltering memory in selecting the proper path to follow. At one stage in their progress the party had to rely on a sketch drawn by an old native who was much more skilful in hunting game than in the arts of cartography. One of the guides accompanying Blanchet also drew maps of the country as the party advanced and although, taken separately, these were very rough representations, in combination they provided a fairly comprehensive depiction of the region's topography.

After what seemed to its members an interminable time the reconnaissance party finally broke out of the high ranges into the wide expanse of a plateau. Blanchet, in a poetic mood, recorded his impressions in his diary: "At last we are clear of the crowding mountains. The sun shone brightly on us today and our view expanded. From the summit of the pass we could see far to the southwest . . . at the limit of the view we could see a massive range where the Selwyns form the continental divide and, dim and shadowy as a cloud, rising above them was a peak which, I think, is Itsi Mountain."[19]

Following Blanchet's reconnaissance it was concluded that the route offered no major difficulties and, in fact, much of it was reasonably satisfactory for road and pipeline construction. In the late winter of 1942-43 a tractor train carried the survey as far as the continental divide. By springtime the reconnaissance on the ground had been completed from Norman Wells to the Alaska Highway. In the surveys that followed some formidable obstacles were encountered. Close distances were required for computing sites of pumping stations and these were sometimes difficult to obtain because construction factors led, in a number of instances, to local changes of route. At times resurveys were required when the pipeline left the line of surveyed highway.

By late September, 1943, Blanchet drove by car over a completed part of the Canol Highway. "It seemed incredible", he observed, "to be driving easily and swiftly over a highway where, just a year before, we had been considering a wilderness from the air, studying the possibilities of penetrating it . . ." Early in December roadbuilding work was largely finished and about mid-January, 1944, the final weld was made connecting the pipelines advancing from Whitehorse and Norman Wells respectively. The rugged mountain barrier had been successfully traversed in 20 months and a long, sinuous oil supply line now wound through the shaded valleys and high passes, close to a new highway that crossed a land remote and uninhabited save for mountain sheep on the steep slopes and by bears as well as moose in the lowlands.

At the cost of fantastic exertions and considerable human hardship as well as expenditures of more than $130,000,000, this basically uneconomic but potentially invaluable project ended in a dismal anti-climax. Five years after its completion, in 1949, the wartime emergency having disappeared, much of the Canol Highway was allowed to fall into disrepair, more than five hundred miles of 4-inch pipeline was dismantled, and the newly-built refinery at Whitehorse was transferred to Edmonton by Imperial Oil Limited.[20]

In subsequent years only parts of the Canol Highway were rehabilitated. But the exploratory surveying and mapping activities carried on by Canadians such as Joseph Keele, Knox F. McCusker and Guy Blanchet made possible the launching and completion of major wartime projects at a critical stage in the defence of North America in the 1940s. Their efforts to probe an unmapped and remote northern land in order to unlock its secrets and to overcome its problems, represent triumphs of the human spirit and of human endurance over heavy odds. Their achievements reflect immense credit upon the profession in which these doughty trail-blazers served with such resourcefulness and distinction.

The construction of the Alaska Highway, completion of the Canol Project, and the establishment of a system of airfields in northwestern Canada created a pressing need for Canadian surveys of various types. To meet this requirement both military and civilian authorities, in the mid-1940s, launched programs of control and miscellaneous surveys designed to extend over a period of years. Early in 1946 the Department of National Defence took over from the Americans the maintenance of the Canadian portion of the highway, access roads to airfields as well as landing strips along the Northwest Staging Route, in accordance with the terms embodied in the 1942 exchange of notes between Canada and the United States.[21] The Corps of Royal Canadian Engineers, in particular, was entrusted with the administration of this undertaking known as the Northwest Highway Maintenance Establishment. Realignment and relocation work had become necessary on the highway in some sections. Several temporary bridges had to be replaced by permanent structures. All these reconstruction activities called for the special services of the Army Survey Establishment, R.C.E. For example, in the five-year period, 1953 to 1957 inclusive, a total of 89 major survey tasks was carried out by army survey parties. The Royal Canadian Air Force continued its program of aerial photography designed to assist in mapping the region. Map sheets were completed on each side of the highway over its entire length.

FIGURE 65
Plaque near Whitehorse, Yukon, commemorating transfer of the Alaska Highway from United States to Canada, 1946.

Special reference should be made to the important part played by the Royal Canadian Air Force in air-survey work in the Canadian Northwest. From the summer of 1919 when a former R.F.C. pilot engaged in private enterprise, Captain Daniel Owen of Annapolis, Nova Scotia, used airborne cameras to photograph 250 square miles of timberland in Labrador, the air force had employed aerial photography in northern surveys.[22] Prior to the Second World War, and beginning with hand-held cameras, the Royal Canadian Air Force photographed more than a quarter-million square miles.

Processing techniques gradually improved so that raw film could be successfully converted into forms suitable for map making.

As the end of the war approached the Royal Canadian Air Force resumed its intensive air-survey work. Cameras could now be installed in long-range, multi-engine aircraft capable of high-altitude flights. The trimetrogon camera came into use, permitting aircraft to take three photographs simultaneously, portraying the full sweep of the horizon ahead. From 1944 to 1955 the Royal Canadian Air Force photographed every square mile of northwestern Canada and supplied data to cartographers in the form of photographs of three and a half million square miles, the largest such program undertaken in the world up to that time.[23]

While its trimetrogon work was being carried on the Royal Canadian Air Force experimented with vertical photography in order to provide more detailed pictures for use in large-scale mapping activities. Civilians were encouraged to increase the scope of their ventures in air-survey work. In fact the Royal Canadian Air Force loaned aircraft and released trained men for such employment. As civilian operations increased in this field, Royal Canadian Air Force activity lessened.

On the ground and along the Alaska Highway Canadians were increasingly active. A technical officer, James Quong, serving with the army maintenance organization, was in charge of control for bridge design engineering. One of his most memorable experiences occurred during the winter of 1944-45 when he was surveying on the Alaska Highway one very frosty morning, assisted by a rod man. The temperature reached thirty below zero during the performance of their duties. About mid-morning Quong looked through his instrument but failed to see either rod or man. The assistant did not reappear. Either he had been dragged off by a wild animal or, more likely, had departed from the scene without due formality and headed for points south. In all probability his sudden leave-taking was inspired by the conviction that no sane person would attempt to carry out a survey under such adverse conditions![24]

Geodetic, topographic, legal and geological surveyors in the employ of the federal government, began to appear on the Alaska Highway and in adjoining areas in increasing numbers. Field parties of the Geodetic Survey of Canada were busy during the seasons 1944 to 1953 inclusive. In the 1943 season a party of the United States Coast and Geodetic Survey had completed an extension of its Alaskan triangulation net from White Pass station, north of Skagway, along the line of railway to Whitehorse and then along the Alaska Highway to Fairbanks. J. V. Thompson of the Geodetic Survey of Canada served with the American party, accompanying it as far as the Yukon-Alaska border. In 1945 the primary net in the region was projected as an extension from Whitehorse to the vicinity of Watson Lake. The Canadian program involved the continuation of this triangulation net along the entire length of the Alaska Highway eastward to Dawson Creek and beyond until a junction could be made with the Alberta primary net in the vicinity of Edmonton. These activities were intended to provide immediate control for surveys and mapping along the British Columbia-Yukon boundary as well as control for surveys of the highway itself and areas adjoining it.[25] During the five-year period some of the geodetic surveyors active in this work were George Hueston, G. M. Gibling and F. P. Steers.

In the spring of 1948 experiments were made in the use of the helicopter in order to test its capabilities for transporting reconnaissance, observing and light-keeping personnel and equipment from base camps to triangulation stations in mountainous terrains. Washouts and floods along the highway resulted in delays, including the delivery on site of helicopter gasoline. It was not until the morning of June 20th that the first test flight was made. This event marked the initial trial of a helicopter on Canadian geodetic work.[26] Rain and fog hampered observing work during much of the 1948 season. But these surveyors encountered troubles other than those related to inclement weather. One of the light-keepers reported ill and asked to be taken to the outside. Fortunately his case was quickly and correctly diagnosed as the effects of an allergy to pollen of balsam trees. Removal of the man from the vicinity of any heavy concentration of balsam speedily corrected his bronchial and asthmatic condition. Two days after this cure one of the two packers employed by the survey party began to suffer with a badly infected tooth. It was necessary to transport him to Whitehorse for the extraction. In his absence three pack horses wandered off and were lost for three weeks. While the search was under way for these missing steeds, two others were found and used by the party until autumn when the animals were turned over to their owner at Lower Post.

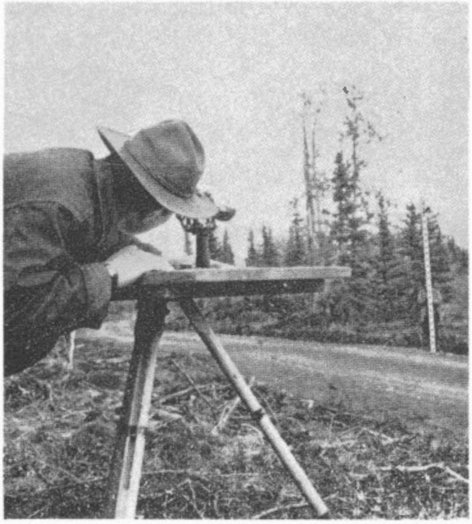


FIGURE 66
Levelling operations along the Alaska Highway, Geodetic Survey of Canada.

In addition to triangulation work for the Canadian government, the Geodetic Survey undertook in 1944 to extend the precise level net from Edmonton to join at Whitehorse the corresponding net established in the previous year by the United States Coast and Geodetic Survey. David MacMillan (1888-), in later years chairman of the Ottawa Transportation Commission, was in charge of this work in the season of 1944. Two double-unit levelling parties were involved in this plan to add an important link to the international level system of North America and to provide as well basic vertical control which, up to that time, had been lacking in northwestern Canada.

The need for various kinds of legal surveys quickly grew with the turnover of the Alaska Highway to Canadian administration. McCusker, assisted by the Dominion land surveyor John Bevan Walcot, monumented along the highway, beginning in the survey season of 1944 and continuing until the early 1950s, and produced plans of the right-of-way.[27] In the field season of 1946 Lorne Louis Anderson and Theodore Hans Kihl, both of whom became Dominion land surveyors a few years later, assisted McCusker as articled students. In the 1947 season Edgar John Benson, destined to become Minister of National Revenue (then Finance) for Canada in the 1960s, served as chainman on the final 100 miles of survey on the highway up to the border between the Yukon and Alaska.

In addition to right-of-way surveys there were legal surveys conducted to define intersections of the highway with lines of private property, for highway relocation and, on occasion, the establishment of airport boundaries.

Men of the Topographical Survey of Canada were also exceedingly active in postwar seasons in the regions served by the Alaska Highway. As an example, in the 1948 field season 12 parties from this organization surveyed 26,700 square miles by phototopographical methods for maps published on a scale of 4 miles to the inch, also 1,052 square miles for maps to be published on a one-mile-to-the-inch scale. These surveys, beginning in 1947, were reinforced by five parties from the Canadian Army Survey Establishment. The Dominion land surveyor, William N. Papove, B.C.L.S., A.L.S., was engaged during this same period by the government of British Columbia in boundary (British Columbia-Yukon) survey work, frequently conducted in the vicinity of the Alaska Highway.

7

CANADIAN HYDROGRAPHIC SURVEYS: 1917-1947

"*. . . no gold for sounding:*"

—*Romeo and Juliet*, Act 4, Sc. 5.

Charts may be described as road maps of navigable waters for the use of mariners, designed to reveal the bend of the coastline or shorelines, the position of rocks, shoals or other submarine hazards, and of lights and buoys. Charts also show depths by figures representing fathoms or feet, as well as depth contours. All this vitally important information is derived from hydrographic surveying, a service inseparable from, and indispensable to, safe navigation. Because sand tends to shift, especially in estuaries, and because larger ships with deeper draughts continue to be built, many areas in Canadian waters require resurveying from time to time. Increases in volume of ship traffic in a waterway or sealane also may call for renewal of surveys.

As has been shown in previous volumes of *Men and Meridians* hydrographic surveying has been closely linked with the story of the discovery, exploration, colonization and economic growth of Canada. The spectacular expansion of British sea-power in the 19th century, both in naval and mercantile functions, was accompanied by considerable hydrographic survey work. Seacoasts in all parts of the travelled world, including those of Canada, were surveyed and charted by ships of the Royal Navy. A result of all this scientific and exploratory activity was the accumulation by the British Admiralty of a stock of charts, compiled and published by its Hydrographic Department, covering the navigable waters of the world.

Admiralty charting came to an end in British Columbia waters following the 1910 survey season (*Men and Meridians*, Vol. 2). It was under Captains Cook and Vancouver that charting by the British Admiralty had commenced along that part of the Pacific Coast of North America a century and a quarter earlier. Canadians, two decades before

1910, had taken over from the "Men of Admiralty" the task of surveying waters of the Great Lakes. On the Atlantic Coast Admiralty surveys in Canadian waters largely concluded about 1902 and in Newfoundland waters in 1939. During the Second World War numerous surveys were conducted for defensive purposes by the Canadian Hydrographic Service along the Newfoundland seaboard, although it was not until 1949 that Newfoundland became Canada's tenth province.

Since the cessation of their surveys in the waters of Canada the British Admiralty has been content to accept Canadian data in the updating of their charts applicable to this part of the world. About the middle of the 20th century the Admiralty turned over to Canadian authorities the responsibility for the production, distribution, and maintenance of all their charts of harbors, coastal waterways, and inshore waters of Canada, where Canadian information was not available to them. In pursuance of this decision reproduction material was provided by the Admiralty for more than 100 charts. These were published as Canadian charts, with due acknowledgment in the legends to information sources.

When the First World War began in the summer of 1914 the Hydrographic Survey of Canada, as it was still known at that time, had six vessels in commission, five steamers and an auxiliary schooner. Of this fleet the *Acadia* and *Cartier* were on the Atlantic seaboard; *Bayfield* and *La Canadienne* on inland waters (Great Lakes); *Lillooet* and schooner *Naden* on the Pacific Coast. In 1917 the *Acadia, Cartier* and *Bayfield* were taken over by the Canadian Navy for the duration of hostilities. Due mainly to years of severe economic depression in the 1930s, followed by the period of the Second World War and its immediate aftermath, it was not until the 1950s that Canada's hydrographic fleet began to return to its 1914 proportions. During the period 1939 to 1945 certain hydrographic survey projects in aid of the allied war effort were carried out by the Canadian organization. On the whole, however, only routine surveys, performed by small field parties, were undertaken in Canadian waters during the years of widespread conflict.

But the advent of the First World War did not prevent the carrying out of Canada's first oceanographic cruise in 1915. Under the direction of Dr. Johan Hjort the *Acadia,* with Captain F. Anderson in command, conducted offshore soundings between Halifax and Newfoundland as part of an oceanographic study bearing on the long-term outlook for Canada's east-coast fisheries.

FIGURE 67. Captain Frederick Anderson (seated) using sextant and artificial horizon at Rigolet, Hamilton Inlet, 1921. G.-A. Bachand, at left, was drowned 10 years later in Netagamu River.

During the 30-year period reviewed in this chapter, Canada's hydrographic survey organization was shifted in 1922 from the Department of Naval Service with which it had functioned since 1910, to the Department of Marine and Fisheries; then, in 1930 to the Department of Marine and to the Department of Transport in 1936. Until its transfer to the Department of Mines and Resources in 1936 the organization, for a brief period, was in the Department of the Interior, a title that disappeared in that year. Throughout these administrative changes its duties remained basically the same, namely, to investigate the navigable waters of Canada; to take soundings of and to chart courses through its rivers and along its coasts; and to survey and chart its various harbors and their entrances.

In the season of 1917, despite service curtailments imposed by wartime priorities as well as by heavy rains that washed out a total of 82 working days, surveys were carried out along the Pacific Coast of Canada by the *Lillooet's* crew under Captain P. C. Musgrave. Soundings were taken in Hecate Strait as well as between Ocean Falls and Prince Rupert. By means of launches and other small craft similar work continued along the Atlantic Coast. Since 1912 automatic gauges had been installed and maintained on the Great Lakes and in the St. Lawrence River. Also in that year certain stream measurements had been commenced in the Great Lakes, activities that were transferred to the St. Lawrence River below Montreal in the following season. These efforts were temporarily discontinued in 1917.

With the release of hydrographic vessels from naval duties, survey work resumed in the 1919 season. When Musgrave died in the next year, Henry Dalpe Parizeau (1877-1954) took charge of Pacific Coast operations and produced new charts of Victoria and Esquimalt harbors. In 1920 Commander J. H. Knight resurveyed Quatsino Sound near the northwest tip of Vancouver Island. This survey project was made necessary by the establishment of a large pulp plant and sawmill at Port Alice.

In 1921, at the request of the federal Department of Public Works, a preliminary survey was made of Ripple Rock in Seymour Narrows, 110 miles northwest of Vancouver. This submerged reef had been a deadly hazard to navigation through the Narrows. Its tragic toll over the years included at least 114 lives lost and 20 major ships sunk. The 1921 survey was an essential prelude to the eventual destruction of the twin-pinnacled menace. After years of study and careful preparation Ripple Rock was demolished in April, 1958, after underwater shafts had been drilled and explosive charges laid at the base of the pinnacles. The resulting blast, the largest non-atomic explosion engineered up to that time, was powerful enough to have lifted New York's Empire State Building one mile in the air. The hydrographic vessel *Parry* investigated effects of the demolition upon channel depths and the tidal-current conditions in this part of the Inside Passage.[1]

In the early 1920s Canadian hydrographers, in the east and west alike, rebelled against the inadequacy of funds voted by Parliament to cover the cost of their survey programs. In the face of increasing complaints from owners whose vessels had been all too frequently scraping bottom in the St. Lawrence ship channel, the annual report for the Survey in 1923 contained the following admonition:

"Unless the larger development of the river is proceeded with in the near future it is . . . highly desirable that a new survey of this part of the river (Cornwall to Kingston) be made without loss of time. The only charts of that portion are from American sources. They were made by the Lake Survey many years ago when the appliances for proper hydrographic work were not as fully developed as today. The

FIGURE 68.
Prince's Shoal lighthouse, St. Lawrence River off mouth of Saguenay River. Note landing deck for helicopters.

channels are all on the Canadian side of the boundary line and nine-tenths of the traffic is Canadian or in Canadian waters."

This tart observation was matched by an accompanying complaint from the Pacific Coast office: "The work of the Hydrographic Survey in British Columbia is particularly important; most of the old charts are very much out of date and new rocks are from time to time reported. Calls are frequently made on the Survey for examinations and much time is lost in running about to get this information. It is hard to see how such a condition can be avoided unless more funds are put at our disposal and the staff increased, with additional steamers."[2]

Despite the continuing lack of funds, experiments were carried out between 1919 and 1923 on the *Acadia* off the south shore of Nova Scotia in radio compass work. Efforts to improve offshore positional accuracy for survey purposes by means of the new direction-finding equipment were not entirely successful. Shore stations, under this system, provided bearings to wireless-equipped vessels with sufficient accuracy for navigation but the results were not precise enough for survey purposes.

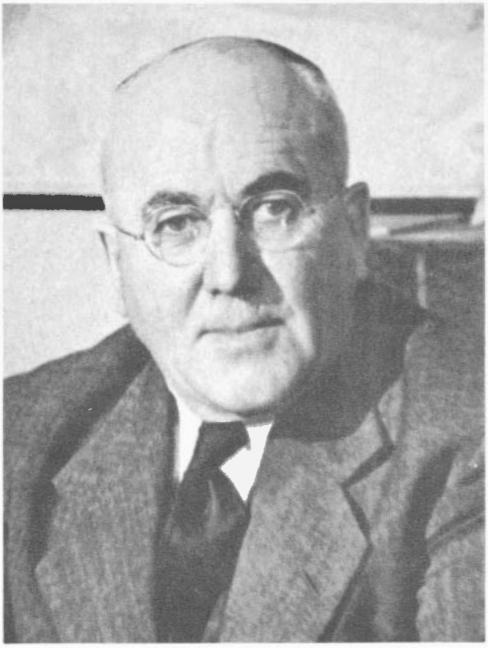


FIGURE 69. R. J. Fraser.

The extent of Service dissatisfaction with a decade of impoverishment imposed upon it by federal fiscal policies found renewed expression in the strongly-worded declaration, probably composed by R. J. Fraser, that appeared in the 1924 annual report of the organization:

"Over 100 years ago the British Admiralty took up the hydrography of the waters of Canada, starting in the Great Lakes in 1820 [1815: ed.] and about 25 years later the Atlantic Coast, and 10 years after that, the Pacific Coast. However, owing to the primitive methods at their disposal and the large areas covered, their surveys were little more than the delineation of the coastline, taking a few soundings, with the exception of important harbours where an attempt was made to compile a finished chart . . . Wood has given place to steel, sail to steam . . . every attempt is being made to save time, taking the shortest routes . . . and causing the demand for accurate charts. In days of sailing craft, a vessel lost meant the loss of a few thousand dollars; today it may mean millions. In 1904 Hydrographer to the Admiralty [Wharton] stated: 'The surveys of the shores of the Dominion, made as a rule by Imperial officers some years ago, are very inadequate to the needs of modern navigation.' Since then 20 years have passed and the size and number of ocean-going vessels have increased immensely, demanding the most accurate information regarding bottom contours when approaching the shore, especially in frequent fogs off the Atlantic Coast . . .

"Since the Hydrographic Survey Branch was formed in 1905 when Canada, at the urgent request of Great Britain, consented to undertake the recharting of her own waters, considerable progress was made in the Atlantic and to a less extent on the Pacific Coast, however, not one-half sufficient to meet the demands for new surveys and, considering the entire coastline of Canada, it will take a long time to complete the whole."

In the concluding part of this statement it was emphasized that from Belle Isle to the Bay of Fundy, 100,000 square miles of coastal charting remained to be done and that the Magdalen Islands survey had been only half-completed. It was also pointed out that existing charts of the Gulf of St. Lawrence were "more of a menace than a benefit" and apt to mislead navigators. As to the performance of a complete survey of the Labrador Coast, of Hudson Bay and Hudson Strait, no estimate could be made. On the Pacific Coast, it was pointed out, 5,500 miles of coastline remained to be surveyed, although 2,700 miles had been charted.

A quarter-century after this resounding statement was published, and soon after Fraser was named first Dominion Hydrographer, the British Admiralty announced that in regard to the coast of British Columbia, it would in future rely on Canadian charts and would be withdrawing from circulation upwards of 40 charts of its own construction. The announcement indicated that the policy of the Admiralty in future would be to confine its own chart coverage of Canadian seaboards to general coastal sheets and intermediate-scale charts.

In 1924 Dr. W. Bell Dawson retired as head of the Tidal and Current Survey. Under terms of the relevant Order in Council the position was not filled. Functions of that unit were assigned to the Hydrographic Survey and administered as part of that organization. Although the Chief Hydrographer was nominally responsible for its activities, Harold William Jones (1880-1950) as Senior Tidal and Current Surveyor, Atlantic Coast, stationed at Ottawa, carried the main administrative load. Sydney C. Hayden (1876-   ) with a similar title, Pacific Coast, was stationed in British Columbia. He had been assigned to that region in the year that Dr. Dawson retired. In May, 1940, Jones was made Chief, Tidal and Current Survey Division of the Canadian Hydrographic Service.

For some years, while the Tidal and Current Survey had developed through its early stages under Dawson, the federal government failed to provide funds for the publication of Canadian tables of tidal predictions. Dawson, accordingly, was forced to arrange as best he could, and from port to port, for the printing and circulation of this hard-won information. Early in the 20th century, however, the Survey began to print and distribute its own tide tables. By 1923 their annual circulation, including Atlantic and Pacific regions, attained a total of 66,500.

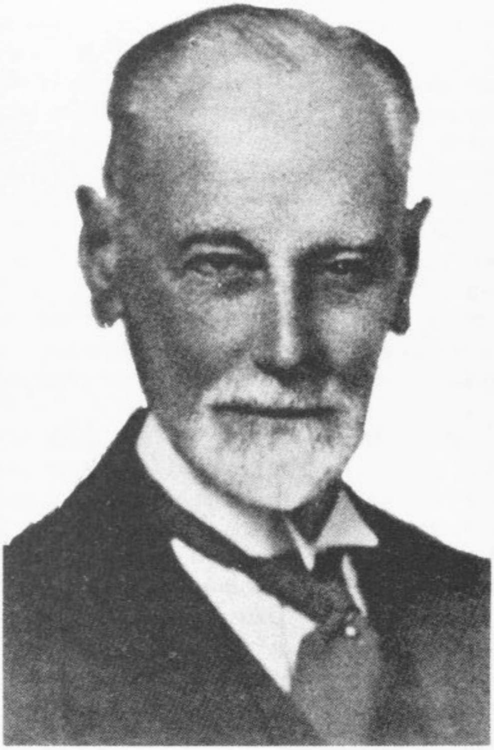


FIGURE 70. Dr. W. Bell Dawson.

FIGURE 71. H. W. Jones.

Along the coast of British Columbia, where the inflow and outflow of tidal waters create dangerous turbulence, the relationship between tides and currents is obvious. Dawson's investigations in British Columbia were directed mainly to the prediction of the time of slack water in the various passages. Usually these investigations could be carried out from shore positions. By 1917 methods of calculating slack water conditions in Seymour Narrows and related channels had vastly improved. All of this information was essential to coal transportation and lumbering industries in that part of Canada. To these interests it was particularly valuable to know the exact periods during which passages and river entrances were navigable, as well as to have data on the direction and force of currents. In the same way tide tables and associated publications relating to Hudson Bay and James Bay proved highly useful to commercial interests using those waters, especially to the Hudson Bay Railway in the operation of its terminal facilities.

Years of steady improvement in Canadian tidal and current surveys culminated in a vast leap forward with the appearance of the computer. By this mechanism only about one hour would be required in the making of calculations for, and printing of, tide tables for one port for a year. About 100 computer hours would result in the production of tide tables for all Canada covering any single year.[3]

The investigation of currents in and near the Gulf of St. Lawrence was attended by formidable difficulties. The currents, which could be observed properly only from a ship, proved immensely complex and varied. Dawson found that the waters of the Gulf circulated generally in a counter-clockwise direction and that the current shifted speed and direction throughout the course of a day. The tide pours into the Gulf through Belle Isle and Cabot Strait. It builds up rapidly as it travels through the narrowing St. Lawrence estuary, taking about ten hours to cover the distance from Seven Islands to Lake St. Peter. On the river above this point tidal action does not exert any important influence. The rise in height is greatest at Quebec City, reaching 13 or 14 feet. On the Pacific it takes the tide about six hours to travel up Juan de Fuca Strait into the Strait of Georgia, increasing in height until it reaches 12 feet at the north end of the latter strait. Knowledge of tidal phenomena in our Arctic waters is still relatively sketchy but is growing year by year. Generally the action of the tides is slighter in Arctic regions than elsewhere on Canada's coasts. But the first tide tables for the Arctic Ocean of this country, calculated and published in Canada, were not to appear until the mid-1960s.

On all three ocean coasts the intensive accumulation of tide and current data has taken on a new significance owing to the insatiable appetite of the digital computer allied with the skill and dedication of hydrographic personnel in translating raw facts of their investigations into computer terms.

In the year following Bell Dawson's retirement, Chief Hydrographer William James Stewart (1863-1925) died and was replaced in that post by Captain Frederick Anderson (1869-1957). For more than four decades Stewart had served the hydrographic organization with special distinction and for about half of that period had given outstanding leadership in the direction of its affairs.

In 1926 funds for the Survey were too limited to maintain the *Bayfield* and *Cartier* in active service and the latter vessel was loaned to the Preventive Service, Department of National Revenue, until the end of the season. Two years later, in 1928, the title "Hydrographic Survey of Canada" was changed to "Canadian Hydrographic Service" and the title "Automatic Gauges Unit" was altered to "Precise Water Levels Division". In that same year the structure of civil service positions in the organization was also transformed and made retroactive to April 1, 1927. The system of senior and junior hydrographer was thereby supplanted by the establishment of graded positions of that general title. That same season, 1928, marked the beginning of hydrographic survey work in Great Slave Lake (under H. L. Leadman), and renewed work in Churchill Harbour (under F. C. G. Smith) initiated by Bachand and Savary in 1910. That season

FIGURE 72. F. C. G. Smith.

also marked the commencement of electronic surveying in the Service with the installation of the first gyro compass on the *Acadia*. In the following year, 1929, the *Acadia*, newly fitted with the first echo sounder to be installed in a Canadian hydrographic vessel, entered northern waters for the first time since 1914.

By 1933 an echo sounder, known as the Acadia-Challenger model and named after the Canadian ship and H.M.S. *Challenger* (the British Admiralty survey vessel) had been installed on the *Acadia* as well as the *Cartier* and the new ship on the Pacific, the *Wm. J. Stewart*. A version of this sounder was also placed aboard the government ice-breaker *N. B. McLean* for special use in Hudson Strait. In that same season the first of the fleet of government launches to be equipped with a supersonic model of echo sounder was the *Boulton*, built in 1926.

The pioneer echo-sounding apparatus included a 70-pound air hammer, electromagnetically controlled, employed to deliver resounding blows on an anvil assembly to which was attached a steel diaphragm, inside the hull of the investigating ship. In this manner vibrations were set up to which the sea bottom would respond. This early equipment included head phones in which a certain pitch of tone would indicate to the operator that the signal from the hammer was being returned. By the beginning of the Second World War about a dozen Mark 2 and Mark 3 echo sounders had been installed on Canadian hydrographic vessels. These classes of sounders dispensed with the air hammer and head phones. The pulse was produced by the magneto-striction principle and a recording apparatus was added in order to obtain a profile of the bottom.

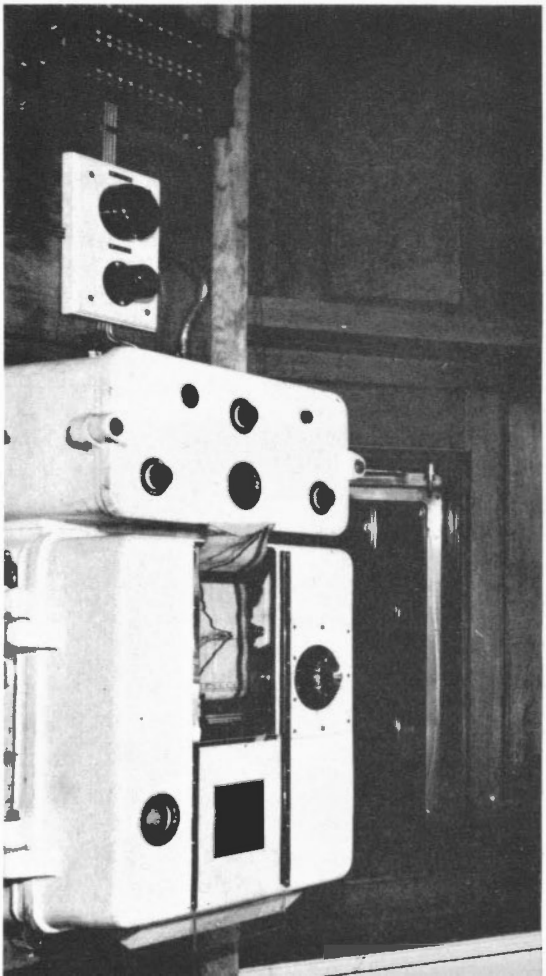


FIGURE 73
Echo sounder, about 1937.

During the seasons of the early 1930s men of the Canadian Hydrographic Service discovered and charted several dangerous formations, consisting of submerged rocks along the main trans-Atlantic steamship lane through the Strait of Belle Isle to ports along the St. Lawrence River. Two of these hazards, Bent Rock, and nearby Roach Rock, were situated off the north shore of the Gulf, not far from Cape Whittle. The first was named for R. W. Bent, who had been an assistant to Bachand; the second for Captain James Roach, a skipper of the *Cartier*. In the season 1930 the *Bayfield,* in Leadman's charge, located and charted Superior Shoal, a previously undetected hazard to shipping, situated near the direct route between the head of the lakes and Sault Ste. Marie. This submerged rock formation is now believed to have been the cause of mysterious disappearances of a number of lake vessels over the years.

In the 1931 season the *Bayfield* ended her survey days in the Gulf of St. Lawrence, and in the following year this vessel was taken out of the Hydrographic Service. In 1933 the Esquimalt-built, twin-screw *Lillooet,* which had been active as a hydrographic survey vessel on the Pacific Coast since 1908, was replaced by the *Wm. J. Stewart,* constructed in Collingwood, Ontario, and brought to the west coast through the Panama Canal. Two years later the launch *Henry Hudson* was added to the national fleet and, for the first few years of its career, surveyed in Hudson Strait.

Air photographs were first used in 1930 as a survey aid by the Hydrographic Service. During initial stages of the season's operations the Royal Canadian Air Force performed the photographic work, flying along the north shore of the Gulf of St. Lawrence opposite Anticosti Island. A newcomer to the Hydrographic Survey at the time, New Brunswick-born S. R. Titus, studied the resulting photographs in Ottawa during the succeeding winter months with a view to applying the information to hydrographic purposes. Air photography has since continued to be an indispensable aid to the charting of Canadian waters and, over the years, various refinements in this special service have been developed, including the provision of photographs of specified areas, taken both at low and high tide.

First fatalities in the history of the Service occurred during the 1931 season when G. A. Bachand (1874-1931), chief of the *Cartier,* and two seamen were drowned on June 8th in the Netagamu River near the north shore of the Gulf when their heavily-loaded canoe capsized in turbulent waters. In this tragic manner Bachand's long and distinguished career, beginning in 1905 and during which he had served his country well as a hydrographer, came to an end. The extent of his contribution may be judged from the repetition of Bachand's name on some 40 Canadian navigation charts.

Surveyor General F. H. Peters, Ottawa, succeeded Captain Anderson as head of the Hydrographic Service in 1936. Soon after his appointment to the dual functions of

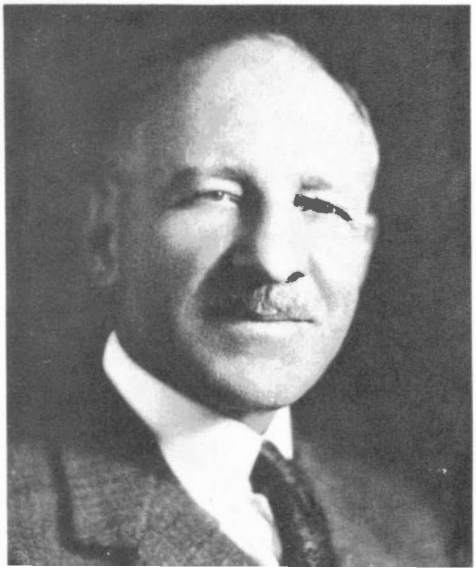


FIGURE 74 F. H. Peters.

Surveyor General and Chief, Hydrographic and Map Service, Peters visited the Pacific Coast on an inspection tour and, as a result, from 1938 onwards there has been a permanent regional office of the organization at Victoria, operating on a year-round basis.

When the Second World War commenced the *Cartier* was active off the coasts of Cape Breton Island under Leadman's charge. His senior assistant at the time was Yarmouth-born Norman Gerald Gray (1906-), destined to become Dominion Hydrographer. Louisbourg was then the *Cartier's* port of call for supplies, the place where, in 1758, the era of Paris-directed surveys in the New World gave way to a new age of British surveys and surveyors leading up to Confederation.

FIGURE 75
N. G. Gray (at tiller) with fellow hydrographers sounding near Magdalen Islands about 1931 in one of the last hydrographic sailing gigs to be employed off Canada's coasts.

Immediately after the declaration of war (in which Canada became a foe of Hitler's Germany) the *Cartier* proceeded to Shediac, New Brunswick, where survey launches, dories, and equipment were left for the prosecution of survey work in Shediac harbor and its approaches. By way of Charlottetown, where its remaining survey gear was placed in storage, Leadman took the *Cartier* to Halifax. There the vessel was turned over to the Canadian Navy. Charlottetown, incidentally, was the home port of the *Cartier*.

In 1940 informal discussions took place between representatives of the United Kingdom, the United States, and Canada bearing upon the need for ferrying bombing planes from North America to the British Isles over a North Atlantic route. These discussions led, in turn, to the decision to establish an air base in Labrador. At the time, both Canadian and United States air forces were conducting operations in Labrador, searching for a suitable airport site. On receipt of survey reports from the Dominion

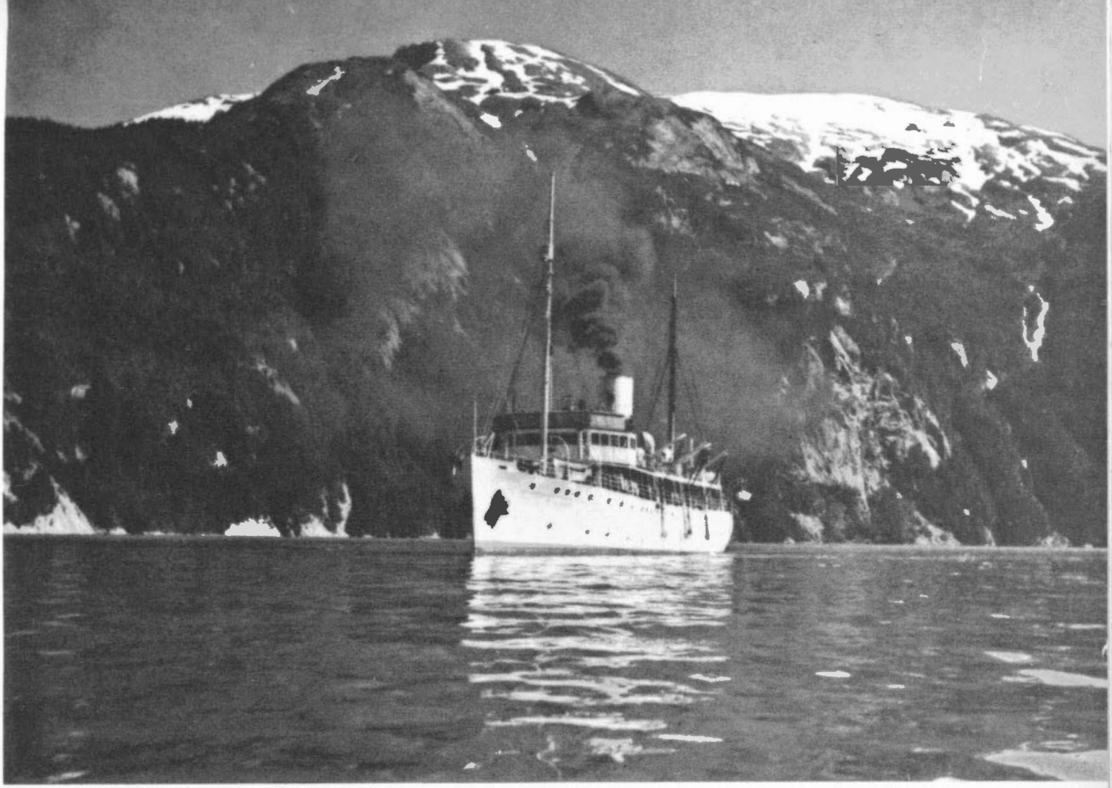


FIGURE 76. CHS *Wm. J. Stewart.*

land surveyor, Eric Stanley Fry (1890-) of Canada's Topographical Survey, that a relatively level area had been found at the head of Hamilton Inlet, accessible from the sea, the suitability of the location was confirmed. By late September, 1940, construction work on the site began. On April 15, 1942, a Liberator plane winged its way to Goose Bay airport en route to the British Isles, inaugurating east-bound flights on what was to become a busy trans-Atlantic wartime air ferry service.

An approach by sea to the vicinity of Goose Bay airport was essential to the movement of equipment and supplies to the construction site. In this regard men of Canada's hydrographic organization performed valuable services. A location for the main wharf was selected at the head of Terrington Basin, the westernmost extension of Hamilton Inlet, leading off Goose Bay which, in turn, is an arm of saltwater Lake Melville. Arriving on the *N. B. McLean,* Ralph Hanson, working alone, accomplished triangulation work in the area during most of 1942 season. A. L. Mack arrived to assist him late in the same year. Toward the end of October, 1943, soundings were taken throughout the inner basin. These surveys were carried through the narrows to Goose Bay and confirmed the existence of a natural channel of sufficient width for all shipping needs and of a depth of about four fathoms. The existence of a shallow bar across the eastern end of Goose Bay restricted passage to vessels drawing up to 21 feet. The maximum tidal range in these waters was found to be two feet.[4]

For many months German submarine thrusts, directed against the Atlantic lifelines that linked Great Britain with the food sources and war supplies of North America, gravely threatened the ability of the British people to resist a resourceful and powerful enemy. Allied ship losses continued to mount dangerously to a monthly peak in 1942 of 671,000 tons.

FIGURE 77
Captain D. M. Snelgrove (using sextant), only ship's officer to serve on all three major CHS vessels: *Acadia*, *Cartier*, and *Bayfield*.

FIGURE 78. CHS launch *Anderson*.

FIGURE 79. H. D. Parizeau (with beard) and group of Pacific Coast hydrographers on the *Wm. J. Stewart*, about 1933.

Halifax never ceased to be in the front line of the naval war. In the vicinity of that port protective measures were developed not only to meet the submarine menace but also to reduce losses by the ingenious magnetic mine. A de-gaussing technique, devised by British scientists, was used to neutralize the innate magnetism of a ship by fitting electrically energized cables around its hull. The first 'open range' to be established in this connection outside the British Isles was located in Bedford Basin. Subsequently similar ranges were set up at Sydney, Nova Scotia, in Quebec City, and on the west coast. Hundreds of vessels were passed over these ranges for calibration of their magnetic properties and for the purpose of equipping them with de-gaussing cables.[5] Members of the Canadian Hydrographic Service were active in the delineation of these ranges and in furthering wartime harbor protection projects such as those at Halifax and St. John's where surveys were carried out from launches operating in advance of vessels laying antisubmarine nets.

Merchant ships for the British Isles from Canada, during the Battle of the Atlantic, were organized into convoys and escorted across the ocean by whatever naval or semi-naval units could be spared for the purpose. In Halifax, early in November, 1940, the armed merchant cruiser *Jervis Bay,* commanded by Captain Fogarty Fegan, R.N., required a gyro compass. Accordingly the *Cartier's* compass was removed and fitted aboard the escort ship just before she sailed with a 37-ship convoy. In mid-Atlantic the long line of vessels was approached by a powerful enemy raider, the new pocket battleship *Scheer*. Under orders the merchant ships scattered while the *Jervis Bay* engaged the *Scheer* in a most unequal contest, replying as best she could to the attacker's deadly broadsides with her old six-inch guns.

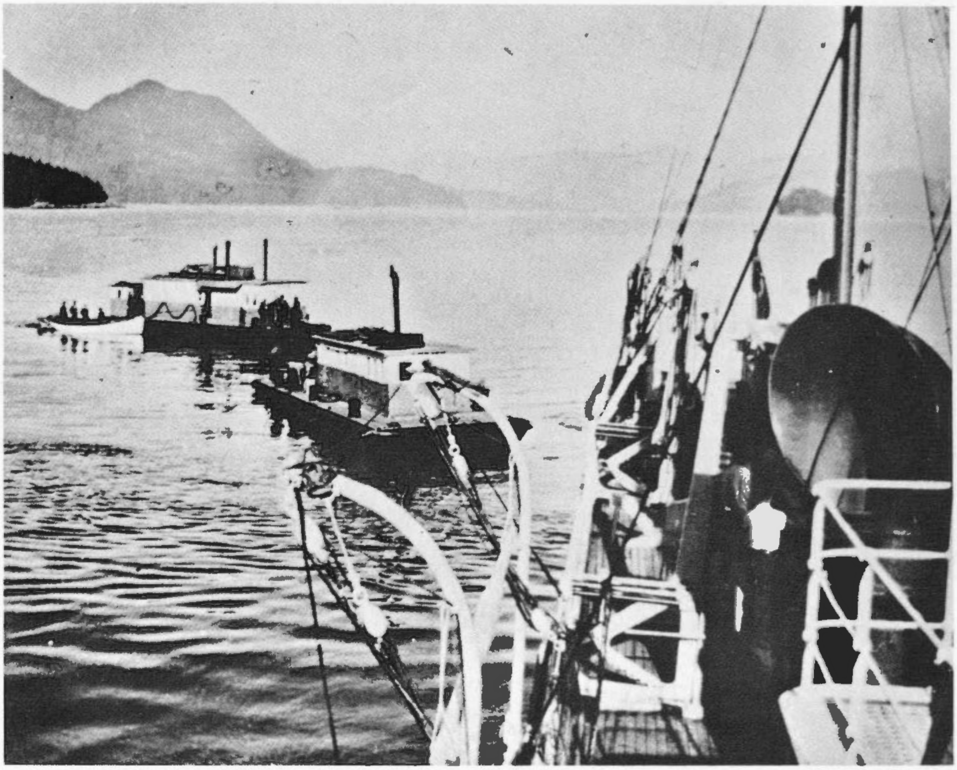


FIGURE 80. *Somass* (houseboat) and *Fraser* (water tender) being towed by CHS *Lillooet*.

Within the space of an hour the *Jervis Bay* was reduced to a shambles and soon sank, carrying to their doom its brave skipper (posthumously awarded the Victoria Cross) and more than 200 officers and men. But because the enemy's attention had been diverted from its helpless prey for a critical period, most units of the convoy escaped in the fast-gathering wintry dusk. Only five of the merchant ships were lost in the short time remaining to the *Scheer* before darkness set in. The gallant, sacrificial conduct of the *Jervis Bay's* captain and crew remains forever a shining page in the annals of sea warfare and in the most illustrious records of the British Navy. Later in the war the *Scheer* was sunk by allied air action while she sheltered in Kiel harbor.[6]

After the entry of the United States into the war President Franklin D. Roosevelt, through an emissary, conveyed to Prime Minister Churchill his desire to meet the latter in some "lonely bay" to be selected for the purpose of quietly discussing and formulating a joint Anglo-American declaration of principles.[7] The Placentia Bay area, south of the narrow isthmus linking Avalon Peninsula with the main part of Newfoundland, was favored by naval authorities as a meeting place for the two famous leaders. Although the special object of their request was kept hidden at the time from Canada's hydrographic service, that organization was asked by the British Admiralty to perform a survey of Mortier Bay, a relatively narrow body of water leading off the west side of Placentia Bay. Accordingly Heamen Lawrence Leadman (1887-1963) and a small staff sailed on the *N. B. McLean* from Saint John, New Brunswick, in June, 1941, and carried out a standard hydrographic survey of Mortier Bay, completing the task on August 1st. On the basis of this and other information made available to London the place of meeting chosen was Argentia harbor on the east side of Placentia Bay. In August Churchill arrived at the scene aboard the battleship *Prince of Wales*. Appropriately Roosevelt came on the United States cruiser *Augusta*. Broad agreement on joint war aims was reached along lines embodied in what came to be known to the world as the Atlantic Charter. None could have foreseen at the time that within a few months the *Prince of Wales* would be sent to a watery grave in Far Eastern waters by Japanese torpedo planes.

Canadian hydrographic surveys at Coral Harbour, Southampton Island, were instrumental in the establishment in that area of an airfield forming part of a system over which warplanes were ferried from Churchill to Frobisher Bay, thence across Greenland and Iceland to the British Isles. Another important wartime hydrographic survey on the east coast developed out of the decision to establish the large naval training base, H.M.C.S. Cornwallis, in Nova Scotia. In the 1942 season, N. G. Gray, using the launch *Anderson* and with the aid of two survey officers, began a survey of Annapolis Basin on the east shore of which the base was being constructed. This work was finished late in the following season, after completing a survey assignment for the Department of National Defence at Saint John. In 1944 hydrographic surveys were made, also under Gray's direction, in Northumberland Strait involving preliminary studies of a possible causeway crossing between the mainland and Prince Edward Island. Surveys in the Strait, using the *Anderson,* were continued in the 1945 season.

The volume of Canadian chart production and chart distribution rose steeply during the war period. In 1943, for example, 244 charts were printed and 83,936 copies distributed. This latter total represented an increase over the corresponding 1942 total of 65 per cent. In 1944 the total number of Canadian charts distributed reached a high figure of 106,042. Following the end of the war these totals declined sharply but this tendency was partly offset by an increasing demand for charts for civilian uses. Canada emerged from the Second World War showing a considerable advance in the total area of coastal waters charted as well as possessing sets of navigation charts superior to pre-war issues. Despite the increase in surveying of strategic waters for defence purposes, charting of other extensive ocean, lake and river areas had, perforce, to be postponed and a heavy backlog of civilian chart requirements accumulated. To that extent a marked imbalance in the general charting situation in Canada developed during the years immediately following the end of hostilities.

On the Pacific Coast, Parizeau was denied opportunities to expand the hydrographic service fleet and personnel, because of economies imposed by years of economic depression and world conflict. Despite these limiting factors Parizeau directed the transition on the Pacific Coast from traditional hydrographic survey methods to more modern techniques, including the use of echo-sounding equipment. He directed a gradual change in functions of the federal service over the years. In its early activities the Hydrographic Service on the Pacific concentrated largely on assisting the natural resource industries

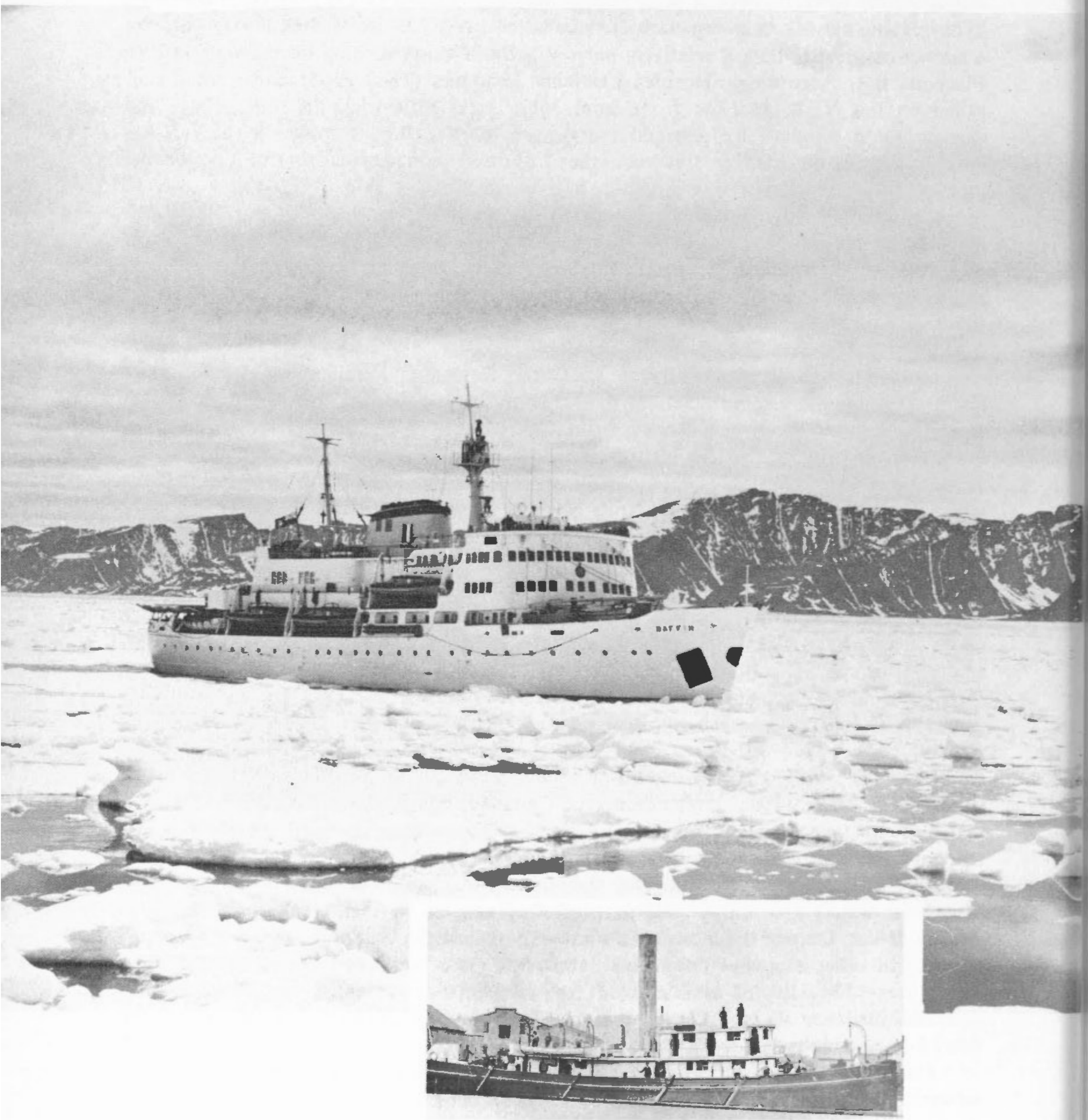


FIGURE 81. CHS *Baffin* in Frobisher Bay, compared with the first *Bayfield* (inset).

of British Columbia. For example, its work aided grain shipments through the port of Prince Rupert; of ore from Anyox and Alice Arm through Observatory Inlet; of forest products from Port Alberni; the salmon fisheries of the Skeena and of Pacofi; pulp and paper from Ocean Falls. But in the years after the war the work of consolidating and updating hydrographic charts became paramount. Generally the whole coast of British Columbia was surveyed with the aid of new equipment. The houseboats *Somass* and *Pender* were used to accommodate survey parties in the field. After Parizeau's retirement in 1945 W. K. Willis was placed in charge of Pacific Coast hydrographic surveys. In 1955 he was succeeded by R. B. Young.

FIGURE 82
Sketch of CSS *Parizeau*.

In summary it may be observed that, in addition to the construction and maintenance of charts, the Canadian Hydrographic Service continued over the years to contribute substantially to the safety and growth of waterborne commerce and recreation in Canadian waters by the periodical publication of Sailing Directions, of Tide Tables, and of Water Level Bulletins. Since 1917 notable improvements had been made to navigational equipment. Loran (long range aid to navigation), a system by which ships and planes can fix their positions with exceptional accuracy, and radar came into more frequent use for position-finding. Depth-sounding apparatus became more sophisticated. By these and other means it became possible over broad reaches of the seas and over large inland bodies of water to navigate effectively otherwise than by reference to heavenly bodies and by the use of the leadline.

Before the end of the first half of the 20th century the entry of Newfoundland into Confederation enlarged the challenges facing the Hydrographic Service by adding to its charting responsibilities several thousand miles of coastline, including that of Labrador.

As Canada's tasks in these realms increased so also did the concept of the nation's place in the world of hydrography broaden. Early in 1951 Canada became a member of the International Hydrographic Bureau, a world-wide affiliation of hydrographic offices. Founded in 1921 the Bureau had its headquarters in Monaco. Through the services of this organization the exchange of information between maritime nations had been improved and expedited, standardization of chart features and of hydrographic publications generally increased, and periodic conferences of representatives of member nations held to discuss common problems. The Bureau is a consultative agency, seeking to induce conformity in hydrographic work methods and in publication forms, although its resolutions are not binding on its member states. As a result, however, hydrography has become one of the fields of human activity in which international coordination and cooperation are most extensive.

8

THE GEODETIC SURVEY OF CANADA: 1917-1947

"Of all these bounds, even from this line to this,"

—*King Lear*, Act 1, Sc. 1.

The Geodetic Survey of Canada had not reached the tenth anniversary of its informal beginnings* when the country became actively engaged in the First World War. By the end of hostilities 30 per cent of its staff members had enlisted for service overseas. The absence of these experienced officials combined with federal government wartime economies severely restricted operations of the survey organization. But under the continuing guidance of Director Noel John Ogilvie (1880-1967) the Geodetic Survey was able, within the limitations imposed upon it, to usefully perform both military and civilian functions during the wartime period.

Geodetic parties, in fact, contributed to national defence on both the Atlantic and Pacific coasts. A group under Ogilvie assisted naval authorities in the vicinity of Prince Rupert at a time when German cruisers were reported to be roving in that general area.[1] In Nova Scotia, in connection with the establishment of geodetic control for military mapping, the Survey extended its triangulation net from the Bay of Fundy to Halifax. The United States Coast and Geodetic Survey carried out a wire drag (soundings) survey at the head of Passamoquoddy Bay during the 1918 season to ascertain whether waters of the bay could serve as an anchorage for allied war vessels. A Canadian party was detailed to provide exact positions of numerous points to control the accuracy of the American survey. Incidentally an investigation of Campobello Island by Canadian geodetic surveyors disclosed not only the ruins of the building once occupied by Admiral Owen but as well Admiralty charts of the bay waters drawn by him.[2]

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*The official date of its founding is April 20, 1909 (Order in Council, P.C. 766) but types of federal geodetic survey work were being performed in Canada as early as 1905.

FIGURE 83
Noel J. Ogilvie (right), head of the Geodetic Survey of Canada, 1917-1946, with John M. Riddell, D.L.S., in Gatineau area, Quebec, 1931.

In the field season of 1918 a Canadian party also worked in close cooperation with the United States Coast and Geodetic Survey in carrying out triangulation work for the completion of a geodetic arc extending from the vicinity of Tacoma, Washington, to the point where the 141st meridian crosses the Yukon River. This task proved to be of primary importance to subsequent charting of the intricate coastal waterways of British Columbia. It also provided a sound basis for future mapping of the cities of Vancouver and Victoria.

Despite the exigencies of the times, useful triangulation data were supplied to a number of federal government departments and agencies for controlling the accuracy of maps and charts being issued by them. Beneficiaries of geodetic investigations included the Militia and Defence Department; the Hydrographic Survey of Canada, Department of Naval Service; the Chief Geographer's Branch, Department of the Interior; and the Geological Survey of Canada, along with the International Boundary Commission. On the provincial government side, the Quebec Streams Commission and the Toronto Harbour Commission were among organizations benefiting from these findings.

Certain tiresome yet not unnatural difficulties were faced on the home front by geodetic surveyors occupied during wartime on their lawful and constructive tasks. Louis Beaufort Stewart (1861-1937), chief of a reconnaissance party active in Nova Scotia during the 1918 season, incorporated the following terse comment in his official report:

"With everyone kept on the *qui vive* by reports of German submarines operating in Canadian waters it was not surprising that we should repeat the experience of other members of the Geodetic Survey staff and find ourselves regarded with suspicion by the people among whom we were working. This was troublesome on two occasions when it took the practical form of a refusal to all of us to board and lodging until assurance was given that we were what we represented ourselves to be."[3]

The objective of Stewart's party was to connect the main chain of triangulation in the Bay of Fundy and Minas Basin area with stations to be established near Halifax and then to extend reconnaissance of the main chain easterly to Prince Edward Island and Cape Breton Island. A preliminary survey had been made in this area by H. P. Moulton. Claude H. Brabazon was the geodetic engineer in charge of a party at the head of the Bay of Fundy during the 1918 season.

Stewart, an Ontario land surveyor, was commissioned a Dominion land surveyor in 1882, at the age of 21; he was resident of Winnipeg at the time. Five years later, while at Banff, Alberta, he became a Dominion topographical surveyor. In the year 1898 he was appointed a lecturer of Surveying and Geodesy at the University of Toronto. In 1901 he was appointed professor of those subjects and taught in that capacity for 31 years. But Professor Stewart never allowed himself to become cloistered in academic halls. He served as a surveyor in the field not only in the Maritimes but also in Labrador, in Alberta and in the Yukon Territory. He was an uncommon mixture of pedagogue and practical man. By his character and exceptional ability Professor Stewart exerted a challenging and constructive influence on the survey careers of many who had studied under him.

The Canadian Geodetic Society was formed in February, 1918. A glance at its first program of talks reveals not only the sort of subject that was of topical interest to members of the Society in the post-war period but as well the names of surveyors then active in geodetic and related surveying:

Reconnaissance	L. O. Brown
The Determination of Geodetic Datum	W. M. Tobey
Side and Angle Equations	D. J. Fraser
Service: The Motto of the Geodetic Survey	J. L. Rannie
The Fort Rupert Base	W. M. Dennis
Aerial Photo-Topography	H. F. J. Lambart
The Influence of Laplace Points	F. A. McDiarmid
The Canadian and United States Boundary East of the St. Lawrence,	J. A. Pounder
Survey of a Prehistoric Indian Village	W. J. Wintemberg
Field Artillery	G. S. Raley
City Triangulation	A. M. Grant
Map Production	J. R. O'Connell
Precise Levelling	D. MacMillan
Stereophotogrammetry	W. C. Murdie

In the meantime the motor age had dawned in North America and its revolutionary impact upon the mobility of the people of the continent was soon to be felt by Canadian surveyors. In 1919 the transition from the horse-and-cart era to that of the internal combustion engine was marked by the decision by survey authorities in Ottawa to make use in the field of railway motor cars* in place of railway hand-cars. The now more mobile geodetic surveyors, organized in five field parties, ran a total of 1,042 miles of precise levels in the season. The parties were under the direction of D. MacMillan in Saskatchewan, A. J. Rainboth in Alberta, G. F. Dalton in Ontario, N. H. Smith in British

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*A typical section hand-car fitted with a 4-h.p. gasoline motor.

Columbia, and G. E. B. Sinclair in Quebec. In the Maritimes parties headed by Claude Brabazon, Hazen P. Moulton, Professor L. B. Stewart and J. W. Menzies were engaged in reconnaissance work. Experience with the operation of motor trucks in the field indicated conclusively that important economies could be effected in transport costs where 'much running around the country' was required. For reconnaissance surveys a light runabout with a delivery box attached at the rear was favored. For tower-building parties a two-ton truck proved to be the most useful vehicle. One enthusiastic chief of party reported that his men were able to perform "200 to 300 per cent more work when provided with a car than when it was necessary to depend on trains and hired livery for transport."[4]

But all was not smooth progress for motoring zealots bound for survey work in the provinces. Moulton, whose assistant at the time was W. N. McGrath, reported for 1921 from the Maritimes that a provincial law in Nova Scotia prohibited the use of automobiles on country roads earlier than the first day of May. The impatient surveyors delayed their start on field work accordingly. The season's activities covered an area of about 5,000 square miles and was completed on Cape Breton Island. Moulton concluded his report to Ottawa on an exuberant note:

"The owners of land on which [geodetic] stations are located were very pleased to have observing towers erected, in many cases wishing that they were built higher on account of the beautiful views afforded by them. The scenery in Cape Breton is without rival in Eastern Canada." One is left to ponder whether head office in Ottawa was gratified or not over the inadvertent transformation of a practical and prosaic enterprise by government surveyors into a structure conducive to a greater exercise of the aesthetic and poetic sides of the Nova Scotian's nature.

Although use of the motor car brought about startling changes in ground transportation, an even more profound change was about to challenge surveying procedures, including geodetic work. With the introduction of the aeroplane, air survey photography and the transportation of parties and equipment over long distances took on new dimensions. In the 1920 season initial Canadian experiments in the photographic field were carried out in the vicinity of Ottawa. A Bristol Fighter (No. 433) with a Rolls-Royce engine and a LB (Mark 1) semi-automatic camera were employed for the purpose. In these try-outs photographs were taken from a height of 10,000 feet.[5]

In 1921 an officer of the Geodetic Survey of Canada, in charge of triangulation reconnaissance in the Fraser River watershed of British Columbia, was able, through the cooperation of the Canadian Air Force, to carry out part of his assignment by air. A triangulation net some 200 miles long was flown in the mountainous region eastward from Vancouver, the results being checked by ground visits to all stations.[6] Quite possibly this was the first practical application of aerial methods to geodetic survey operations in this or any other country.

In the use of a plane in 1928 over an area of 4,400 square miles between Senneterre and La Tuque in Quebec, it was found that costs of the survey operation in that area could be halved. Primary and supplementary stations were established during 17 hours of flying, spread over 10 days. Due to the relative inaccessibility of the region at the time, the same work would have required two seasons of operations if carried out entirely on the ground. Similarly on the Island Lake surveys related to the Ontario-Manitoba boundary surveys, planes made trips from Norway House each way within the span of a few hours. The one-way journey by canoe over the same distance normally required at least six weeks.

Flights were made in February and March of 1929 by officials of the Geodetic Survey to re-affirm the time-saving and cost-saving abilities of planes when used in geodetic tasks, not only in mountainous terrain but in less rugged country as well. Their verdict removed any doubt but that "much of the future triangulation reconnaissance in Canada, as well as transportation of field parties in certain areas, will be done by aeroplane." In all, more than 300 hours were flown for the survey in 1929 and, as a result of these novel operations and those of the previous season, it became clear that, especially in regions where roads were few and lakes abounded, geodetic reconnaissance, both general and detailed, could be accomplished by the use of pontoon or ski-equipped planes in the course of a few hours in contrast to weeks and months of laborious ground travel. After the selection of a triangulation station a tower-building party could be flown in and landed at the next point as required. Air operations also made possible quick and constant communications between chiefs of parties and Ottawa headquarters as well as between them and widely scattered units of surveyors in the field. Cabin monoplanes, accommodating five persons, were used at this time for geodetic survey purposes.

Difficulties were encountered in obtaining suitably detailed air photographs in these pioneer stages. Lenses of larger aperature, cameras of greater focal length, filters, special emulsions, infra-red photography and other equipment and supplies were subject to experimentation in the progressive application of stereo-oblique photography to the intervisibility of stations and the determination of the direction of lines. But even when ground checking of air survey work proved necessary, reconnaissance by plane, in areas where ground travel was inevitably slow, was decidedly more economical than a completely earth-bound operation.

Three major flying operations were carried out in 1931, one in Saskatchewan and the other two in northern Ontario.[7] By 1932, in various parts of Quebec geodetic reconnaissance, station preparation and angle measurements were undertaken, using aeroplanes as the sole means of transportation.[8] Checking of the results on the ground could be accomplished more rapidly because of information made available from the air concerning the position of hills and the best methods of approaching station sites. It was found that preparation and angle-measurement parties could be placed in the field one year earlier than if ground methods only were utilized. For ground reconnaissance the equipment normally used included a prismatic compass, protractor, ruler and map. For air reconnaissance a small apparatus, based on the plane-table principle, combined all these tools within one instrument. This consisted of a stand screwed to the deck of the plane. On a shelf a compass was mounted and at the top was a circular, revolvable plane table on which was placed the best available map of the area to be flown over. Economical results in aerial reconnaissance depended, in the last analysis, on a combination of expert piloting and proficient aerial geodetic engineering.

At this stage of national development it had become apparent that the ultimate aim of the Geodetic Survey of Canada was to lay down a network of primary triangulation extending from the Atlantic to the Pacific with branches of the network extending along both these coasts and at intervals into the interior. As this triangulation coverage progressed it was anticipated that surveys of lesser degrees of accuracy could be tied in with it and in time all would be shaped into one harmonious whole on a fully coordinated basis, affording the correct relationship of one part to another.

In this country growing recognition of the value of geodetic surveys was linked with the high competence and personal integrity of leading practitioners of the work in Canada. Outstanding among these men was John Leslie Rannie (1886-1954). His contributions to improvements in the performance of field instruments were noteworthy. Rannie was especially enthusiastic over the revolution in theodolite design introduced at Jena by Heinrich Wild and developed to the production stage in the early 1920s at Heerbrugg. When the T2 model reached Canada, Rannie quickly perceived that the small aperature of its telescope would mitigate against the widespread adoption in this country of the lightweight instrument in place of the rather heavy, cumbersome first-order theodolites then in use. It was partly owing to Rannie's advice to the makers that the T3 model, introduced in Canada in 1927, incorporated a larger telescope. Other improvements in this instrument derived from investigations in Ottawa by Rannie and his co-worker in this form of research activity, W. M. Dennis.

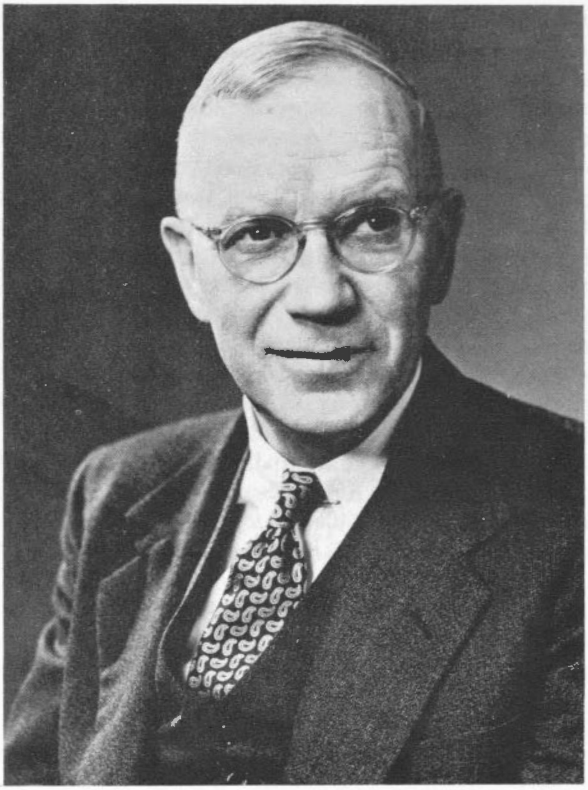


FIGURE 84. John L. Rannie.

Rannie, a graduate of the University of Toronto in 1907, was commissioned a Dominion land surveyor in 1909 and a Dominion topographical surveyor five years later. His professional career, in its entirety, was served with the Geodetic Survey of Canada and in 1947 he was appointed Dominion Geodesist. Three years later he became International Boundary Commissioner for Canada, retiring from the federal civil service in 1951. His term at the helm of the Geodetic Survey from 1947 to 1951 foreshadowed the rise to that post, in turn, of such able surveyors and administrators as J. E. R. Ross, J. E. Lilly, and L. A. Gale.

Triangulation work in Canadian cities had early become an important function of the Geodetic Survey. In the solving of modern engineering problems in urban areas, accurate topographical maps have always been considered a fundamental requirement. Geodetic surveyors had the training and ability to gather data beneficial to city mappers. As early as 1918 such work was being conducted by the Survey in Montreal and Toronto. Within a few years this type of activity had been extended to London, Quebec, Halifax, Saint John, Vancouver, and New Westminster. One great advantage of these operations was that if any points fixed by geodetic triangulation within city limits should be displaced or lost, these could be accurately re-established at any time.

A. M. Grant, a geodetic surveyor, reported in 1919 that "engineers of the City of Montreal have long felt the necessity for a complete new map of the territory embraced within city limits as well as of adjoining municipalities . . . . As the first requisite of such a map is triangulation control, the Geodetic Survey of Canada was asked if control could be provided. . . . The control points which were established were all selected so that their positions could be easily and accurately transferred to permanent marks in the streets. Where there were no sidewalks, marks consisted of copper bolts set in the tops of concrete monuments. . . ."[9]

In all this work there was a 'stepping down' from primary triangulations to shorter lines in and around built-up areas. Whereas in Montreal and London civic authorities asked for points to be accurately established on streets and sidewalks, in Toronto the City Surveyor requested that such stations be established at the top of prominent buildings. A number of years were required to complete the task of surveying London. Each year, however, showed a noticeable decrease in the unit cost of the operation as improvements took place in survey organization and methods. It was forecast by some experts in such matters that if aerial mapping could be employed to 'fill in' the interior of city blocks the cost of the cartographic operation could be reduced to about 75 per cent of the initial year's expenditure for the purpose, namely, by about $260 per acre. Publication No. 9 of the Geodetic Survey of Canada, 1921, titled *The Making of Topographical Maps of Cities and Towns: the First Step in Town Planning* aroused considerable interest in professional circles in Canada and the United States.

By 1926 it had become obvious to federal government authorities that with the rapid proliferation of engineering projects sponsored by municipalities and by private industry, there would be needed, even for points in some instances distantly removed from then existing industrial centres, precise data on latitude, longitude, and elevation above sea level. The Department of the Interior, Ottawa, recognized this trend by drawing up programs of work involving extension of levelling and triangulation nets of the Geodetic Survey.

The establishment of horizontal and vertical controls to meet survey requirements of a country such as Canada demands careful planning from year to year. The vast extent of the land area, the relative lack of highways, railways and navigable water routes, the heavily indented coasts fronting on three oceans, sparseness of settlement in many areas, all imposed formidable difficulties in the prosecution of geodetic work in the years between the two world wars. As recently, in fact, as the 1940s no continuous first-order triangulation existed from coast to coast on Canadian territory. A gap of about 600 miles persisted in the Lake Superior region of the trans-Canada chain or framework.

In the 1942 field season a special study was made by Cecil Herman "Marsh" Ney (1889-   ) of the Geodetic Survey concerning air navigation in polar areas involving

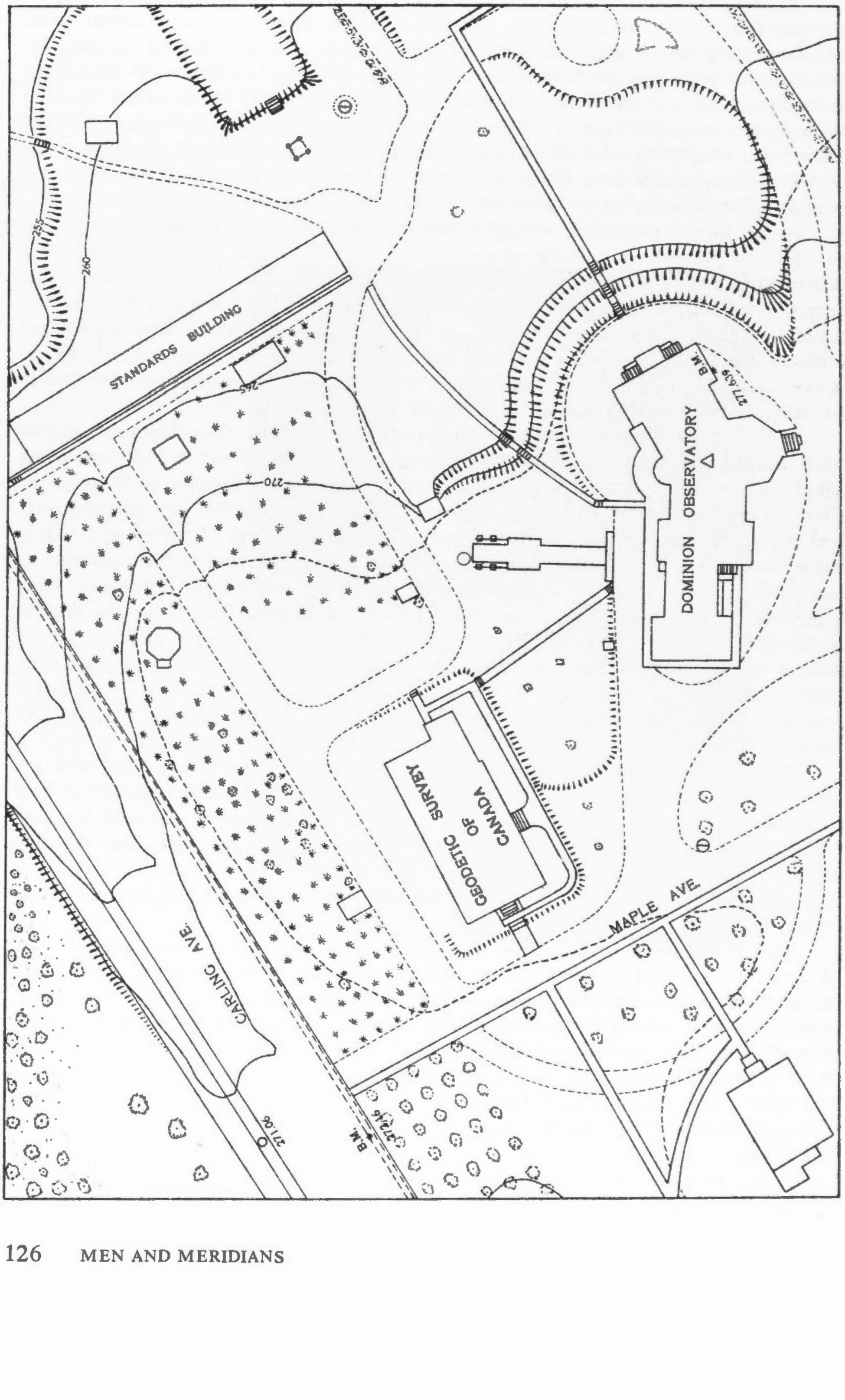
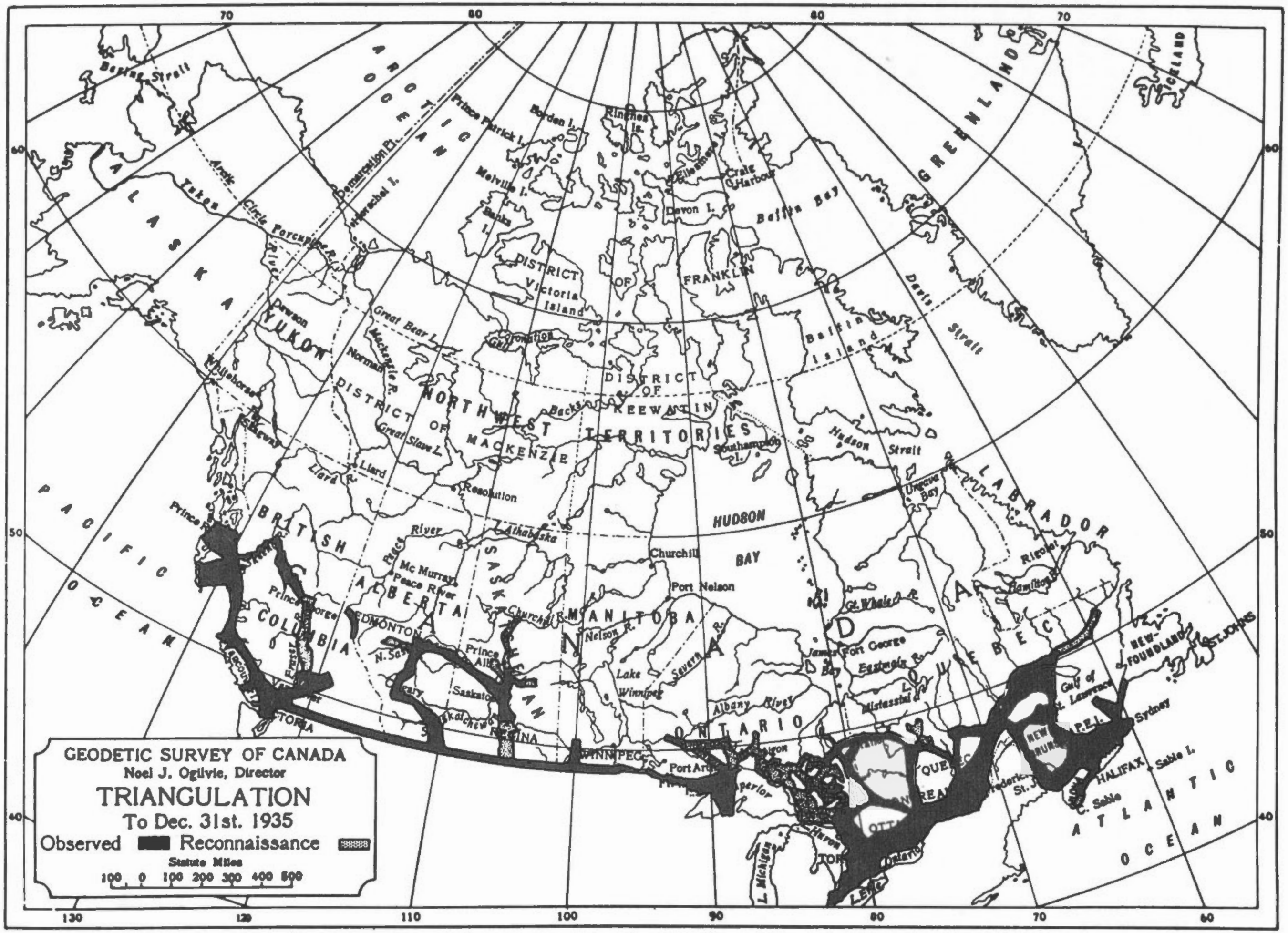


FIGURE 85. Part of City Map (Ottawa) from Geodetic Survey of Canada publication No. 9, 1921.



MAP 3. Portrayal of triangulation work, Geodetic Survey of Canada, up to December 31, 1935.

compilation of all available weather and magnetic data for use on high-altitude flights in the Arctic. The study also included research in the development of methods for determining positions astronomically when the usual procedure was not suitable. Ney's adaption of a map projection for northern latitudes was a most important contribution to air navigation in those regions and it was probably for this achievement that Ney was made a Member of the British Empire.

Ney's survey career reflected the nature, scope and significance of Geodetic Survey activity in Canada during the period under review in this volume. Born in Bradford, Ontario, and educated in nearby Aurora, the town to which the Ney family moved when "Marsh" was ten years old, the youngster went on to the University of Toronto. There he was trained for geodetic survey work, selecting the then rather exotic courses of geodesy and astronomy. Professor L. B. Stewart was one of his instructors. Ney was fascinated by the science of precise measurements and by the surveyor's constant search for extreme accuracy.

During the months between college terms Ney took employment as a student attached to survey parties in the field. This exacting but useful apprenticeship prepared young Ney for the challenges ahead. During this period he served under such men as Ontario land surveyor James H. Smith in the vicinity of Cobalt, Ontario, as well as in Alberta: with Dominion land surveyor Wilbert Norrish in Saskatchewan; and with Guy Blanchet, D.L.S., in Manitoba. After a short span of service with the air force overseas Ney returned to Canada in 1919 and almost immediately joined the staff of the Geodetic Survey in Ottawa. In all, Ney served 29 years with the Survey, rising to the position of Assistant Dominion Geodesist. While in the field he worked on the Pacific Coast, along the Ontario-Manitoba boundary, the British Columbia-Yukon boundary, in the Eastern Arctic Islands and along the Mackenzie River.

An example of the risks so often faced by surveyors operating in the north country was experienced by Ney in the winter season of 1913-14 while he was an assistant on settlement surveys with Sid Fawcett, working along the lower Mackenzie River. With the onset of cold weather the survey party was forced to return upriver from Fort Norman by dog train. In the beginning the river ice was smooth but soon hummocky formations were encountered, reducing progress to an arduous seven miles per day. Between Fort Norman and Fort Wrigley the party ran out of food. Two elderly axemen, finding even that pace too exhausting, asked to be left in a tent with a supply of tea. The remainder of the party kept on the trail, drinking large quantities of tea, the only nourishment left to them, finally making it to Wrigley. Aid was sent in time to the encamped axemen. Sleeping in those latitudes in the open, with little or no solid food, in winter temperatures, proved to be the most rugged test endured by Ney in the field.

Despite its occasional rigorous conditions Ney always felt strongly attracted to the North and during his career witnessed a marked transformation in the manner of living there as the geodesist, geologist, hydrographer, and aerial photogrammetrist all helped in the process of rolling back the frontier in that part of the world.[10]

Notable advances made during the Second World War in the art of distance measurement by electronic means heralded the application of these ingenious methods of surveying to the tasks of civilian mapping. Radar was used for determining the height of a plane above the ground and this led, in connection with improved aeronautical charting, to the development of instrumentation known as the Air Profile Recorder. The invention and refinements of this new tool in air survey work will be considered elsewhere in this volume. Shoran, a name derived from the term "Short Range Navigation", was a system developed by scientists of the Radio Corporation of America for use in allied war raids and which proved readily adaptable to peacetime surveying tasks. This was one of the first radar systems developed during that war for use in the navigation of bombing planes and in the indication of bomb-release points. Shoran was first put into tactical military use in Northern Italy by the Americans late in 1944, with impressive results.

Soon after hostilities ended, a long-term member of the Geodetic Survey of Canada, John Earl R. Ross (1892-   ) recognized the feasibility of applying shoran methods to the solution of geodetic measurement problems in Canada. Late in 1945 the Associate Committee on Survey Research, under the sponsorship of the National Research Council of Canada, decided to institute a study in this regard. That was one possible use of shoran. Another possible function was that of providing the required horizontal control for air-survey photography in connection with the mapping of large areas. Late in 1947, at a time when Ogilvie was being succeeded as Dominion Geodesist by Rannie, Ross took an active and leading interest in initial field research near Ottawa, testing shoran as a tool in the provision of primary control for mapping purposes.

FIGURE 86. J. E. R. Ross.

Experiments were carried out in that year, and again in October, 1948, as a joint effort by the Royal Canadian Air Force, the National Research Council, the Army Survey Establishment, R.C.E., and the Geodetic Survey of Canada. These pioneer shoran-controlled air surveys, followed by a successful field operation covering parts of Manitoba and Saskatchewan in 1949, provided results the accuracy of which surpassed all expectations.[11]

In a geodetic sense the basic difference between the shoran method and normal triangulation procedure is that *distances* or *sides* of triangles are measured in the case of the former system, *angles* in the case of the latter. Whereas the sides, in ordinary triangulation networks, extend 10 to 50 miles, shoran lines vary from 100 to 400 miles in length. Horizontal control over large areas can thus be made rapidly available despite the nature of the terrain. The consistency of the results obtainable by these electronic measurements was definitely superior to that produced by astronomic fixation. For small-scale topographical mapping, such as that on a scale of 1:250,000, a shoran net could be used without alteration for control of air photography over areas previously devoid of survey control. The conviction grew in knowledgeable quarters that applications of the radar principle, such as shoran, could make a contribution to mapping in Canada approaching that of photography.[12]

In shoran, the distance between two non-intervisible ground stations was measured to an aircraft flying above the mid-point between the stations. Appropriate corrections were applied to allow for the geometric relationship between the curvature of the earth altitudes of airborne and of ground stations above sea level, and the effect of refraction. Calculations were then made to arrive at the distance between the two stations.[13]

Successful initial field operations employing shoran in 1949 were followed by intensive and extensive preparations for a wider use of the system in this country. By the season of 1953 a total of 11,000 linear miles had been shoran-surveyed and shoran-controlled air photography covered more than 100,000 square miles of northwestern Canada. By the following season 50 shoran station sites had been selected and so spaced as to provide control over 1½ million square miles of Canada north from existing triangulation nets to the southern bases of the Arctic Archipelago.[14] Mention should be made of the important services rendered in this realm of survey effort by the Dominion land surveyor Angus Cameron Hamilton (1922-) who was in charge of shoran reconnaissance activities in 1952 and of Canadian shoran operations generally during the field seasons 1954 to 1957 inclusive.

FIGURE 87. Angus C. Hamilton.

The name of J. E. R. Ross, whose long career had made such a noteworthy impact on Canadian geodetic surveying, became intimately associated with Canadian applications of shoran, which he did so much to promote in this country. He was largely responsible for the contents of two manuals describing geodetic procedures involved in shoran operations in Canada. Born in Elmira, Ontario, Ross attended high school in Kitchener, and then proceeded to the University of Toronto, graduating with honors in 1911 as a bachelor of applied science. His admiration for a half-brother, the Dominion land surveyor William F. Ratz, led Earl, as much as anything, into the profession. Ratz, who had played an important part on international boundary surveys from 1906 to 1909, died in Ottawa at the age of 25 years. Ross tells of his first applications to Ottawa for summer work on surveys, one sent to the International Boundary Commission, the other to the Geodetic Survey of Canada at the same time. Two replies came in the same mail. Opening first the letter from the Commission, Ross was downcast by the terse message from Dr. W. F. King, "We're very sorry that we cannot give you employment in summer work." Young Ross was so mortified and rebuffed that he had to be persuaded by his mother to open the second letter, also from Dr. King which read, "You are appointed to a summer position with the Geodetic Survey."

Ross went on his first field party in 1910 as assistant to the party chief, Dominion land surveyor Lindsay Osborne Brown. His pay as student was $1.35 per day, with 75 cents of that amount payable in the field and 60 cents withheld until the end of the season and then paid "if services satisfactory". Food and transportation, but not clothing, were provided for the purpose. This was Brown's first season in geodetic work also. Ross served in the field again as a student in 1911. In the following year he arrived in Ottawa to take charge of a geodetic field party. It was at this time that Ross received a memorable reprimand from his superior in the organization, C. A. Bigger. Apparently only one serviceable tripod remained in the survey stores in Ottawa and this happened to be too short to be useful to Ross. Bigger instructed him to go to the storeroom and get another tripod. Ross could not find another such item of equipment and reported accordingly, "Mr. Bigger, I looked there and couldn't find one." "Go and look again", was the tart rejoinder. "Mr. Bigger, there isn't one there but if there is, will you come and show it to me?" Bigger's pronouncement on receiving this challenging plea was a crushing one, "We are not, Mr. Ross, the servants of those we employ!"

Ross early showed high promise in his chosen profession. He was commissioned a Dominion land surveyor in 1913 and certified as a Dominion topographical surveyor six years later. Except for a period of active service with the Royal Canadian Engineers in the First World War, Ross served continuously on the staff of the Geodetic Survey of Canada from 1912 to 1957. At the peak of his service he was Dominion Geodesist and International Boundary Commissioner for Canada.

The science of navigation over land, sea and in the air has been a story of progress illuminated by the resourcefulness of individuals and marked by a notable evolution in instruments of measurement. From the cross-staff and sextant of the Middle Ages to the era of the compass and chronometer, followed by the advent of a variety of electronic devices, man's ingenuity has kept pace with needs of the times in the realms of exploration, surveying and mapping. The Second World War signalled the beginning of a remarkable period of technical advances in measuring systems and tools, improvements that brought pronounced advantages to the geodetic sciences. Base-line measurements for years before the war had been made, for example, by means of Invar tapes. But with Bergstrand's invention of the geodimeter, an electronic-optical instrument utilized to measure distances, it became possible for fewer men to measure longer lines in shorter periods of time than by the use of tapes. With the appearance in South Africa in 1956 of the tellurometer, capable of impressive daytime performances despite conditions of fog, smoke, haze, or rain, another distance measuring instrument became available to the geodesist.[15]

The invention of the tellurometer, progenitor of a new family of instruments employing microwave propagation to measure distances very precisely, opened an era of notable advancement in the world of survey instruments. The speed and efficiency of these new electronic devices contributed greatly to the science of geodetic measurements.

In physical geodesy the airborne gravimeter and the aerodist, in essence an airborne tellurometer, were soon to appear. The growth of satellite geodesy began to reveal fascinating opportunities for improving knowledge of the dimensions and shape of our planet. This has also given impetus to the development of instruments for use in predicting orbits of satellites and for radio tracking of these and other man-made objects that were soon to be launched into outer space in ever-increasing numbers by various nations engaged in probing the mysteries of that region.

The first known measurement of the earth's circumference at the equator, accomplished by Eratosthenes, was in error by 16 per cent. With the passage of intervening years and centuries since that historic calculation, a succession of ingenious instruments have continued to provide the geodesist with improved knowledge in his persistent search to ascertain the exact size, shape and weight of the earth on which we humans live, move and have our being.

"Not in vain the distance beckons,
Forward, forward let us range,
Let the great world spin forever
Down the ringing grooves of change."

9

EVOLUTION OF CANADIAN HIGHWAY SURVEYS

"To all the points of the compass . . ."

—*Coriolanus*, Act 2, Sc. 3.

In early Canada the waterways provided explorers, settlers, traders and officials with the swiftest, most economical and most comfortable form of transportation. The myriad lakes, rivers and streams of the northern half of North America offered mobility on a scale and with a facility unexcelled by any other mode of pioneer travel. The St. Lawrence River was the main thoroughfare of this extensive network, with its tributaries forming a veritable system of sideroads. In the maritime regions of the country pioneer settlers relied mainly on sea lanes as their chief means of communication, land roads being difficult to build and costly to maintain.

By 1773, for example, streets had been laid out in St. John's, Newfoundland. But a half-century elapsed before these were extended beyond the town's limits. The first overland road of consequence was that constructed from St. John's to Portugal Cove on Conception Bay. On the maritime mainland the first significant road was built in 1606 from Port Royal to a nearby creek, under Champlain's supervision. Not until a century later was another road of importance constructed in what is now Nova Scotia, namely, the 18-foot-wide highway from Halifax to Windsor, later extended to Annapolis.

New Brunswick followed the general pattern of riverbank roads characteristic of central Canada but progress was made in the newer province at a more accelerated rate. As early as 1801 the government of New Brunswick made grants in aid of construction to various localities under its jurisdiction. The first important roadway flanked the St. John River from Fredericton to the Bay of Fundy. By the 1820s a road linked Chatham and Shediac along the east coast. By the middle of the century New Brunswick possessed 1,269 miles of principal roadways as well as several hundred miles of sideroads.

FIGURE 88. Route of the Trans-Canada Highway. (Map from G. B. Williams, Department of Public Works, Ottawa, 1957.)

Prince Edward Island authorities did not lag behind other maritime region governments in the matter of roadbuilding. From entries in the notes of surveyor Charles Blaskowitz we learn that in July, 1771, the Governor (of the Island) wrote to Lord Hillsborough advising that he had ventured "at his own risk to have a road laid out from Charlottetown to Prince Town, and although the surveyor avoided, by his instructions, all swamps, difficult rivers and steep hills, the road as measured was only three-quarters of a mile more than if on a straight line, and it is only 33 miles [in all]."[1]

Roadwork along the St. Lawrence River commenced with the emergence of a second tier or range of farms at the rear of the original river-frontage properties. In order to provide ready access to the St. Lawrence River from these back lots and to link them to each other the first primitive trails to be built by settlers came into existence. As horses arrived from Europe in increasing numbers, roads built under the direction of *grand voyers,* or supervisors of highways, began to appear along the banks of the river itself. One of the earliest of these highways linked Cap Rouge with the town of Quebec, a roadway eventually absorbed into what is now one of the city's principal traffic arteries, the Grand Allée. But prior to 1700 few roads had been built in New France. Actually, before the advent of the 19th century no comprehensive plan of highway construction existed in that part of Canada. The most important roads of the period were those providing access to the town of Quebec from Beaupré, Ile d'Orleans and other settlements in the vicinity. During the first decades of the 19th century the pace of roadbuilding quickened somewhat and several important sections of roads linking Montreal and Quebec were built along both north and south shores of the St. Lawrence.[2]

In British Columbia the period immediately following Confederation with Canada brought a change in emphasis in roadbuilding in that province. During the 1860s the chief objective in highway construction was to link the goldfields of the interior with tidewater. But in the succeeding decade the provincial government concentrated upon opening trunk routes through settled parts of Vancouver Island and in the farming areas of the lower Fraser River. In 1874 work began on the provision of a road from Ladner to Hope as riverborne traffic proved increasingly inadequate to meet mounting demands for service. Following the departure of the Royal Engineers most roads in the early days of British Columbia were built by statute labor working under an elected foreman. During the 1870s nearly half of all British Columbia's revenues were devoted to the construction and maintenance of roads and bridges.

In Upper Canada, later Canada West, although its government spent a substantial part of its meagre fiscal resources on the construction of a few trunk roads, the provision of many lesser roads was left to the settlers themselves. Highway development generally proceeded in rather piecemeal fashion. Asa Danforth, an American, was awarded a contract in 1798 to blaze a road from Kingston west along the north shore of Lake Ontario as far as York. As part of the agreement certain roadbuilding standards or specifications were to be observed. The highway was to be cleared to a width of 33 feet throughout its length with 16½ feet in the centre to be cut even with the ground. Bridges and causeways were to be 16½ feet in width and high enough above the water to lessen possibilities of destruction by floods. Slopes were to be gradual and safe yet wide enough for vehicles to pass thereon. By December, 1799, 63 miles of this type of roadway was opened for travel between York and what is now Port Hope. At this stage of development W. C. Chewett, the surveyor, was asked by the government to inspect the project. Chewett found that hollows needed filling, some hillocks needed levelling and that forest debris should be removed from various parts of the new highway. Bridges and causeways were found to be reasonably good with the exception of one bridge "which", it was found, "shakes or trembles" with a moving horse or carriage on it. Chewett also noted, with some asperity, that his survey ought to have been ordered and made earlier in the year "for when an inspector is almost frozen he cannot act as he ought to."

The general procedure followed in early days of roadbuilding in Upper Canada involved the employment of an explorer who walked ahead of the roadbuilders in order to roughly mark out its course. He was followed by two surveyors carrying compasses. Trail-blazers then used hatchets to notch trees on both sides of the marked trail while axemen chopped out the roadway between the indicated limits.

"Carriages without horses shall go
and accidents fill the world with woe.
Around the world thoughts shall fly
in the twinkling of an eye."

—Prophecy of Mother Shipton (1488-1561)[3]

In a number of ways the development of highways in Ontario over the years is typical of the growth of the road systems in the older-settled regions of Canada generally. From reliance on waterways and Indian trails, the early settlers, traders and the armed forces advanced to the use of blazed paths and winter roads. But when the snow cover disappeared under the warming rays of the spring sun, the rude and exceedingly rough pathways, cluttered with tree stumps, became virtually impassable. In swampy parts roadbuilders resorted to the corduroy treatment, covering the water-saturated, unstable ground with logs laid down alongside each other. These bone-shaking abominations were supplanted in time by graded but unsurfaced roads, ditched for drainage and crowned to shed excess water. Although at the time these highways represented substantial improvements in road travel, the gains remained strictly seasonal, offering poor progress in springtime and autumn months.

Increasing settlement imparted a marked impetus to the growing demand for better roadways. The need for more usable trade routes, for roads affording more rapid movement of troops and military supplies, for better postal service and improved mobility for those engaged in the administration of justice combined with a widespread desire for greater comfort in travelling, brought about the construction of more and more properly graded roads. In time this trend in public opinion resulted in the advent of toll roads, often surfaced either with crushed stone or with wooden planks.

During the period when railway building occupied the public limelight, roads in this country were more or less neglected. The appearance of steam-propelled vessels on the lakes and main rivers also temporarily distracted public and official attention from the pressing need for highway work. But with the arrival on the Canadian scene of the motor car in 1898 the role of the highway in the realm of national transportation once again became paramount. In that year the first gasoline-driven road vehicle to be operated in Canada, an American-built Winton, was purchased by John Moodie of Hamilton. By 1903 there were 220 cars registered in this country, all in Ontario. In 1907 Robert McLaughlin and his son, R. S. McLaughlin, formed the McLaughlin Motor Car Company in Oshawa. The first vehicle this plant produced was a McLaughlin-Buick.[4] These events ushered in a new age of vehicular mobility in Canada. Not even the popularity of transportation by air in more recent times has undermined the restored position in public preference of travel by roadways, although a commission appointed by the Ontario government reported in 1914 that farmers of the province "suspect that the days of the use of the motor car for mere pleasure are already numbered; that in another decade the joy-riding may be done in the air, and the automobile will be relegated to the purposes of sober labour . . ."[5]

As early as 1889 right-of-way surveys were occupying the special attention of some eminent Ontario land surveyors. "Field work", one of them stated, ". . . requires good judgment and experience, especially in towns and villages . . . The object is to find out the quantity of land taken from each owner and to obtain this the surveyor must be given the ordinary width required, also all extra widths and of course, in starting, the position of the located line should be fixed from some well-known point . . . The plan of the right-of-way should show numbers and other designations of town or township lots — the concessions, owners, with the area of each parcel to be taken, with the length along the located line of each parcel and the bearings of tangents and radii of curves."[6]

Up to the end of the First World War neither the volume nor the speed of motor vehicle traffic required departure from traditional road surveying practices. In general, methods employed in the planning, designing and locating of roads advanced relatively little in the 100-year period leading up to 1920. Reconnaissance surveys served to indicate the initial location line and possible alternative routes. These activities were followed, in turn, by preliminary surveys and final location surveys. Preliminary surveys involved the running of an accurate traverse line along the route selected as a result of the reconnaissance. Accurate levels were also run and bench marks established. From this data a basic map of the highway route was plotted and the final alignment of the highway projected. Then came the staking out on the ground of the finally determined road location. In all three stages in these early highway surveys in Canada, field notes, the compass, transit, chain, level and sometimes ground photographs played conventional roles. Where extreme accuracy was not essential the prismatic compass was occasionally employed in preference to the transit.

Within the 30-year span covered by this volume a notable transformation in the system of Canadian highways, along with related surveying and mapping, brought about profound changes in the social and economic climate of the nation. The problems faced and surmounted by highway surveyors and construction engineers may not be as much the concern of today's travelling public as their finished product, namely, smooth, hard-surfaced roads with easy gradients and good alignments. Nevertheless the outstanding contribution made by these specialists to a highly important feature of Canadian progress is a story that ought to be told.

Prior to 1917, when a section of the existing Provincial Highway System was first taken over by the then newly-formed Ontario Department of Highways (The Ontario Highways Act, 5 Geo. V, c. 15), several developments of key importance to highway builders and users had taken place. Toll roads had almost completely vanished from the province. The enterprising device of empowering private corporations to construct and maintain public roads, while collecting fees or tolls from their users, had proved a failure. Administration of highways and of highway building became increasingly centralized. In 1849 cities and towns in Canada West had been granted control of roads contained within their jurisdictional limits. In 1874 county councils were authorized to take over township roads. The formation of the new provincial department during the First World War foreshadowed an even greater degree of centralization as Queen's Park began to exercise a dominant influence and role in the provision of more and better public highways in Ontario.

Other aspects of the burgeoning motor travel industry benefited from this same system of trial and error. Revenues resulting from direct taxation of the road-user for highway construction had proved chronically inadequate for the purpose of financing such projects. A tax on each automobile registration turned out to be as ineffective as the imposition of tolls until the fee was based on the horsepower of the car engine and until some genius discovered that the bitter pill of taxation could be dissolved, with relative freedom from discomfort to the motorist, in gasoline. But at the same time the highway-user was beginning to benefit from increasing government services rendered in addition to road and bridge construction. Highway features were being marked by more descriptive road signs and, in 1923, the department issued its first road map. In the provincial road system of Ontario there were then 1,824 miles of hard-surfaced highways. In all Canada, at that time, there existed a total of 116,000 miles of improved earth highways and some 50,000 miles of various types of hard-surfaced roads. These figures represented, in rough terms, a doubling of mileages in these road categories over the corresponding totals in 1914.[7]

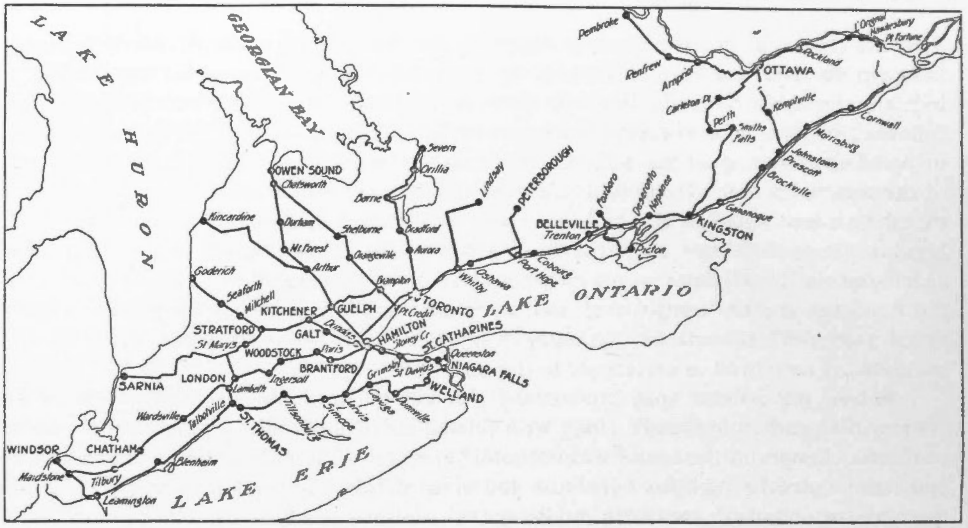


FIGURE 89. System of provincial highways, Ontario, 1922. (Map from Ontario Department of Highways.)

Because the standard width of right-of-way for concession or sideroads in Ontario was 66 feet, practically all the highway surveys performed by the new provincial department were widening surveys. Under the 1915 Ontario Highways Act it was provided that every main road "shall have an allowance at least 66 feet wide and each board [of road trustees] shall have authority to widen such road or to adopt a more favourable route and [to have authority] to widen the allowance an additional 20 feet on each side *when such widening was considered desirable.*" [author's italics]

When a road was taken over to form part of the new provincial system a preliminary route plan, on a scale of one mile to the inch, was filed in the registry office. On this plan the route was shown in red. A land plan was also filed by which the department acquired title to any land required in the widening process. This plan resembled a surveyor's standard plan but incorporated special information used in making the road survey. Between 1919 and 1923, under auspices of the department, several thousands of miles of hignway in southern Ontario were widened to 86 feet.[8]

In the 1920s the department issued instructions to field parties engaged in highway surveys which read in part:

"Notes should be made as to the size, type and condition of culvert span, waterway areas and types of bridges . . . If it is necessary in establishing lot corners to dig for stakes or stone monuments which are not found, note should be made of this, such as 'I dug here and could not find stake. . . .'

"On these surveys four-foot iron bars should be driven at frequent intervals so that the line may be easily re-established at any future date by . . . department surveyors or local surveyors . . . These iron bars should be driven well down to within six inches of the ground [level]. They should be put in by means of the steel tape and plumbobs should be used . . . Important stone monuments and landmarks should also be located with a steel tape and the exact chainage recorded to facilitate reproduction in case subsequent grading operations [should] destroy these points . . . It is not intended that iron bars should be driven at every property limit. If it is necessary to move back the fences, wooden stakes may be planted on property lines to facilitate this."[9]

FIGURE 90. Pattern of highway development, Don Valley, Toronto, looking west to the Thorncliffe apartments complex, 1960.

Monuments were generally set one foot above the surface of the ground but in built-up areas the markers were set flush with the surface. The practice of driving iron bars on the limits of right-of-ways was not uniformly effective. Subsequent investigations revealed that in some areas up to three-quarters of the total number of bars disappeared within a relatively short period. Farmers, apparently, found the markers to be excellent crowbars. Fence builders removed them, road construction machines bent them out of shape and dealers in scrap iron found them to be a ready source of revenue. As an economy move the department experimented with the substitution of 5-foot-long concrete monuments.

During the period under review in this chapter highway survey parties in Ontario consisted of a large crew of 12 men or a smaller crew of 7. The latter group was

FIGURE 91. Along Toronto's waterfront in 1949.

composed of a qualified land surveyor as chief of party, assisted by a trained instrumentman who functioned in the combined roles of transitman and levelman. The remainder of the crew was composed of a front chainman, a rear chainman, a tapeman, a stakeman and a chauffeur. The larger group was divided into a location crew and a levelling crew. The former possessed, in addition to personnel listed in the party of 7, an assistant to the transitman and a property man. The levelling crew consisted of a competent leveller, assisted by his own rodman and tapeman. In addition to a transit, level, metallic tapes, heavy and light pickets, alloy chains and other implements these groups were equipped with the route plan, also a plan showing meridians of longitude and parallels of latitude, the location of geodetic survey bench marks in addition to details of local plans and surveys.

The objective of such parties was to locate and to mark on the ground the centre line of the proposed highway as well as its side limits and to obtain information and measurements essential to the preparation of a reliable plan of the route for registration purposes. In addition, surveyors were instructed to establish, by levelling procedures, bench marks along the route. These marks were never to be more than a half-mile apart. Complete profiles or cross-sections of the road were to be plotted at stated intervals. The property man was authorized to obtain the names of all owners of properties affected by or abutting on the proposed road. The relative positions of the road-

Highway development, including the Gardiner Expressway, up to 1962.

bed, ditches, embankments, culverts, bridges, railway and telephone lines and other man-made structures, as well as rows of trees were to be carefully noted and studied. The accurate location of the highway's centre line was indispensable to the maximum widening that could be achieved with the least possible expense. The locating of sharp angles along the route and at the crest of steep grades was to be avoided. The minimum radius of any curve in the route was set at 300 feet.

In 1930 the Ontario legislature passed an act (20 Geo. V, c. 10) under which the descriptive name of "Provincial Highways" was changed to "the King's Highway". With steadily increasing revenues derived from the gasoline tax and vehicle registration fees, millions of dollars became available from the provincial treasury for new highway construction. As a result of the depression period and the years of the Second World War an immense backlog of postponed road and bridge construction had accumulated in Canada as a whole. Roads with bases of poor quality, narrow, dangerous curves, steep gradients and obsolete bridges aggravated the ever-present problem involved in handling a gallon of traffic within a pint of highways. From the horse-and-buggy, dirt-roads era Ontario plunged, in common with the rest of Canada, into the age of multiple-lane, hard-surfaced highways, of overhead bridges, under-passes and the whole complicated system of traffic interchanges and cloverleafs that now constitute such distinctive features of expressways, throughways, freeways and parkways.

More intensive planning instituted well in advance of actual road construction, along with improved methods in highway building, came to be the order of the day. From the nucleus of Ontario's eight historic routes: Dundas Street, The Governor's Road, Longwoods Road, Kingston Road, Danforth Road, Talbot Road, Yonge Street and the road around the head of Lake Ontario to Niagara, there developed an excellent road system consisting of more than 85,000 miles of highways of which some 12,000 miles were under the direct control of the provincial Department of Highways. By the late 1920s, for example, congested roads linking the Niagara Peninsula to Toronto were unsuitable to carry properly the steadily increasing load of automobile and truck traffic. In 1931 work began on the construction of a new major highway in that area, christened "The Queen Elizabeth Way" and formally opened by King George VI and Queen Elizabeth in June, 1939.

The designing of highways became, in many respects, an exact science. Before any road-building project was undertaken on the ground, the actual and prospective flow of daily traffic to be accommodated was studied intensively. In addition to this traffic census, involving special attention to peak-flow periods, information was gathered on population distribution and industrial development in the areas to be served. Drainage patterns, soil physics, geological and topographical surveys data, sources of road-building materials, location of culverts and bridges, of road signs and survey monumentation were other factors considered in the planning stage. The fruits of all these careful preparations were better-located, better-built and safer highways.

Very early in the development of the new science Canadians discerned the special value of complete, accurate maps in connection with road reconnaissance surveys. At the outbreak of the Second World War Canadian surveyors, particularly in Ontario, were international leaders in experimenting with the use of aerial photographs in locating new highway routes. In the beginning few realized the revolutionary impact that would be made upon highway planning generally by the employment of this type of photography. The first trial project of this description was undertaken in 1931 in the area between Batchawana and Michipicoten during the preliminary survey of this Ontario section of the Trans-Canada Highway. Not until two years later, however, was the new procedure applied in earnest near Bancroft. Again, in October, 1938, a belt of land between Brockville and the Ontario-Quebec boundary was photographed from the air in connection with the locating of Highway 401. In 1942 the Toronto-Windsor section of the same project was flown for the same purpose. Elements of a Photogrammetry Section then began to appear in the Department of Highways. New equipment in the form of an epidiascope and a heavy brass stereoscope came into use in the Ontario organization about this time.

In the construction of the Alaska Highway in 1942 the United States Public Roads Administration, in cooperation with United States military authorities, made good use of Canadian progress in this aspect of photogrammetry. In selecting a route for that wilderness road with the fewest possible river and swamp crossings and with a minimum clearing of earth and rock grading, it was realized that normal road location by ground reconnaissance methods was much too time-consuming. At this point Ontario offered the services of its government surveyors, R. N. Johnson and K. H. Siddall. These men possessed a wealth of practical experience in locating highways by the use of aerial photographs. A Northland seaplane was placed at their disposal. Photographs of the rugged terrain, printed on strips, were examined in stereo pairs and viewed under a Fairchild prismatic stereoscope. The ability to interpret correctly the information made available through aerial photography for road location purposes has always been indispensable to the successful application of this procedure. In this case it was used to establish control points for the location of the Alaska Highway. A straight line was then drawn across the photographs to join successive control points. The next step was to transfer this projected line to the ground.

The size of each party engaged on field location varied with conditions of time and terrain. All lines were run by staff compass, rather than by transit, and simply blazed or marked for easy recognition by construction troops. As a rule each location survey party consisted of two men using a staff compass, five men on line-marking work, and two on chaining activities. With the aid given by aerial photography one regiment of United States engineer troops located and constructed some 230 miles of road between Fort St. John and Fort Nelson in eighty days.[10]

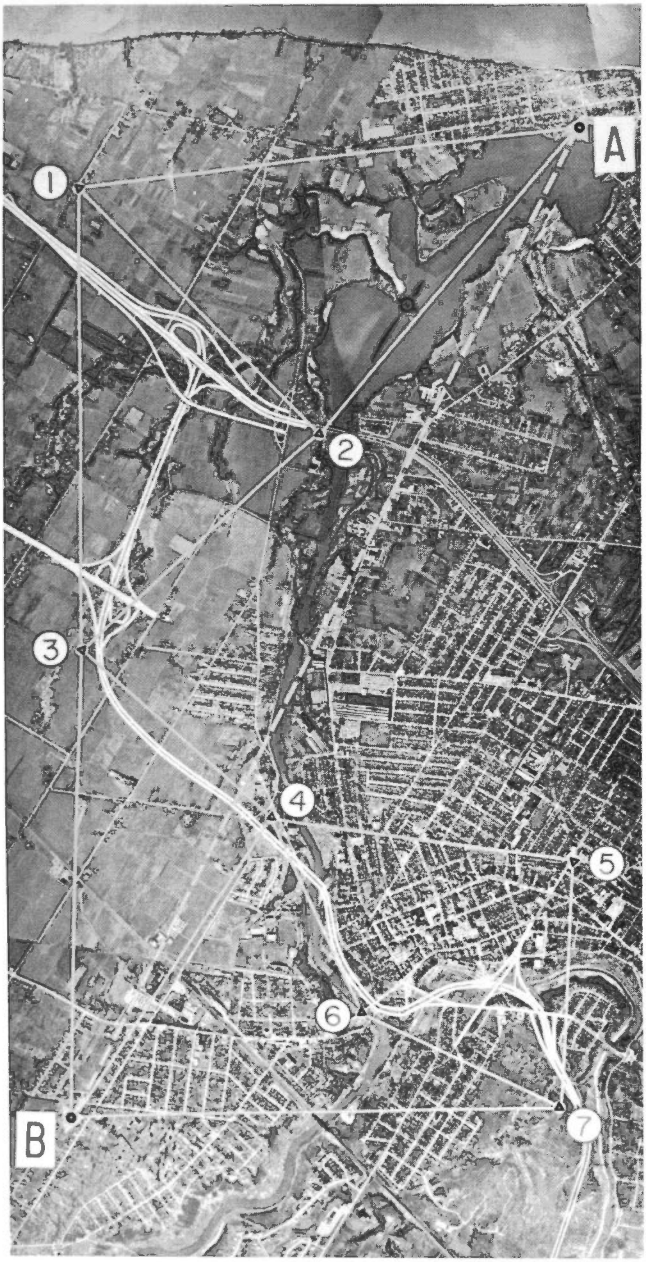


FIGURE 92
Example of triangulation survey control, construction of Ontario highways.

FIGURE 93. Clarkson, east of Toronto, in 1950, showing the Queen Elizabeth Way to the north (top of picture

In 1943 a pronounced advance took place in providing control for plans produced from aerial photographs with improvements in the methods of taking measurements from air photographs and the provision of well identified field control. This enabled the photogrammetrist to control his scale not only along the line of flight but laterally as well. In late 1945 the Ontario photogrammetry group attracted well-trained army personnel in this special type of work. Soon the group acquired the status of a recognized section. The Department of Highways in 1947 purchased what was then the latest in photogrammetric equipment, the multiplex projector. Inventory photography resulting from its use commenced about this time in the province and proceeded until all Ontario

Same view, 1968. Note the highway and urban development.

was covered. In those days a photogrammetrist was included in field parties. His task was to establish on the ground the line of highway determined by careful office study of the proposed route. In bush country, by constantly pacing, measuring, scaling and identifying natural features, he red-flagged the route, closely followed by axemen. In turn they were followed by instrumentmen, chainmen, levellers, and the contour section. Other types of new instruments purchased by the department included the Abrams Sketchmaster, a device for transferring photographic detail to base maps, and a Saltzman reflecting projector, an instrument capable of reducing or enlarging work in a variety of scales. Experimentation demonstrated that the greater the amount of photogrammetric control provided, the greater the accuracy achieved. In this manner the best possible route could be established, with marked savings in time and money, through areas where roadbuilding would be least arduous.

By 1945 highway survey procedure in northern Ontario had become a ten-stage process. Aerial photography of the area in which the road was to be located, establishment of control points, examination of photographs under the stereoscope, and selection of control points for the road location constituted the first four steps. Assembly of photographs on the drafting table was followed by the orientation of each photograph with adjoining prints to form a mosaic of the area. A straight line, joining terminal control points, could then be drawn across the mosaic. These three succeeding stages were followed, in turn, by a study of the photographs under the stereoscope to ascertain and mark on the prints the best location for the highway in relation to the straight line. A map was then made on the natural scale of the photographs depicting lakes, rivers, hills, and other topographical detail. Then the projected location line was transferred to the map. Finally, the map was placed in the hands of the location engineer, who established the projected line of highway on the ground.[11]

In southern Ontario, in locating a limited-access highway, both maps and aerial photography were used to fullest advantage. First, a four-mile-to-the-inch regional map was consulted. Then, on a mosaic of map sheets a line was drawn indicating the tentative course of the projected road. Using this product as a guide two-mile-wide strips of land were photographed from the air along the proposed route. Controls were then established on the ground and a topographical map was made on a scale of 400 feet to the inch. In establishing the line of highway on the ground the location engineer would make use of photographs on which the route had been marked, and by means of which he could more readily provide for railway grade crossings, stream crossings, and road intersections.

Highways in Manitoba received initial legislative recognition soon after that province was created. The 1871 Act Relating to Highways stated in part that "the main highway on the west side of the Red River from Lake Winnipeg to Pembina, and the main highway on the north side of the Assiniboine from Fort Garry to the western line of the Province, also the highway from Fort Garry to the Lake of the Woods . . . shall be known and designated as 'Great Highways' ". All other public roads in the new province were to be designated as 'public highways'. At a later date the width of the Great Highways was fixed at two chains. By 1950, however, highways in Manitoba generally were being constructed to widths of 150 feet and, in some examples of subsequent construction, much wider.

In 1880 all local highways in the province were turned over to the administration of municipalities. In 1910 an act provided for the appointment of a Highway Commissioner who was empowered "to disseminate information respecting the construction and improvement of the public roads and highways of the Province and consult with and advise municipalities with regard to such construction and improvements." A. McGillivray was the first to occupy this commissionership.

Two important acts were passed in the province in 1912, the Good Roads Act and the Highway Improvements Act. Under the latter statute a sum of $200,000 was set aside to aid municipalities in the improvement of main highways, then officially described as 'Great Main Roads'. These two pieces of legislation along with the 1910 act were replaced by the Good Roads Act of 1914, which provided that two-thirds of the cost of constructing 'Great Main Provincial Highways' would be borne by the province as well as one-half the cost of building new roads other than such main highways. Later on the province decided to pay to municipalities as well two-thirds of the costs of maintenance of main highways. In 1925 the category of 'Provincial Trunk Highways' was established. In 1943 the Good Roads Act of 1914 was repealed and under a new Public Works Act a Highways Branch was formed with authority over all provincial highways, drainage and other related works.[12]

Today, in Manitoba, it is a function of the Land Survey Office to conduct field surveys and prepare plans of Provincial Trunk Highways, other government roads and related projects. That office acts as the authority on land survey matters for the Highways Branch and the Chief Land Surveyor of the province is the authority responsible for closing public roads in connection with government road construction.

Up until the creation of the provinces of Alberta and Saskatchewan in 1905 surveying of roads was a function governed by Public Works ordinances. In 1880 it was enacted by authorities of the North-West Territories that all road allowances in townships "now or hereafter to be surveyed and sub-divided in the North-West Territories . . . shall be subject to the direction, management and control of the Lieutenant-Governor in Council . . . Whenever the Government of Canada receives notice from the Lieutenant-Governor that it is considered desirable that any particular thoroughfare or public, travelled road or trail in the Territories, which existed as such prior to any regular surveys, should be continued as such, the Governor in Council may . . . direct the same to be surveyed by a Dominion Land Surveyor and thereafter may transfer the control of each such thoroughfare . . . to the Lieutenant-Governor in Council for the public use of the Territories."[13]

In 1901 an ordinance of the North-West Territories provided that a [highways] commission may cause surveys of old trails to be made and that "such old trails, road allowances, diversions or new roads shall be laid out one chain [66 feet] in width."[14]

FIGURE 94
Pembina Overpass near Winnipeg, 1960.

These provisions were re-enacted by the first legislatures of Alberta and Saskatchewan in 1906, the same year in which the Torrens Land Titles system was established in those provinces, a system that included the registration of plans of roads. The Saskatchewan Land Surveys Act, 1913, c. 23, sec. 22, authorized road surveys. It is interesting to note that in the 1906 Alberta act "surveyor" was defined as "a land surveyor duly authorized under the Dominion Lands Act or any act to survey lands in the province." Dominion land surveyors continued to be eligible to perform surveys within the province until the passage in 1910 of the Alberta Land Surveyors' Act, c. 2, sec. 3 of that year, in which it was provided that "no person shall, within the province, subsequent to January 1, 1911, act as a surveyor of lands other than Dominion lands, unless he has been duly authorized to practice as a land surveyor according to the provisions of this act." In the next following section it was made clear that "duly authorized land surveyors" meant members of the Alberta Land Surveyors' Association, which had been formally incorporated by this 1910 legislation.

In Canada's western interior the practice has developed in recent years of having a Controller or Director of Surveys for the province, with authority over land surveys generally, as well as a Director of Surveys in the provincial Department of Highways and with a Chief Surveyor in the Land Titles offices. For example, in Saskatchewan, John Clair Traynor (1916-   ) whose grand-uncle Isaac Traynor (an Ontario and Dominion land surveyor) performed some surveying in Saskatchewan, served as Chief Surveyor in the Land Titles Office, Regina, beginning in 1949 and in 1956 became Director of Surveys in the Saskatchewan Department of Highways. In Alberta Charles Walton Youngs (1928-   ) served as Assistant Director of Surveys in the Department of Highways of that province for ten years until his appointment in 1964 as Director of Surveys for Alberta.

Any review of the development of highway systems in Canada would be incomplete without some reference to the career and accomplishments of Archibald William Campbell (1863-1927). Born in Wardsville, Ontario, young Campbell, following elementary schooling, apprenticed to Provincial land surveyor James A. Bell of St. Thomas. In 1885 Campbell received his commission as a Provincial land surveyor and entered upon the practice of his profession. Three years later Campbell addressed the annual meeting of Ontario land surveyors on the subject of highway bridges. Professor Galbraith of the School of Practical Science, Toronto, was so impressed by the paper that he incorporated its contents in part into an acknowledged text on the subject. In 1891 Campbell was appointed city engineer of St. Thomas and, in 1894, along with several other citizens of southern Ontario, organized the Good Roads Association of the province. At this time Campbell became associated with W. A. McLean, also an Ontario land surveyor. These two men formed a team that was active for some thirty years and which was vitally instrumental in developing a provincial highway system.

In 1896, when highway travel was still in the horse and buggy stage, the government of Ontario created the position of Provincial Instructor in Road Making. Campbell was appointed to this post, with McLean as his assistant. Four years later Campbell was named Commissioner of Highways in the province, again with McLean as his aide. In 1901 Campbell persuaded the Ontario government and legislature to enact The Highway Improvement Act, 1 Ed. VII, c. 32, under which one million dollars was made available for assistance in the building of roads.* Under the authority of this legislation

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*In 1919 this fund was increased to five million dollars (9 Geo. V, c. 18).

Campbell and McLean began organization of the County Road System. After serving in high civil service posts in both provincial and federal governments Campbell was named federal Commissioner of Highways in 1919.

It was during his term of office as Deputy Minister of Railways and Canals, Ottawa, that Bill No. 77, bearing the short title, The Canada Highways Improvement Act, was introduced in the House of Commons. This initial and novel attempt to enact a federal law under which subsidy payments from the national treasury would be made to provinces for road construction purposes, aroused keen interest not only in Canada but in the United States. This bill, however, never came into force. In that same year (2 Geo. V, 1912, c. 12) the Ontario legislature authorized the province to accept any such federal assistance, subject to certain specified conditions.

In 1919, in a second attempt by parliament, the Canada Highways Act (9-10 Geo. V, c. 54) was passed at Ottawa. Under this measure, similar in its terms to the original Bill No. 77, a total of $20,000,000 was made available for aid to the provinces in their roadbuilding activities. Commissioner Campbell administered this act and in the course of his duties conferred frequently with various provincial government highway officials. He prepared standard specifications for the several classes of highways defined in the federal legislation. Campbell worked diligently to devise and to urge the adoption of a uniform classification of roads across Canada.

In time the Commissioner of Highways became familiarly known from coast to coast as "Good Roads Campbell". A founding member of the Association of Ontario Land Surveyors as well as a founding father of both the Ontario and Canadian Good Roads Associations, Campbell's imagination, energy, and administrative ability distinguished his contributions to the creation and growth of these important organizations.

The story of advancement in Canadian highway construction in the period reviewed in this chapter reaches its climax in the renewal of progress toward the completion, at an aggregate cost of a billion dollars, of a paved Trans-Canada Highway from St. John's, Newfoundland, to Victoria, British Columbia. This formidable concept challenged the ingenuity, skill and resourcefulness of Canadian surveyors, mappers and highway engineers. In the accomplishment of this nation-building task much is owed to the vision and persistence of early promoters of this project, such as A. W. Campbell and Dr. P. E. Doolittle.

Thomas Wilby, in 1912, covered the distance from Halifax to Victoria in 52 days by motor car, bouncing over corduroy roads, splashing across mosquito-infested swamps, bridging creeks on improvised spans and surmounting steep slopes in reverse gear. In crossing long stretches of unfenced, trackless plains Wilby had little to guide him save a compass and the stars. At times heavy rains turned prairie mud into highly adhesive gumbo and compelled the determined driver to use railway tracks, from which he was prepared to leap for his life should the gleam of an approaching locomotive headlight come suddenly into sight. Although this and subsequent adventurous cross-country forays attracted widespread admiration, such isolated performances served more to stir sporting instincts than to create solid popular interest in the building of a nation-wide highway.

More orthodox efforts, on an organized basis, were exerted prior to the outbreak of the First World War to spur federal authorities into action on a Trans-Canada road link, but public support for such an ambitious project failed to crystallize until after hostilities had ended. After 1918 an unprecedented increase took place in motor vehicle registrations in Canada. This phenomenon was accompanied by swiftly-mounting demands from motorists for improved local and inter-regional roads.[15]

It was at this stage of national development that the Canada Highways Act, already mentioned, became law and, under its terms, provision was made for annual grants of money to provincial governments to aid in highway improvement work generally. Although the federal act did not specifically contemplate the building of a Trans-Canada Highway, regulations under it required the preparation by each recipient province of a program map of its main and market roads so linked as to form at provincial boundaries a condition capable of becoming, with the exception of one long stretch of territory north of Lake Superior, a nation-wide system of trunk highways.

In the years of economic depression leading up to the Second World War, federal spending in provincial fields was coordinated with expenditures under the Unemployment Relief Acts and included grants in aid of highway building work. In the terms governing these grants specific reference was made to the Trans-Canada Highway project and about one-half of the total highway construction grants was spent on the route of the national project as it was then designated.

As the post-war volume of long-distance travel, commercial and otherwise, grew apace, the establishment of a Trans-Canada Highway demanded ever-increasing attention. A federal-provincial conference on the subject was held at Ottawa in 1948 and, as a result, a Trans-Canada Highway Act (13 Geo. VI, c. 40) was passed by parliament at Ottawa in the following year. Two problems of administration immediately faced public authorities, namely, the need to obtain agreement on uniform standards of construction as well as agreement on a desirable route. At a federal-provincial conference held late in 1949 a set of minimum standards was mutually approved. In general

FIGURE 95. Trans-Canada Highway along the Bow River, Banff National Park.

the federal government was obligated to pay one-half of the actual cost of construction incurred by each province in providing its share of the coast-to-coast highway. The route within each province was to be designated by its provincial government, subject to federal approval. In essence the highway was to form the shortest, most practical, two-lane, all-weather, east-west road consistent with the needs of each province and with the national interest.

The agreement of 1949 called for a minimum width of right-of-way of 100 feet except where the highway ran through densely populated areas, in which case a minimum width of 66 feet would be acceptable. The paved portion was to have a maximum width of 24 feet, and a minimum width of 22 feet. The width of the shoulders on each side of the pavement was set at 10 feet, except where economy or the terrain dictated a lesser width, in which event a 5-foot shoulder width would suffice. The maximum curvature was not to exceed 6 degrees and, wherever possible, it should be reduced to 3 degrees. The maximum gradient was not to exceed 6 per cent as a general rule although where this was not economically feasible, gradients of 7 or even 8 per cent would be acceptable for short distances. Eventually, in total length the national highway extended over about 4,860 miles, some 140 miles of which crossed national park areas.[16]

Each principal region of Canada offers its own peculiar problems and challenges to road builders but in British Columbia generally and in Glacier National Park in particular certain difficulties occur in rather spectacular fashion. Ontario land surveyor J. E. Jackson reported to his provincial colleagues not long after the commencement of the Second World War that "it is expected the Big Bend Highway in B.C. will be completed for use in the summer of 1941 . . . marking the completion of a through route from Ontario's western boundary to the Pacific Coast around this great northern bend of the Columbia River." Mr. Jackson pointed out that many miles of this newly-completed highway were unpaved and stressed the fact that the need continued to be great and pressing for a transcontinental highway located wholly within Canada.[17]

Within a few years it was found that the Big Bend Highway, to conform to design requirements of the Trans-Canada system, would need to be constructed along its entire length of 196 miles. After careful investigations of alternative routes it was decided in 1956 to build a new cut-off stretch of the highway through famous Rogers Pass from Golden to Revelstoke, reducing the mileage of mountain road in this area by more than one-half.

Severe frost conditions have long plagued Canadian roadbuilding and maintenance engineers but in Glacier National Park, within which the preferred link was located, snow and its potentialities for danger and destruction constituted a major threat to the successful construction of any all-weather highway. This was a section of Canada replete with avalanche-forming conditions and formidable snow-removal problems.

As early as 1953 engineers of the federal Department of Public Works began to collect and collate data bearing on these factors, including extensive meteorological records. In order to devise a workable avalanche-warning system an Avalanche Research Group was organized. Four observation stations were built, two of them at high altitudes, in order to study the origins and behavior of both wet snow and dry snow slides. Out of these studies developed an avalanche-forecasting system as well as measures for stabilizing snow packs and the erection of snowsheds to provide the maximum practical degree of protection for the public travelling on that section of the Trans-Canada Highway.

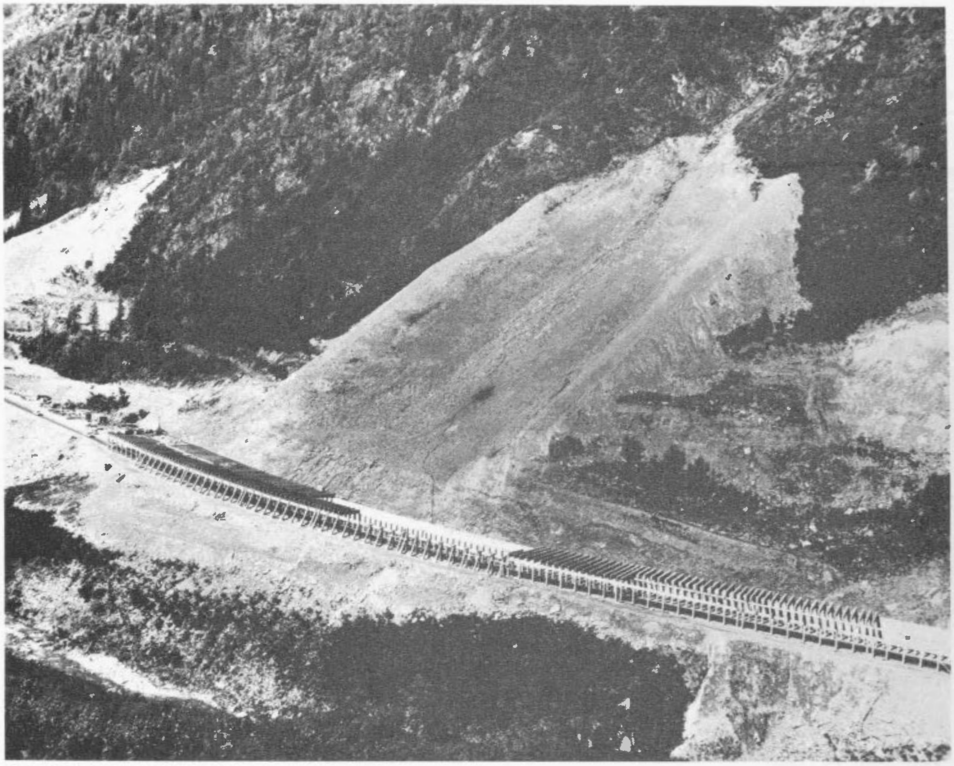

FIGURE 96. Snowshed under construction, Trans-Canada Highway, Glacier National Park.

Patrol work by research parties involved alertness and the exercise of snow craftsmanship of a high order in this avalanche-prone region. With normal precautions, however, tragedies are rare. Nevertheless one gruelling experience occurred when Bruno Engler, a man knowledgeable in the snow lore of the Canadian Rockies, was leading a ski patrol to the Mount Abbott observatory. When about 200 feet from the party's destination Engler suddenly detected a snow formation built up to a critical degree of steepness above them. He had time only to signal his companions to spread out when a slide of giant proportions began. Engler was quickly engulfed in the fast-moving mass and deposited on his back in spreadeagle fashion. His arms and legs were securely trapped and he had little air to breathe. Even worse, he had no reason to believe his companions remained unburied. However, at the time of the avalanche they were sufficiently far apart to avoid the main slide. Engler heard their footsteps as they searched above him and he managed to muster sufficient strength to shout. His cry was heard and when extricated, he was found to have escaped serious injury. But this was the sort of almost daily risk faced by those whose reconnaissance activities helped to ensure safety for motor-vehicle travel in this part of Canada.

Extensive snow packs were stabilized by the employment of artillery units of the Canadian Army. Mortar fire had the effect of releasing impending slides. By building a system of mounds that acted as brakes and by cutting out benches on slopes that

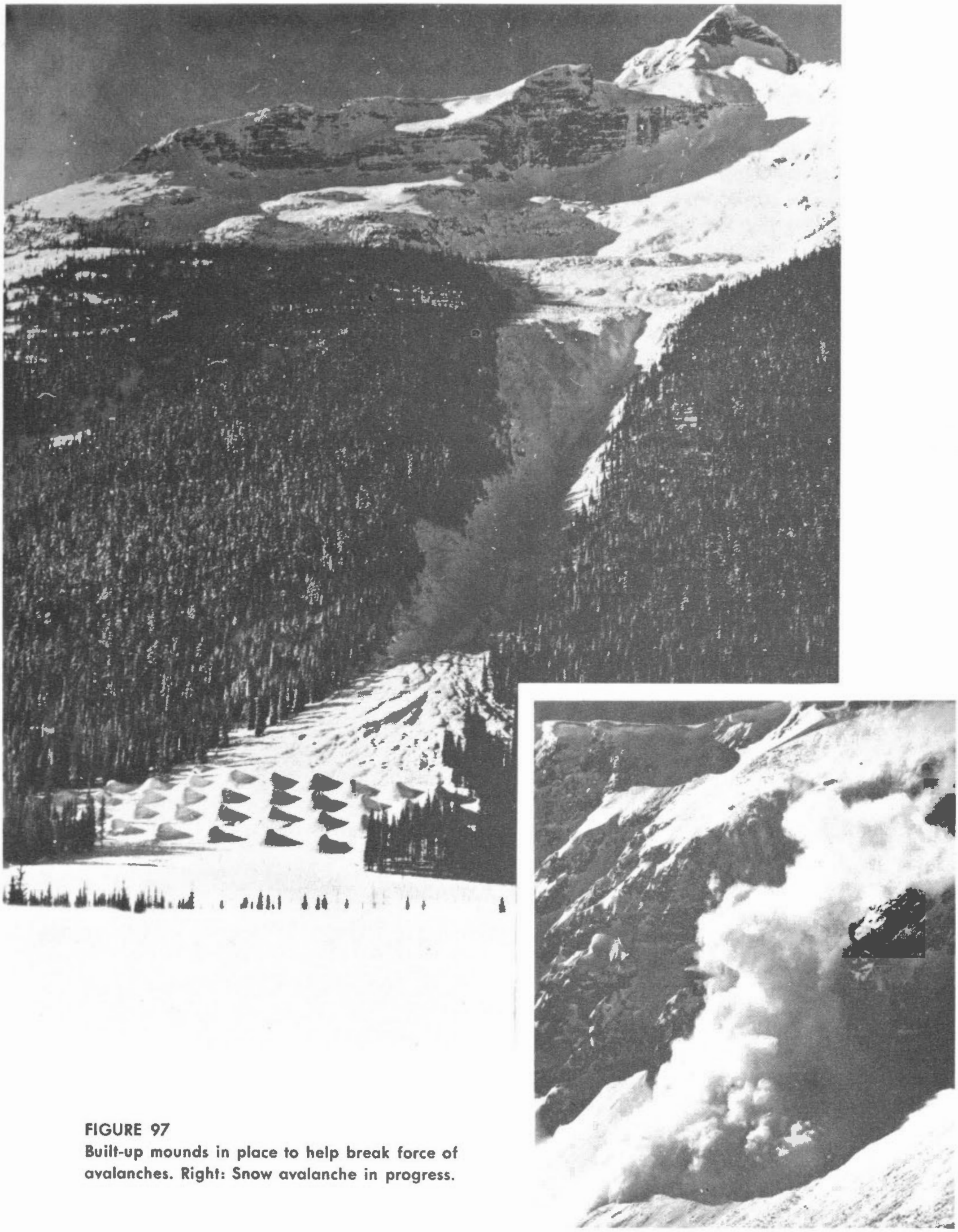

FIGURE 97
Built-up mounds in place to help break force of avalanches. Right: Snow avalanche in progress.

served as catchment areas, movements of vast bodies of snow were more or less effectively controlled. The pre-planting of explosives in critical areas proved useless because park bears displayed a keen appetite for dynamite. Most of the planted charges were eagerly devoured by grizzlies without any apparent ill-effects on them. Other types of diversion works, including snow dams, were erected by which a change in the direction of an avalanche could be achieved. Finally, in a few localities where other methods of control proved useless, costly snowsheds were constructed over the highway. The total distance sheltered in this way amounted to about a mile.[18]

During the 1917-1947 period the foundations for the final establishment of a transcontinental highway in Canada were well and truly laid and these made possible the completion, by the end of 1967, of one of the world's longest, continuous, all-weather roads. The finished Trans-Canada Highway constitutes an engineering as well as scenic marvel. It is a project of national significance in the construction of which surveyors and mappers have played indispensable parts. This unique road serves to promote economic expansion of the nation and to develop among Canadians a sense of oneness and a sense of common destiny.

Roads in Canada have become, in a real sense, renewable resources of the nation. Highways are valuable assets in the field of communications and encourage growth of industries and communities along their routes. They influence as well the growth patterns of the urban areas they serve. The evolution of road location and road construction techniques in Canada during the first half of the 20th century has, in fact, altered to a considerable extent the structure and way of life of our society. This arterial progress has promoted, if it has not created, ready mobility for the general public and a concomitant dissemination of ideas along with a marked growth of intercommunity, inter-provincial and international commercial and cultural activities.

GLOSSARY

Grade Separation: a structure designed to separate vertically two intersecting roadways, thus permitting opposing traffic to cross without impediment.

Control of Access: the condition where the right of owners or occupants of abutting land, or other persons, to a highway is controlled by public authority, e.g., entry ramps are built only at points where access is approved.

Limited Access Highway: a highway to which access is not provided except at certain closely controlled points.

Arterial Highway: a general term denoting a highway primarily used by through traffic, usually on a continuous route.

Expressway: a divided arterial highway designed for through traffic and on which full or partial control of access is exercised; usually it is a highway featured by grade separations at intersections.

Freeway: a completely grade-separated expressway on which full control of access is exercised. This term includes similar descriptive titles in use in other countries.

Parkway: an arterial highway for non-commercial traffic on which full or partial control is exercised and usually located within or bordering on a parklike development.

Traffic Interchange: a system of interconnecting roadways used in conjunction with grade separations, thus providing for an interchange of traffic between two or more roadways built on different levels.

10

CANADIAN MILITARY SURVEYING AND MAPPING: 1917-1947

Military topographical survey units, that relatively small but vitally important force operating within the orbit of army engineers, exist for the purpose of meeting defence mapping requirements in peace and in war, at home and abroad. Their functions include the training of personnel in surveying and mapping skills, the upkeep of mobilization stocks of maps, and the maintenance of a base plant capable of rapid expansion upon the outbreak of hostilities involving Canada's armed forces. This cartographical assignment, including map production and reproduction functions, was quite distinct from artillery survey duties which included, during two world wars, the fixing of Canadian gun positions and the location, by flash spotting (gun flashes) and sound ranging (supplemented by radar in the Second World War) of enemy artillery emplacements. Canadians were quick to perceive the value of surveys in warfare and to adapt various survey techniques to military operations.

The pronounced advantages of military map production and reproduction accomplished with commendable rapidity under actual battle conditions were firmly impressed upon Canadian army commanders and troops during the First World War. During intensive preparations, for example, leading up to the historic Canadian assault on Vimy Ridge in early April, 1917, and on the basis of aerial photographs taken by the Royal Air Force, the complex German defences were reproduced in full-scale detail in an area back of front lines. In this rear area, flags marked enemy strongpoints and tapes represented his trench system. Repeated rehearsals of attack procedures were staged. Large numbers of maps were provided. All essential targets were carefully catalogued with the aid of aerial photographs and arrangements were made to take immediate action upon the correlation of information obtained from powered aircraft and balloons as well as by flash spotting, sound ranging and ground observation.[1]

In the First World War Brig.-General A. G. L. McNaughton (1887-1966) evinced a special interest in improving the effectiveness of artillery bombardments, especially counter battery action. By 1918 he had been promoted to General Officer Commanding, Canadian Corps Heavy Artillery. McNaughton regarded the primary object of our counter battery work to be the protection of Canadian infantry from the firing of hostile guns. In earlier days soldiers in battle could actually see the target at which they were firing, even with artillery. During the First World War, however, the practice of indirect fire was developed and military grids became essential to the effectiveness of these operations.

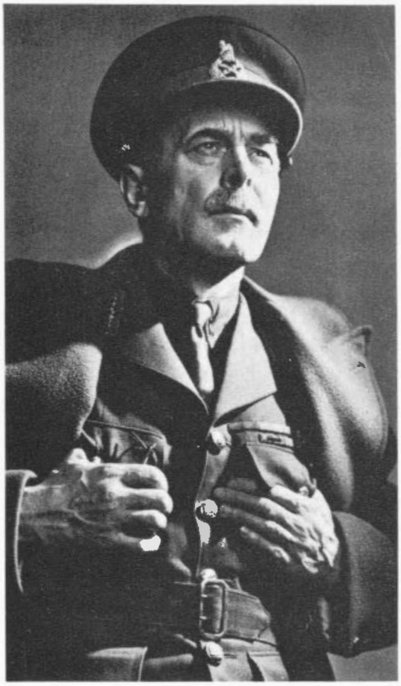

FIGURE 98. General A. G. L. McNaughton.

Intelligence concerning enemy gun positions, their locations, number and the targets being fired on, was an indispensable factor in any successful counter battery activity. The final arrangement was to have two or more survey posts placed on commanding ground, equipped with the most efficient types of survey instruments and interconnected by telephone lines to a headquarters. As one post made its location of an enemy emplacement, the bearing would be reported by phone to the headquarters and then other posts would be advised of the finding. Following this advice telephone communications would be suspended while each survey post, observing the gun flash, corrected its bearing and pressed a key lighting a corresponding lamp at headquarters. When all lamps were lit simultaneously it could be assumed by the operator that all survey posts were fixed on the same flash. In the triangulation work frequently involved, bearings would be phoned in and plotted so that the location of the enemy gun could be determined with considerable precision, often to within five yards.

A second important function of surveyors in battle is that of sound ranging. A unit or section organized for this purpose consisted of a headquarters connected to three or more microphone stations along a battle-front, situated about 1½ miles from the firing line. When a listening post heard the report of an enemy gun discharging, a key was pressed, activating an apparatus at the headquarters on which sounds caught by the microphones at each station would be recorded. From the time intervals existing between the response of each microphone the location of the source of the gun report could be calculated. Under heavy enemy bombardment, however, these procedures, to put it mildly, became somewhat more complicated.

Other sources of survey information included powered aircraft, balloon observations and ground observers as well as intelligence officers. Gun flashes, particularly, were subject to efficient spotting from the air. Air photography was employed to reveal the exact position of enemy gun emplacements. Camouflaged positions could be detected by stereoscopic photography. As early as 1926 McNaughton prophesied that in the next war involving Canada "survey sections and sound rangers will become of increased importance but the greater part of our [artillery] fire will be based on information gleaned from air photographs."[2] This proved to be an accurate forecast. Canadian military surveyors, of course, performed the vitally important tasks of providing datum for pivot guns of Canadian batteries in action, enabling their firepower to be concentrated on a single target.

In the capture of Valenciennes in France by Canadian troops near the end of the First World War (November 1, 1918) strong points in enemy structures and trenches were located and mapped by Intelligence units employing air photographs and other survey information. In the Canadian Corps at this stage of the conflict cooperation between artillery and aircraft was particularly close.[3]

Following that war Brig.-General McNaughton, who had become Deputy Chief, General Staff, Ottawa, publicly noted that during the last 100 days of the hostilities in North-West Europe some 73,000 tons of artillery shells had crossed above the Canadian Corps in the direction of the enemy, nearly all of which ammunition had been fired on the basis of information derived from maps or from location data supplied by survey sections attached to Canadian formations. On the same occasion he remarked that "the making of maps and the work of surveyors in the field is an even more basic art in war than that of [military] supply." He pointed out as well that the only possible way in which a commander in the field could achieve a high degree of precise cooperation of the various formations under him would be by the use of maps, uniform in character, in his possession and the possession of his officers and troops. In addition he observed that in peacetime, when preparations had to be made against the eventuality of any war, one of the most important features was the production of military topographic maps "both for defence purposes and in case of any active operation in which troops may be called upon to take part." In short, the substance of the message McNaughton sought to convey was that no modern army could fight efficiently without the support of a competent, resourceful surveying and mapping organization.[4]

On May 14, 1918, in the closing months of the First World War the Canadian Corps Survey Section was formed, absorbing the Corps Topographic Section and the Intelligence Observation Section. This new, wireless-equipped Survey Section was attached to Corps Headquarters and, as noted in Volume One, was commanded by Captain W. R. Flewin, C.E. It was composed of 5 officers and 172 other ranks and the unit worked closely with the 1st and 5th Field Survey Battalions, Royal Engineers.

Its duties consisted mainly of flash spotting and the accurate fixing of Canadian battery positions. It was from this modest beginning that Canadian artillery survey regiments later developed. On April 12, 1919, the Corps Survey Section returned to Canada.[5]

At the conclusion of the First World War the (Military) Survey Division at Ottawa, formed under that title in 1906, was still engaged in the apparently endless task of depicting the topography of eastern Canada, mainly on its standard series of one-mile-to-the-inch maps. Motor transport was first used by the Division on ground control survey work in the summer of 1920. This increased mobility helped greatly to expedite activity in areas served by passable roads. In less well developed regions the horse remained supreme as a reliable aid to transportation of military surveyors and their equipment. In 1921, and typical of work being done at the time, a survey began of Camp Hughes Reserve in Manitoba, adjacent to the subsequently established Camp Shilo. About this time revisions of military map sheets covering areas in Ontario and Quebec provinces became necessary.

In the early months of 1922 a lengthy series of annual courses was inaugurated, designed to train Permanent Force personnel in surveying and mapping work. As vacancies became available the best students were transferred to the Survey Division which, at the time, consisted of 2 officers, 12 warrant officers and sergeants, and 23 civil servants. Other students were returned to their units to serve as map-reading instructors. In April of that year the Survey Division, after nine years of "exile" in the Branch of the Master General of the Ordinance, returned to the direct control of the General Staff (Director of Military Operations and Intelligence).* As a result of this transfer it took on the new title of Topographical Survey Section although its former name, Survey Division, remained in common use until 1925 when it was renamed the Geographical Section, General Staff, or G.S.G.S. in common terminology.

In the years immediately after the First World War, disturbing rumors circulated in the Canadian capital concerning the future of organized military survey work in Canada. Indications emanated from Privy Council Office, Ottawa, that the organization might be abolished and that the 1920-21 vote of funds by Parliament in its support might be, in fact, the final item to be included in federal estimates for the purpose. This threat was only removed after the most urgent representations had been made to the then Minister of Militia and Defence, Hon. Hugh Guthrie. At about this time, however, an era dawned in Ottawa in which a new spirit of cooperation flourished among the various federal departments and agencies engaged in surveying and mapping activities. In order to reduce duplication of effort as well as to promote greater uniformity of work among such military and civilian organizations, the interdepartmental Board of Topographic Surveys and Maps came into existence in 1922, on which the Department of the Interior, the Department of Mines, and the Department of National Defence were represented.† It was in that same year, by virtue of an act of Parliament (12-13 Geo. V, ch. 24) that the Department of National Defence was created in succession to the former Department of Militia and Defence. In the following year five Dominion land surveyors were loaned by the Interior Department to take one month's course in military survey practices and then to share in the summer field work of the Army's topographical survey. Under the arrangement entered into between Surveyor General Deville and the Department of National Defence, through its Minister, these Dominion land surveyors performed preliminary work with their military brethren on the Warwick Sheet

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*P.C. No. 874, April 26, 1922.

†P.C. No. 540, March 8, 1922.

(Quebec) and on the Ottawa Sheet in the interests of greater uniformity in federal map-making procedures.[6]

When Brig.-General McNaughton became Deputy Chief of the General Staff in the early 1920s he became profoundly dissatisfied with the traditional but more or less obsolete and time-consuming methods of map compilation and reproduction employed by the Geographical Section. He made a trip to England to investigate British Army procedures in this type of military activity. On his return to Canada McNaughton embarked upon a personal campaign to modernize the Section's map-making techniques. His innovating influence was soon felt in a number of directions. Early in 1923, for example, the Section was equipped with its first rotary offset press. This machine made possible the printing from zinc plates on offset rollers and the gradual elimination of the flat-bed system of producing maps. This acquisition served to speed up production and to reduce operating costs.

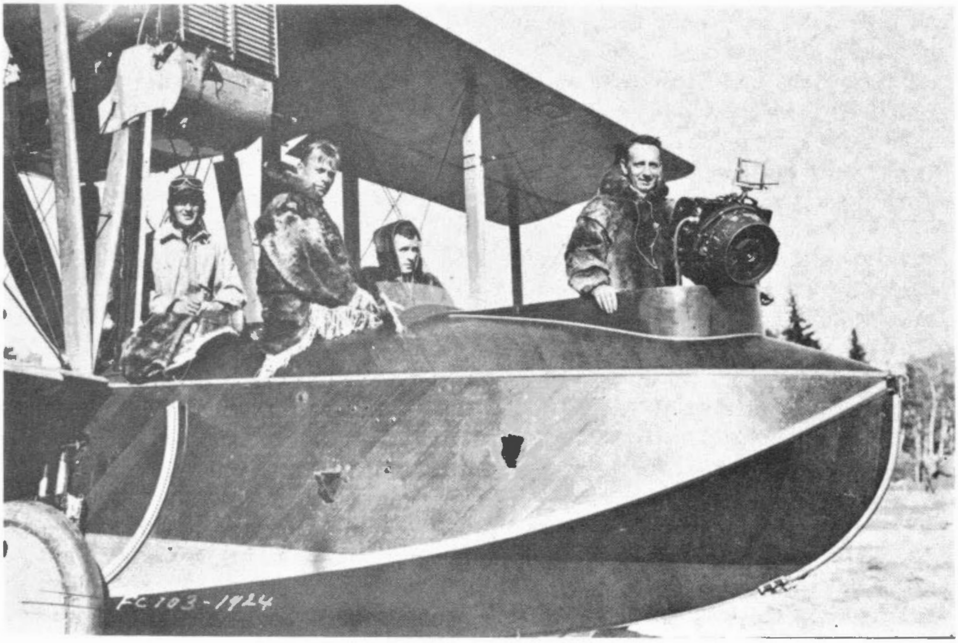

FIGURE 99. Canadian pioneers in air survey photography, Reindeer Lake area, 1924. Crew of Vickers Viking plane: (L to R) Sgt. A. Milner, mechanic; S/L Basil Hobbs, D.S.O., pilot; R. D. Davidson, navigator; and F/O J. R. Cairns, photographer.

McNaughton's continuing interest in the adaptation of aerial photography to survey work was immensely helpful in bringing about early developments in that field in Canada. During the 1924 field season the Royal Canadian Air Force embarked upon an experimental program of vertical photography covering some 40 square miles at an altitude of 6,000 feet. From this time onward steadily increasing use was made of aerial pictures in military mapping in this country. McNaughton, in fact, felt that the most important leap forward in map and chart production since the invention of printing had been accomplished by practical applications of aerial photography to surveying and mapping generally.

Before long the improved output of military maps of the Geographical Section began to attract international attention and comment. Karl Baedeker of guide book fame stated in his edition on Canada, "Of the detailed maps of the various parts of the country on larger scales there must be first mentioned the excellent topographic maps published by the . . . Department of Militia and Defence in two editions." A senior officer of the War Office in London, England, reported that "the maps sent me [from Canada] are a very creditable production. The blacks are excellent, beautifully sharp, and dense in colour. I have shown the maps to our draughtsman and my chief and they consider the work is above our production, and I personally feel that your chief and others for whom you reproduce work must feel a touch of personal pride when they see such results from a new press and a new process."[7]

By 1924 some 30,600 square miles of Canada had been surveyed and mapped by this military organization, with about 9,000 additional square miles in various stages of completion. A total of 90 sheets in the military standard one-mile-to-the-inch scale had been published by the Geographical Section. When other federal departments had produced good topographic results such work was incorporated into these military maps and, conversely, the departments made use of military surveying and mapping.

Of all the steps taken by General McNaughton in advancing the status and work of the Geographical Section, General Staff, the most significant was his success in attracting one very promising recruit and youthful First World War veteran to this military survey organization. McNaughton had become aware of the special abilities of Captain E. L. M. Burns after assigning to him "the task [as the General put it] of applying the Euclidian principle to air survey work." Few men have made a contribution to the progress of Canadian military surveying and mapping that could match that of Eedson Louis Millard Burns (1897-   ). He rose to national and international prominence initially as an able commander of Canadian Army formations in the Second World War and, subsequently, for his leadership of United Nations truce organizations and also as Canadian representative at disarmament conferences. But he first came to the special notice of military and civil authorities in Ottawa as a gifted mathematician and as a man keenly interested and highly proficient in military surveying.

Born in Westmount, Quebec, in central Montreal, young Burns received his higher education at Lower Canada College and at Royal Military College in Kingston. At the age of 18 years he was commissioned in the Royal Canadian Engineers and served in France during the First World War, winning the Military Cross in 1916. After the war's end he joined the staff of Royal Military College as an instructor and later was appointed General Staff Officer, Surveys, Militia Services, Department of National Defence, with the rank of major. In 1931 Burns was appointed officer in charge of the Geographical Section. In the early 1930s, in response to the steadily expanding need for aerial photographic surveys in Canada several committees were established in Ottawa to direct and to coordinate all such federal government activity. An interdepartmental committee, under Dr. Charles Camsell, exercised general control over operations. Officials of the Topographical Survey (Interior), under the chairmanship of Dominion land surveyor, Athos Maxwell Narraway, investigated new uses of aerial survey photographs. At the National Research Council another body, concentrating on survey research work, encouraged development of new methods of producing reliable air photographs for mapping purposes. Narraway, who served also as secretary of the interdepartmental and National Research Council committees, provided the essential liaison link between all three bodies. Soon Burns was immersed in committee work in Ottawa

FIGURE 100. Lieut.-General E. L. M. Burns.

becoming, in short order, convener of the Subcommittee on Mapping Methods, operating under the Associate Committee on Survey Research, National Research Council.[8]

The strong, aggressive leadership given the Geographical Section by Major Burns is revealed, among much other evidence, in the records of a meeting held in Ottawa on September 2, 1932, on the subject of "Compilation of Area Maps for Air Navigation". In attendance were Major-General McNaughton, J. A. Wilson, A. D. McLean, Col. H. H. Matthews, Major Burns, Surveyor General Peters and A. M. Narraway, Chief Aerial Surveys Engineer. Apparently there had been a developing conflict of opinion over whether or not the Geographical Section would compile and print a certain map sheet or sheets relating to the Montreal area.

The Surveyor General explained that the Topographical Survey (Interior), under his direction, was about to issue a series of 8-mile-to-the-inch maps of the National Topographic Series to replace the Chief Geographer's Series then going out of print and that this publishing venture was a legitimate function of his organization. A start had been made on Sheet 31 S.E. He considered these small-scale topographic maps to be the logical bases for air maps of Canada, provided that necessary aviation information was overprinted on the maps.

This proposal met with general agreement at the meeting but the military representatives present pointed out that the demand for air navigation charts, especially those intended for guidance of trans-Atlantic flights, was urgent and that the Geographical Section was manned, equipped, and ready to render help in meeting this requirement. In the end it was decided that Surveyor General Peters and Major Burns should consult together as to style and conventional signs to be adopted in the 8-mile-to-the-inch series. If they could not agree on the selection of any particular sign, the matter was to be referred to a superior authority or to the government department directly concerned. Any maps produced were to bear the usual titles employed by the Topographical Survey (Interior) and distributed to the public by that organization. The fact that the compilation and printing had been done by the Geographical Section, General Staff, was to be noted at the foot of each such map.[9]

The Subcommitte on Mapping Methods concentrated its efforts on the development of forms of aerial photogrammetry peculiarly applicable to Canadian conditions, including the need for small-scale maps that could be produced efficiently and economically. This body, on which Dr. L. E. Howlett also rendered distinguished service, sponsored the construction of an instrument for extending control by radial intersection through strips of air photographs. The principles of the resulting radial-stereoplotter were worked out by Burns who, by 1935, had risen to the rank of Lieut.-Colonel. The design and construction of the first model of the machine was undertaken at a cost of $3,400 at the National Research Council by R. H. Field, and his staff in cooperation with Burns and with the advice of Dominion land surveyor, Robert B. McKay.

The original model of the plotter was delivered to the Geographical Section in January, 1935. Photographs taken from the air at Meach Lake, near Ottawa, and along the shoreline of Great Slave Lake were tested in the plotter and, as a result, certain modifications of the instrument were recommended. "The results of these experiments", Burns commented at the time, "are considered to be very satisfactory. While no new discoveries in the technique of air photo survey are claimed, it has been shown that methods devised and partially tested by experiments elsewhere can be practically applied in Canada and that great advantages in speed, accuracy and economy of effort in topographic mapping can be obtained."

In the same year Lieut.-Colonel Burns brought to the Section an instrument of German origin, the Zeiss multiplex aeroprojector, the first instrument of the kind to be imported to Canada. By means of this device a strip of overlapping air photographs could be viewed and measured with precision in three dimensions. Only fifteen years earlier the first instruments for automatically plotting aerial photographs under stereoscopic observation had been built. One great advantage of this highly significant improvement was that, with the multiplex, all of the area being mapped could be seen at one glance in the fullness of all its topographic detail. It was possible, therefore, for the topographer to bring all parts of his work into harmony with the various land forms depicted.[10] At about the same time the Zeiss firm in Jena brought out a new wider-angle aerial camera lens, thus providing greater general coverage from the same flying height; accordingly, fewer photographs were required in order to cover a specified area. With less flying involved, costs of air operations were reduced and there was also greater freedom from distortion in the views produced. Burns, in fact, prophesied that if the new lens proved successful in field use it would replace the seven-lens camera then being tested in Canada for use in aerial photography.[11] This particular development is now regarded by some authorities in cartography as constituting the initial break-through in 20th century map making, leading to more economically produced and more accurate maps. Refinements in both plotting equipment and in aerial cameras followed the introduction of the multiplex aeroprojector. In 1935 Burns was awarded the Order of the British Empire for his valuable contributions to the progress of aerial surveying and mapping.

A second plotter was devised by Burns, incorporating features of an invention of Dr. Fourcade, a South African scientist. Fourcade had devised a new method of solving the problem of tilt in the taking of survey photographs from the air, thus permitting two overlapping pictures to be set in relative orientation.[12] This second plotter, intended for use in Canada, was constructed in the United Kingdom by Barr and Stroud of Glasgow. The cost of its production was borne by Imperial Oil Limited. In the summer of 1940, before the plotter could be shipped to this country, a German bomb struck the building in which the instrument was housed, completely demolishing the structure and its contents. There was no effort made to replace the equipment and by the war's end that model, in any case, would have become obsolete.

The 1st Field Survey Company was formed in 1936 at Ottawa as a unit in the establishment of the Royal Canadian Engineers and as part of the reorganized Canadian Militia. Its function was to provide authentic information, in map and other graphic forms, for use in field operations under battle conditions. Its full peacetime complement, assigned to surveying, drawing, lithographic, and photographic sections, was fixed at 64 all ranks. Specifically the unit's duties included the establishment of mapping control either by traversing or by triangulation methods; the making of detailed topographic surveys by use of the plane table and providing the artillery with accurate survey data. The application of aerial photographs was to have high priority in its activities. In effect the company was to operate as a mobile mapping unit, trained to supply a wide range of detailed cartographic information on short notice and under conditions of extreme stress. Its personnel was to be recruited, in the main, from government surveying and engineering branches, from universities, and from upper grades of high schools. Lieut.-Colonel Burns devoted much thought and effort to the tasks of organizing and training this unit. In early 1939 the company consisted of about 35 men with Dr. H. S. Bostock and Dominion land surveyor C. H. Taggart as officers.[13]

Lieut.-Colonel Burns left the Geographical Section in 1936. In the Second World War, after commanding various brigades and divisions of the Canadian Army overseas he rose to the command of the First Canadian Corps in Italy. With the restoration of peace in Europe Major-General Burns, as he had become, returned to Ottawa to serve as Director General of Rehabilitation and subsequently as Deputy Minister of the Department of Veterans Affairs. From 1956 to 1959 he commanded the history-making United Nations Emergency Force in the Middle East, following the Suez crisis. In 1958 he was promoted to the rank of Lieutenant-General.

During the Second World War the Geographical Section, General Staff, continued its normal work program within Canada as well as performing some tasks connected with military operations. Lieut.-Colonel J. E. Lyon who, as a major, had succeeded Burns in charge of the Section, was posted to the Directorate of Military Operations and Intelligence in the autumn of 1940. Subsequently Major R. A. V. Nicholson, M. F. Phelan and A. E. Attfield shared in the direction of Section affairs and all signed on behalf of the non-existent Staff Officer (Survey). The first two named of this triumvirate retired at the end of 1942. From that time until the end of the war Attfield functioned as Acting Superintendent in actual charge of the Section. Col. J. H. Jenkins, as Director of Military Operations and Planning, continued to oversee activities of the Geographical Section, holding weekly conferences with Attfield to decide upon points of mapping policy.

On the outbreak of the Second World War there were in Canada only two Non-Permanent Active Militia engineer survey units. These were the 1st Corps Field Survey

Company, based in Ottawa, and the 2nd Corps Field Survey Company, based in Toronto. There was also an artillery survey battery in Montreal. Between the two world wars survey responsibilities for flash spotting, sound ranging, and gun-position fixing had been allotted to the artillery. In time each of the two corps of the Canadian Army overseas came to include an artillery survey regiment. The 1st Survey Regiment, Royal Canadian Artillery, served with the First Corps in Italy. The 2nd Survey Regiment, Royal Canadian Artillery, took part in the campaign in North-West Europe. There was also an Artillery Survey Reinforcement Unit stationed at a training centre at Borden, Hampshire, commanded by Major Lorne Swannell, son of the Dominion land surveyor famous for his survey work in British Columbia.

Military surveying and mapping had played an important part in operations during the First World War. In view of the wide-ranging technological advances that had taken place between the two world wars it is not surprising that these types of activity played a much more vital role in the Second World War. The longer range aircraft, with advanced methods of navigation required reliable aeronautical charts in the planning and conduct of bombing and other attack missions. The detection of enemy aircraft by the use of radar required accurate locations for the radar antennae, and coastal defence guns, firing great distances, had to be accurately positioned. In addition to the foregoing the services of surveyors were required in the layout of airfields, the building of roads and in many other wartime construction tasks. A number were also engaged in air photo interpretation work where their special knowledge of ground and air photographs was used to develop information about enemy installations, troop movements, assessment of bomb damage and so forth.

The greatest concentration of surveyors was to be found within the artillery and engineers. Besides the regimental and battery surveyors in each artillery unit there were the two survey regiments of the Royal Canadian Artillery. Their survey support to the artillery of each Corps included flash spotting, range finding, extension of theatre grid into requested areas as well as detection of enemy gun positions by radar. The surveyors in the engineers were largely concentrated in field survey companies and, in addition, each engineer field unit had sufficient surveyors to perform the survey tasks associated with the miscellaneous construction tasks in which they became engaged.

The military portion of the Geographical Section, General Staff, namely, the Permanent Force Survey Detachment, Royal Canadian Engineers, was based in Ottawa. This detachment was organized as No. 1 Survey Section, Royal Canadian Engineers, and was placed on active service on March 1, 1942, under Lieut.-Colonel F. G. Bird.

Canada's mobilization plans in 1939 called for the departure overseas of only one survey unit. Accordingly the Ottawa-based 1st Corps Field Survey Company left for England in January, 1940, with 7 officers and 137 other ranks, under the command of Major W. J. Baird.[14] During its sojourn in England this company was posted to a variety of stations in that country while undergoing intensive training and development. In May, 1942, the unit was renamed the 1st Field Survey Company, Royal Canadian Engineers, and was greatly expanded. Its personnel included topographers, trigonometrical surveyors, stereoplotters, lithographers, draughtsmen, and printers. When Major Baird became ill the company was commanded, in turn, by Major J. W. Robinson, Major H. L. Meuser, Major W. K. MacDonald, and Major S. G. Gamble.

In May, 1943, the 1st Field Survey Company was disbanded in order to form the 2nd, 3rd, and 4th companies. The 2nd Field (Topographic) Survey Company was under

Major T. C. Keefer. The 3rd Field (Reproduction) Survey Company was under Major C. H. Smith and the 4th Field (Air) Survey Company was under Major L. G. S. Trorey. The 10th Air (Survey) Liaison Section, Royal Canadian Engineers, came into existence under Major G. S. Andrews, destined to become, after the war, Surveyor General and Director of Surveys of British Columbia. Major H. L. Meuser of the original Canadian field survey company became Colonel and Deputy Director of Surveys, First Canadian Army, in April, 1942.

In the latter part of July and in early August, 1944, the 2nd and 3rd Field Survey companies and No. 1 Army Field Survey Depot disembarked in France, the latter unit under the command of Capt. W. J. Gordon Wadsworth.* Survey formations suffered their first battle casualties on August 8 during Operation Totalize. Lieut.-Colonel MacDonald, as he had become, was wounded and Lieut. R. B. Logie and nine men of the 2nd Field Survey Company were killed while fourteen others were wounded working along the Caen-Falaise road. The loss of fifteen topographical surveyors, listed among these casualties, seriously handicapped the unit. On August 12, Major Samuel Gill Gamble who, in 1958, became Director of the Surveys and Mapping Branch, Ottawa, was promoted to Lieut.-Colonel and replaced Lieut.-Colonel MacDonald as Assistant Director of Survey, Headquarters, First Canadian Army.

Canadian military surveyors at this stage of the campaign in Europe were exceedingly active producing defence overprint maps and artillery-fire plans, which were in heavy demand, in addition to the reproduction of numerous topographic maps. The first mobile map-printing press used by Canadian servicemen in England had been a hand-fed Mann press, mounted in a trailer and hauled by a Matador truck. This arrangement was replaced late in 1940 by a Crabtree press, scaled down in size to fit into the space available in the vehicle and mounted in a 3-ton, 6-wheel Leyland Retriever truck. Under active service conditions the 3-ton vehicle proved to be too light to handle efficiently the truck's normal wartime load. By 1943 printing plant contents, including the miniature press, had been transferred to a 10-ton Foden diesel truck, also equipped with expanding sides. By using the heavier vehicle working space was increased to an area 20 by 14 feet. A separate truck, containing a Lister diesel generator, provided power necessary to the operation of the press.

Surveyors of the 2nd Field Survey Company provided the basic survey data or theatre grid, assisted artillery surveyors when the need arose and undertook numerous other field survey assignments, such as the accurate positioning of devices for locating launchers of enemy V2 missiles. From the time of landing in France map production was maintained at a high peak. During the heaviest week of the campaign the Canadian unit produced 304,000 maps for a total of 1,045,000 impressions. Following the production stage, depot units stored and distributed maps as needed to division headquarters or to higher formations. This remarkable total performance, accomplished under the most trying conditions, well justified the use of a slogan summarizing the role of the engineer survey in war, namely, "An army moves and fights on maps".

Aerial revision of maps was carried on continuously during this eventful period. After the decisive clash at Falaise the speedy Allied advance soon outran the area of map revision for tactical purposes. Nevertheless by mid-September the 3rd Field Survey Company reported that all demands upon it for map reproduction work had been met

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*Later, Director of Surveying, City of Toronto.

FIGURE 101
Two platoons of No. 3 (Map) Reproduction Company, equipped with Ford and Foden photo-mechanical and press trucks, somewhere in Surrey, England in 1944, preparing maps for the invasion of North West Europe.

on time and in the quantities needed. On September 5 the 4th Field Survey Company suffered its first casualties when Lieut. E. F. Klemmer, Sergeant W. E. Tose and Sapper G. Bell were killed. The 1st Map Photo Section of the 3rd Field Survey Company had been assigned permanently to the 4th because of the growing need for fast photographic action as well as for speed in the preparation and proving of plates.

FIGURE 102
Leyland Retriever truck containing an army map press. Note extended sides to accommodate printing press.

By mid-November the Field Survey Depot had moved up to Tilburg, Holland, just before a flying bomb destroyed the building it had been occupying in Hoboken. Its stock of maps had been moved in 70 vehicle loads, a caravan forming marked contrast to the one lorry possessed by the original unit in England. At this time the Field Survey Depot carried some four million map sheets, representing more than 1,200 different maps.

On February 22, 1945, a Canadian map-printing detachment, specializing in the production of artillery-fire plans, moved into Germany. On March 12 it was followed by the 2nd Field Survey Company, ordered up in support of the 2nd Survey Regiment, Royal Canadian Artillery. After the Rhine crossing, topographers aided in the advance of Canadian troops into Germany and West Holland, conducting surveys of various bridge sites among other duties. On April 13 the 2nd Field Survey Company reached Meppen, Germany, and by May, 1945, the German surrender in North-West Europe had taken place.

The training and retraining of men for civilian surveying in Canada commenced at the location in Holland of the 2nd Field Survey Company in June, 1945. The unit had turned over its equipment to a Preliminary Dominion Land Surveyors' School, later renamed No. 2 Canadian Army Rehabilitation Training Centre (Survey). At least a score of candidates passed the examinations, supervised by Capt. A. I. Bereskin of the Royal Canadian Engineers who, after the war, became Controller of Surveys in the Province of Saskatchewan. Survey classes, however, came to an end before September 26 on which date the unit, with a complete change of staff, began to offer both general trade and academic classes at Zeist, Holland. This survey training program was curtailed by the unexpectedly rapid repatriation of troops to Canada.

On June 1, 1945, No. 1 Survey Section, Royal Canadian Engineers, serving with the Geographical Section, General Staff, became interim No. 1 Field Survey Company, Royal Canadian Engineers. The first officer to command this unit was Major (later Colonel) C. H. Smith who was also in charge of the Geographical Section. The company was re-designated and reorganized as the Army Survey Establishment, R.C.E., effective October 1, 1946.[15]

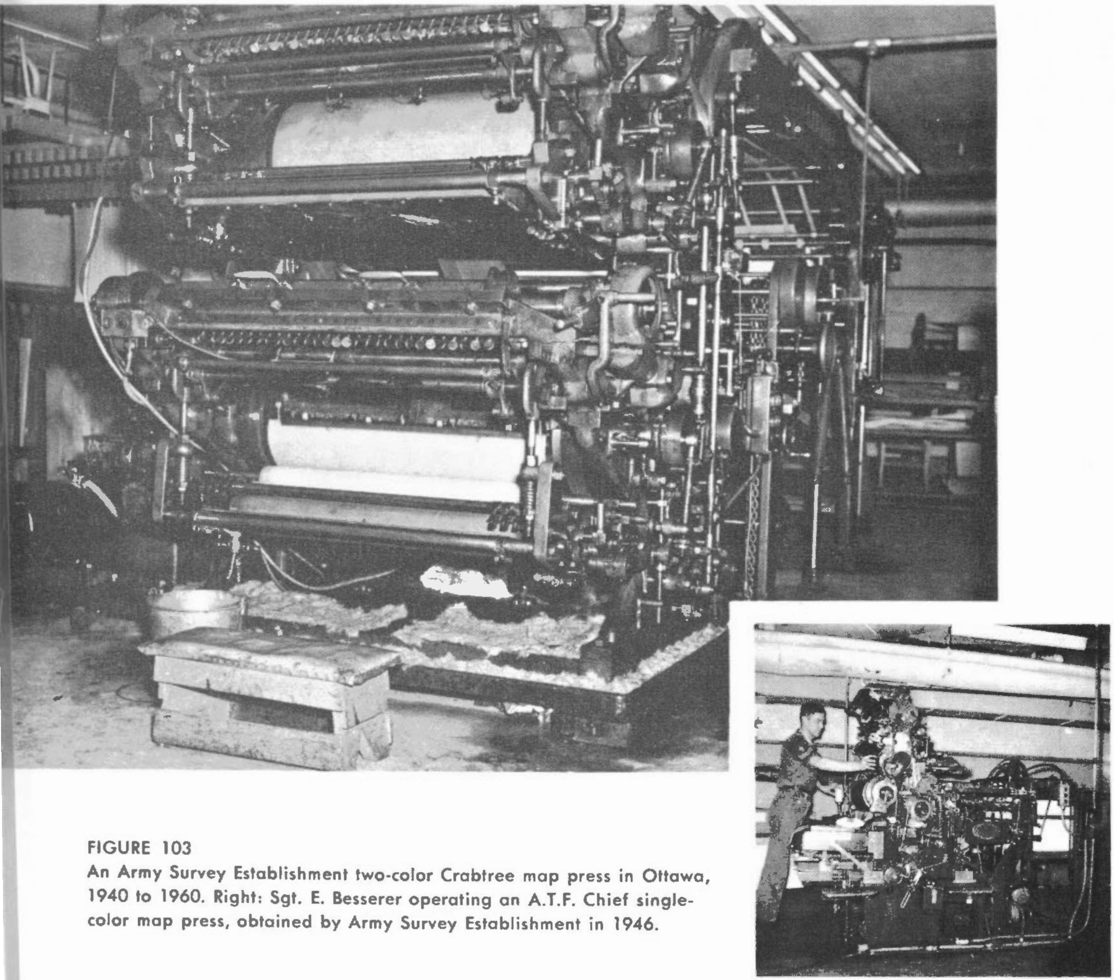


FIGURE 103

An Army Survey Establishment two-color Crabtree map press in Ottawa, 1940 to 1960. Right: Sgt. E. Besserer operating an A.T.F. Chief single-color map press, obtained by Army Survey Establishment in 1946.

The Geographical Section then ceased to exist although there followed a period of some months during which the Section continued to be mentioned as such in official correspondence. In reality, however, the civilian and other staff of the Section had been absorbed in the new Establishment which, within a short time, acquired its full complement of 14 officers, 189 other ranks, and 13 civil servants.

To faithfully record the story of surveyors and mappers in Canada's armed forces during the Second World War would require a full volume in itself. Because of the close relationship between civilian surveying and mapping in Canada and the activities of the engineer survey units in the United Kingdom and North-West Europe, and to a lesser extent of the artillery survey units, this all too brief résumé may serve, at least, as a guide to those who wish to delve more deeply into this significant chapter of Canadian military history.

One of the great military surveys in Canada, and one in which a Dominion land surveyor played a highly important part, involved reconnaissance and subsequent surveying in 1941 of Goose Bay airport in Labrador. The story of its discovery and rapid development is acquiring, with the passage of time, the peculiar sheen and durability of a legend.

The hazards resulting from German submarine activity during the Second World War made shipments of fighter and short-range bomber aircraft from Canada to Great Britain impracticable. As early as 1940 authorities in North America pondered over the problem of how such aircraft could be ferried, under their own power, across the North Atlantic in large and urgently-needed numbers. Long-range bombers were being flown to the United Kingdom from Gander airfield in northeastern Newfoundland but this station had become a traffic bottleneck and was of little assistance in providing facilities for a trans-Atlantic crossing by other types of warplanes. Discussions between Canada and the United States led to an undertaking by the government at Washington to investigate airfield-building possibilities in Greenland and Iceland. Canada agreed to reconnoitre Labrador for the same purpose. Such was the inter-government genesis of the Northeast Staging Route.

The coastline of Labrador was far from being adequately mapped at the time. Allied ship convoys bound across the North Atlantic to the British Isles were acutely conscious of the unrelenting menace of hostile submarines and enemy surface raiders. The Royal Canadian Air Force required a landing field of major proportions in Labrador and the Royal Canadian Navy needed charts of its coastal waters. On June 1, 1941, a Royal Canadian Air Force plane left Dartmouth, Nova Scotia, and headed for Labrador. Aboard this plane, on loan from the federal Topographical Survey Division, was Dominion land surveyor Eric Stanley Fry (1890-). On this assignment Fry and another Dominion land surveyor, Ralph William Clark (1907-) had been instructed "to obtain latitude and longitude fixes at points suitable for the control of mapping."

Fry, a tall, wiry, loose-jointed individual of 50 years of age, joined this historic venture through a strange combination of circumstances. Born on Dominion Day, 1890, in Sandbach, Cheshire, England, son of a Congregationalist minister, Fry experienced at 12 years of age a sunstroke of unusual severity. This illness resulted in his absence from classes for about six months and, not long afterwards, to an abrupt termination of his formal schooling. In 1917, when approaching his 27th birthday, young Fry came to South Edmonton (then Strathcona) in Alberta to join his older brother there.

Until 1910 Eric Fry worked at a number of occupations, mainly that of driving teams of horses for Grand Trunk Pacific Railway construction contractors. But on August 10, 1910, he began work with Dominion land surveyor Thomas Wood Brown who, at the time, was surveying townsites along the Grand Trunk Pacific right-of-way. For two months Fry served as an axeman, then "ran" an instrument. By the following season he had become a semi-qualified instrumentman, working on the townsites of Watrous, Melville, and Wainwright. In the field season of 1915, on Brown's recommendation, Fry served with Dominion land surveyor J. W. Pierce in the Athabasca region of Alberta. "I can't give you a job as assistant, as you are not a university graduate but come along with me as a chainman." This was Fry's first connection with the Department of the Interior and he was paid $70.00 per month for his services. F. W. "Weary" Beatty, later to become Surveyor General of Ontario, was a member of that same field party, surveying townships downriver from McMurray.

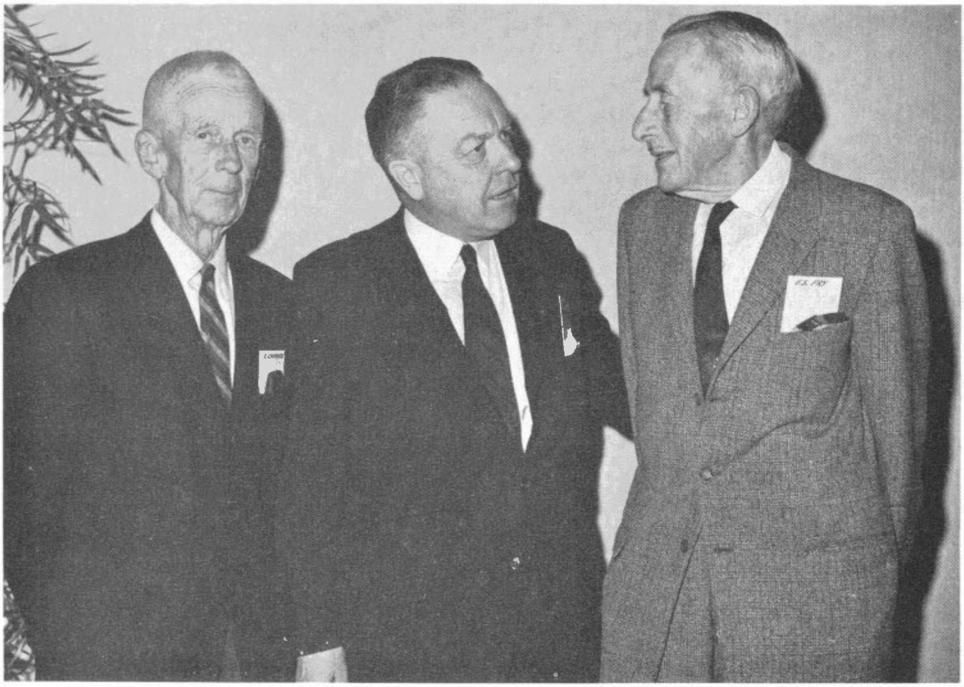


FIGURE 104. Honourable Wm. Benidickson (centre) with two veteran surveyors, K. G. Chipman (left) and Eric S. Fry (right).

Fry enlisted in the Canadian armed forces late in 1915. After serving on the Somme and at Vimy Ridge, injuries sustained in those actions brought about his hospitalization and final convalescence at Vancouver, British Columbia. On his release Fry returned to serve one season with Pierce in the field and then, on word from Ottawa, he reported to Dominion land surveyor Vicars at Kamloops. In the field seasons 1920 to 1923 inclusive, Fry was with Vicars, a man whose character and example influenced him to a greater extent than any other individual. In the following year Fry was awarded his Dominion Land Surveyor's commission, and shortly afterward began to take lessons in piloting planes. In 1926 he was asked to serve as a navigator on aerial surveys and to report to Winnipeg. Fry served in this capacity in various parts of Canada until 1938, a year when ambitious plans were being formed to conduct air surveys in Labrador.

Fry possessed a special feeling and fondness for the Canadian North. In part, perhaps, this preference may have arisen out of his need to protect himself at all times from the effects of strong sunlight, aftermath of the severe sunstroke he had suffered in his youth, and partly because he disliked crowds. He preferred the solitary life, far from the dullness of routine urban living.

So now, in the early summer of 1941, Fry was about to set forth on what was to constitute the most dramatic and significant survey experience of his career. The Stranraer flying boat, carrying the survey party, took off from Botwood, Newfoundland, on June 3rd and headed for Northwest River in Labrador. Sleet and icing conditions forced the plane back to its Botwood base. Venturing forth again the next day bad weather compelled a landing at Battle Harbour. After 12 days of enforced inaction, a sudden change of wind opened up a stretch of ice-free water and once again the party was airborne. Setting a compass course northwest by west they flew direct to the head of Lake Melville and to a landing near the settlement of Northwest River. Near here the mighty Hamilton (now the Churchill) River flows into Goose Bay, an arm of salt-water Lake Melville.

Fry was astonished at the difference in weather and temperature conditions existing between the two points, Battle Harbour and Northwest River. On the coast he had shivered amid ice floes and banks of clammy fog. Vegetation in the vicinity had been sparse. But at the head of Lake Melville, although still on tidewater, dense stands of timber extended down to the shoreline. Flower gardens bloomed and men moved about in straw hats and shirtsleeves.

It was decided that a ground investigation should begin at once of two possible sites for the required large airfield, sites that had been previously reported as promising. If it was then considered necessary a wider search of the region was to be made. Both of the suggested sites were found to be unsuitable under close scrutiny. Fry engaged Dan Michelin and a companion along with a power boat and stocked it with a week's provisions. His course was laid for the head of Goose Bay, where he visited John Groves, a man reputed to have an extensive knowledge of the surrounding country. It was while Fry chatted on the shore with Groves that he glanced westward across the inner Terrington Basin, beyond the narrows in Goose Bay, and was suddenly impressed by the profile of a distant elevated terrace silhouetted against the sunset.

Questioned about this geographical feature, Groves was less than enthusiastic over its possibilities as a site for an airfield. He cited the well-nigh impassable swamp existing between the ridge and tidewater. It appeared that Robert Michelin, brother of Fry's hired boatman, was the only white man known to have frequented the plateau. With Robert as guide Fry struggled along a footpath for some time and finally emerged, after a strenuous climb extending more than two miles, on an imposing terrace, flat as a billiard table and with perfect natural drainage, located about 120 feet above sea level. Two hours spent in examination of the plateau confirmed Fry's initial impression that the locality would meet all the requirements of a major airfield. The area, in fact, offered a veritable pattern of advantages; an airfield site on an elevated plateau, free of local ground fogs; the prospect of one-mile-long road across the coastal lowland; a sheltered, deep-sea ship harbor and seaplane site in nearby Terrington Basin. In addition, on closer inspection, the barrier swamp did not seem so impassable after all. Subsequent probes disclosed the existence of a natural ship channel in Terrington Basin of a width sufficient for all normal shipping needs and possessing an average depth of about four fathoms.

Without loss of time Fry prepared a preliminary report to Ottawa on his discovery. He strongly recommended the selection of the plateau and referred to it in his text as the "Hamilton River Site". This name, however, was destined to remain in the files at headquarters when officials there, perceiving the special fitness of "Goose" calling to "Gander" and vice versa, much preferred the appellation "Goose Bay Site".[16]

Fry's party, enlarged by local recruits, then proceeded to the plateau and began blocking off areas for future levels. A party was also formed to locate and mark out a road from Hamilton River at a point where barges, after being towed upstream, could be unloaded. Following this survey of block outlines, spirit levels were run around each block. A site for the main wharf was then selected and the location of a road from the wharf site to the plateau was surveyed. Rough soundings were made in the intervening swampy ground and the possibility of establishing a crossing of this obstacle by modern road-building methods and machinery was confirmed. Soundings were also taken throughout Terrington Basin and through the narrows to Goose Bay. These activities disclosed the existence of a natural channel of sufficient depth for serving the project by ships. Back at Northwest River plans and reports were drawn up and information compiled on which a final choice of site could be based.

During June, 1941, a United States exploratory party, headed by Capt. Elliott Roosevelt, son of President F. D. Roosevelt, undertook an aerial reconnaissance of Labrador for the same reasons that had inspired the Canadian search. The Americans also recommended to their headquarters in Washington, D.C. that the plateau site near Northwest River be selected but that advice was rejected at that time.

On July 14, 1941, Air Commodore (later Air Vice-Marshal) A. E. Godfrey, then stationed at Halifax, arrived with an engineer officer at Northwest River in a Catalina flying boat. Next day, with Fry, they examined the recommended site first by air, then on foot. Immediately following the subsequent quick flight to Ottawa of Air Commodore Godfrey the project was officially approved. In August advance parties of the Royal Canadian Air Force engineers flew in from Halifax to commence detailed surveys for the wharf, roads and runways. Soon a rough wharf was erected and within a short time thereafter the government ice-breaker *McLean* passed through the channel approach to dock at the new structure.

Contracts for construction work having been signed, other vessels arrived in mid-September, loaded with additional men, materials and machinery. These arrivals were forerunners of a small army of well-equipped workers, totalling more than 3,000 men. Three runways were rapidly levelled off and cleared to lengths of 7,000 feet each. Early in December the first landings of twin-engined bombers were successfully accomplished. A ski-plane had made the initial landing on the plateau one month earlier.

A depressing event in the early months of the Goose Bay airfield development was the loss at sea of two high-pressure boilers intended for the steam heating plant at the construction site. These boilers had been part of the cargo of a vessel sunk by enemy action en route to the project. With winter weather impending the prospects for providing suitable means of warming the living quarters appeared grim. The use of small local stoves seemed to offer the only practical alternative. But about 25 million feet of timber fuel would be required to maintain minimum comfort for personnel at the airfield until spring. To William Durrell, General Superintendent of the McNamàra Construction Company, fell the task of locating needed wood-supply sources.

While reconnoitring in the bush, laboriously marking out areas containing stands of suitable timber, Durrell caught sight of what must have appeared to him at the moment as a mirage. Suddenly he had come upon two high-pressure steam locomotive boilers reposing in this northern wilderness, at least a thousand miles from the nearest railway. This sight was apparition enough but on closely checking the boilers Durrell found them to be freshly painted and completely rust free!

Durrell made his way back to camp with all possible speed. On his way he must have wondered whether the mysterious boilers would still be in existence when he returned to the place. The party that accompanied him on the return journey quickly confirmed the validity of his astonishing find. Later the whole story came to light. In 1907 a lumber company operating in the area had brought the boilers to the locality in order to provide power for their sawmill. The company began to experience financial troubles and its operations were suspended. The bank that had backed the venture with funds took title to the boilers as security for loans made to the ill-fated firm. There seemed to be little point in bringing the boilers out of the wilderness. Accordingly bank officials arranged to have a local Indian maintain the equipment in good working condition. True to his word the native looked after the boilers for more than three decades until their discovery by Durrell and subsequent installation as part of the heating unit of the airfield construction camp.[17]

Throughout the winter of 1941-42 construction continued apace and, by early summer, paving of the runways had commenced. On July 4, 1942, Eric Fry was on hand to witness the arrival at Goose Bay airfield of the first flight of fighter aircraft destined for points overseas, several score Lockheed "Lightnings". Two days later this air armada took off on a trail-blazing first-stage journey to the southern tip of Greenland. By early autumn, 1942, military aircraft of all types were passing through Goose Bay airfield in a steadily mounting stream. Early in 1943, for example, a group of 55 Flying Fortresses landed en route overseas. July 4 of that year proved to be the busiest day ever experienced at the airfield when 149 aircraft arrived and departed. In the 12-month period ended September 30, 1945, more than 24,000 planes had made use of this Labrador air station. With the advent of peace the Goose Bay and Gander stations continued as partners, rather than as rivals, to serve as major fields in the progress of aviation in general and in the growth of trans-Atlantic air traffic in particular.

In 1949, when Newfoundland entered Canadian Confederation, existing agreements between the Government of Newfoundland and the Royal Canadian Air Force became obsolete. The Royal Canadian Air Force was no longer "a lodger with a lease" on the Goose Bay airfield site. The changed situation also affected the legal position of the United States Air Force there and, in 1951, new inter-government agreements relating to occupancy were negotiated.

One of a number of abortive efforts made over the years to bring about an amalgamation of federal survey resources by combining the civilian and military survey organizations in Ottawa, took place early in 1947. A National Defence Department memorandum, drawn up on February 5 of that year by Lieut.-Colonel (later Brigadier) F. L. T. Clifford, indicated that evidence existing at that time was considered by the writer to be inadequate to justify the launching of official negotiations envisioning a merger of the Topographical Survey Division, Department of Mines and Resources, with the Army Survey Establishment. "We have at present a tidy little organization", Clifford stated, after investigating the possibilities of such a move, "whose war establishment should be filled up and on which the Army can rely." He pointed out that the Army Survey Establishment was then capable of producing 6,000 square miles of 1-mile-to-the-inch maps per year, a capacity that could be doubled when the organization was brought up to full strength. At the time also the Establishment was printing many maps on the 4-mile-to-the-inch scale, compiled by the Topographical Survey Division which, unlike the Army Survey Establishment, was not equipped to print its own maps. "Nevertheless", commented Clifford somewhat glumly, "it is inconceivable that Mines and Resources will ever allow its Topographical Survey Division . . . to leave their control. Consequently if there is to be any amalgamation it is most likely that the Army Survey Establishment would, in fact, become part of the Department of Mines and Resources." Military authorities in Ottawa, however, have continued to remain cool toward any suggestion of a merger under which their survey establishment would lose its identity in a predominantly civilian organization.[18]

Lieut.-Colonel John Richard Odlum Vicars (1855-1929), although not a military surveyor in the strict sense of the term, nevertheless deserves mention in this chapter as a highly competent Dominion land surveyor whose record of service in Canada's armed forces overseas was marked by special distinction. A number of land surveyors, including Eric Fry and H. L. Land, who served under Vicars during the course of various surveys in British Columbia, were indelibly impressed by the force of his character, innate dignity and outstanding integrity. He was invariably addressed or mentioned by these civilian subordinates as "Colonel" — seldom, if ever, as "Chief" (as is customary in survey parties) or any of those less exalted descriptions used by survey assistants in moments of extreme stress in the field.

Born in Ireland, Vicars was brought by his parents to Ontario at a very early age. At 31, after articling with Dominion land surveyor, W. T. Thompson, the apprentice was awarded his Dominion Land Surveyor's commission and began surveying in the western interior of Canada. He was also an Ontario land surveyor. But he spent most of his active career in British Columbia, including some years in the Railway Belt. In 1916 Vicars proceeded overseas in command of the 172nd Canadian Infantry Battalion. On demobilization he rejoined the Topographical Survey of Canada, Department of the Interior.

A six-footer of trim, sinewy build Vicars was regarded, even in advanced years, as equal in strength and endurance to many men half his age. Although he left most technical details of a survey project to his assistants he would always be "out on the line". Preferring the job of picketman above all other occupations in the field, he had an unerring faculty for locating transit station sites. When progress was being made smoothly Vicars would whistle or sing, somewhat unmelodiously, snatches of what came in time to be recognized by close associates as "It's a Long Way to Tipperary". He seldom was mistaken in his judgment of a man. As one of his assistants once expressed it, "when he focussed those piercing eyes on you, the pages of your mind just kept turning; he even read the footnotes . . . He stood out in a group of men in the same way that a Douglas fir dwarfs lesser pines; not by virtue of physical superiority alone but in the radiation of a personality that made itself felt in any environment."[19]

Vicars believed in permitting young surveyors to learn by hard experience. One day, for example, the axemen had left a small tree with branches that obscured the line of sight. Vicars sent the front chainman to cut the tree, warning him to be careful, although not giving any particular reason for the admonition. Explanations of his casual conduct were not long in forthcoming. The chainman, in carrying out orders, aroused a nest of hot-tempered hornets. The "oath of chainbearer" which resounded through the mountain glen was not that of the formal type set forth in Clause 95 of the Manual of Instructions to Surveyors.

Vicars was engaged in the field until the mid-1920s. Ottawa authorities then felt that he was too old for such strenuous activity. He was transferred, much against his wishes, to an office position in Calgary. Eric Fry tells of bidding him goodbye in that city in 1924. Five years later Lieut.-Colonel Vicars died in Kamloops in his beloved British Columbia at the age of 74. Shortly before the end he called for the bandmaster of the battalion he once commanded. "When you take me out to the cemetery", he requested, "you can play any kind of funeral march you please, but I want you to promise me that you'll play 'Tipperary' on the way back." His dying wish was respected and one of the bandsmen, much moved by the occasion, was heard to remark afterward, "That cold wind from the North Thompson sure can make one's eyes water."

An account of the role of military surveying and mapping in Canada, however brief, would be incomplete without a reference to the distinguished part played in these endeavors by Dominion land surveyor, Robert Douglas Davidson (1892-1960). Born in Newcastle, Ontario, Davidson studied astronomy and geodesy at the School of Practical Science, University of Toronto, graduating with honors in 1914. During the summer seasons of his student years Davidson worked with survey parties in the field in western Canada, an experience that led him to join the Topographical Surveys Branch of the Department of the Interior. His civilian career was soon interrupted, however, by enlistment in the Canadian Army. Davidson served as a gunner in France from 1916 to the end of the war. On returning to Canada he rejoined the Interior Department. "I recall", one of his colleagues of later years has recorded, "his mention of the fact that he disappeared into the bush in 1919 with a survey party and remained in the wilderness for almost 18 months in order to regain a truer perspective of life after the years of upheaval and conflict."[20]

In the post-war period when large-scale experiments in aerial photography for surveying and mapping began in Canada, the Royal Canadian Air Force assumed responsibility for the flying chores involved. The navigation of planes engaged in this type of work presented, at the time, a technical problem of considerable proportions. In 1924 Davidson, as has been noted earlier in this volume, was chosen to be one of the crew of four of the Vickers Viking flying boat, assigned to make the now famous pioneering photographic flight in the course of that survey season. This undertaking, lasting five weeks, covered areas featured by Pelican Narrows, Lac Ile-à-la-Crosse, Wollaston Lake and Lac Brochet. The name of the Viking's pilot, Squadron Leader Basil Hobbs, is perpetuated among those listed on the impressive Memorial at Wright Field, Dayton, Ohio, as one of the trail-blazers who contributed notably to the progress of aviation in the Americas.

Davidson's navigational feats during the early days of aerial surveying in Canada also became legendary. As work progressed and the need for navigators grew in this field of effort, Davidson was joined in the performance of these special tasks by Dominion land surveyors John Carroll, Frederick Hay Wrong, Cecil Donnelly, and Eric S. Fry. During the decade following the development of the Canadian perspective grid by Dominion land surveyor Robert B. McKay and associates, including Max

Cameron, airborne photographic crews traversed large, previously unmapped regions of northern Canada.

In 1932 Davidson joined the staff of the Geographical Section, General Staff, as technical advisor to Burns, at a time when the main emphasis was being transferred from oblique to vertical air photography. Davidson's unusual skills as a field topographer and as a practical photogrammetrist proved invaluable to the Section. He possessed a special ability to analyze any new method and to detect, with quick perception and insight, its main advantages and disadvantages. "Most of our work [in the 1930s]", Davidson once pointed out, "extended along the south border of the Dominion which is the most heavily settled district with much man-made detail to interpret. These conditions at once ruled out the oblique method [of aerial photography], so successfully used for maps of smaller scale in more sparsely-settled districts and, from the first, our attention was concentrated on vertical photographs, with obliques relegated to a minor role."[21]

After more than a half-century of service, initially in land surveying and, later, in aerial photography applied to surveying and mapping in Canada, Davidson retired from the Section. In 1959 he was the recipient of a special award given by the Canadian Kodak Company "for the most outstanding contribution to aerial photography" made during the years spanned by his illustrious career.

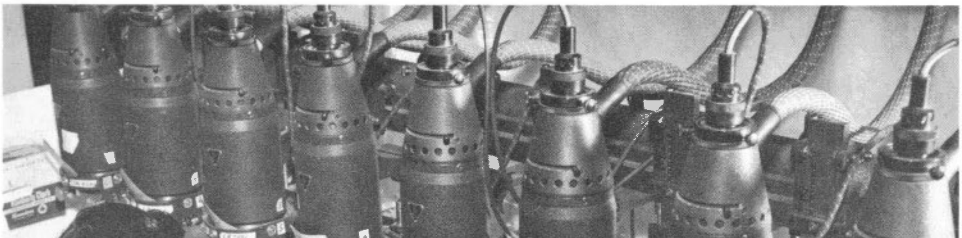


FIGURE 105. Army mappers using multiplex plotter for contouring.

As pointed out by Davidson in his 1946 address to the Canadian Institute of Surveying as its president at the time, one of the few redeeming by-products of war is the impetus given scientific research.[22] New developments in science, expedited by the exigencies of world conflict applied to destructive purposes, have been put to good use in times of peace. The professions of surveying and mapping, in particular, have benefited substantially from this phenomenon in human affairs. Out of the First World War the airborne survey camera emerged to become an important instrument of the surveyor and mapper engaged in promoting the peacetime development of Canada. Out of the Second World War came a number of practical applications of radar and of electronic instrumentation in these same fields and for the same constructive purposes. Increasing use was made of the newest photogrammetric equipment. Computers began to be employed in the reduction of field survey computations and in the resolution of the geometry of aerial photography. Scribing techniques replaced pen and ink draughting in map making. New developments in lithographic offset printing served to expedite map-reproduction work. Military mapping extended to all of Canada, interlocking with civilian operations conducted under the direction of the federal Surveys and Mapping Branch and by provincial government surveying and mapping agencies. The time was not far distant when the annual production of maps by the Army Survey Establishment would approach the total national output of all maps published in Canada prior to 1947.

11

TOWN PLANNING AND THE TORONTO SURVEYS

> *"But to the place,—it standeth north north-east by east from the west corner . . ."*
>
> —*Love's Labour's Lost*, Act 1, Sc. 1.

Town planning, as the term has been applied to Canadian conditions, has been defined as "the scientific and orderly disposition of lands and buildings in use and development with a view to obviating congestion and securing economic and social efficiency, health and well-being in urban and rural communities."[1]

The increasing concentration of Canadians living in urban centres during the 20th century resulted in greater emphasis being placed on the role of the surveyor in land subdivision work on the fast-spreading outskirts of the larger cities. Undivided acreage of this description becomes to the town planner what a canvas means to a painter — a canvas on which a mere daub, a fairly presentable picture, or a veritable masterpiece may appear. The subdivision of land, in more than one aspect, is the foundation of all subsequent town planning and no single factor has exerted more influence on the future of a city or its suburbs than the original layout.[2]

Before the advent of the professional town planner in Canada the land surveyor, in a limited sense, planned a town or city, and the municipal engineer constructed, maintained and operated the urban organism. This combination operated effectively in many communities in Canada's western interior. Accordingly the surveyor's work had an important bearing on that of the municipal engineer and the efforts of both exerted a significant influence on Canadian life and progress in urban centres in the first few decades of the 20th century. The practising land surveyor, because he was involved directly with the establishment of property boundaries, had continuous contact with both the landowner or developer of a subdivision as well as with municipal authorities. He was thus in a unique position to reconcile, wherever possible, their points of view. The surveyor and the engineer contrived together to create an environment which provided a city or town with form, if not with substance. Their decisions usually reflected the attitudes, traditions and dynamism of their times and had a profound impact upon the entire urban complex of Canada.[3]

Town planning in Canada, on a professional basis, began as early as 1914 when the federal Commission of Conservation appointed the Edinburgh-born land surveyor Thomas Adams (1871-1940) as its Town Planning Advisor. Adams, who had achieved prominence in England as a consultant in the planning field, had been induced to accept the Canadian post by a town planning enthusiast of Ottawa and Toronto, Noulan Cauchon. Adams felt strongly that land within township boundaries should not be settled

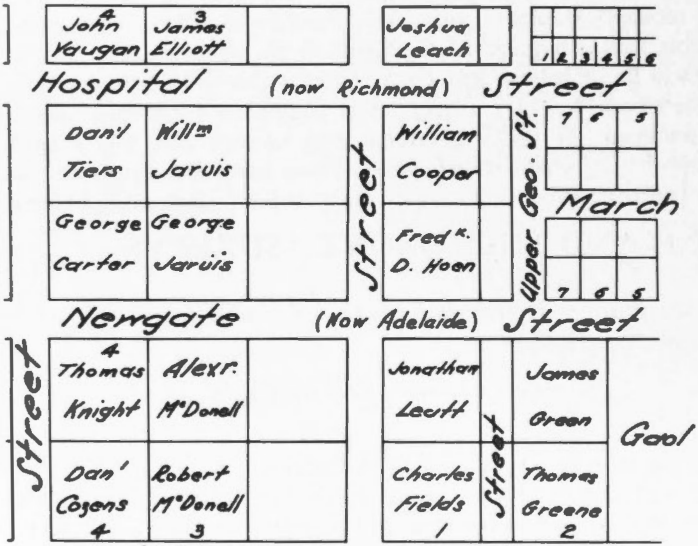


FIGURE 106
Sketch of downtown Toronto. Map from Office of Director of Surveys, City of Toronto (Town of York, July 14, 1830). Tracing by George Wood.

FIGURE 107. Toronto: Old and New.

upon until a proper plan of development covering the township as a whole could be prepared and then approved by a competent director of surveys acting in collaboration with a skilled director of planning located in each province.[4] Incidentally, by 1917 most of the provinces of Canada had town planning legislation on their statute books. Alberta, in 1913, was one of the first of the provinces of Canada to pass legislation of this nature. Some of these provincial acts were permissive, others mandatory.

A surveyor, according to Adams, should not only measure the land but should make a survey of its potentialities for beneficial use. In his opinion the rectangular form of survey should not have been the basis for settlement but should have provided only the foundation on which a proper development plan for each township could be prepared. Adams, in particular, criticized the rectangular system in its application to cities, claiming that this approach resulted in little better than "block plans for sites, planned gridiron fashion, to facilitate the operations of speculators in real estate." Adams regarded the land surveyor as more than a measurer of lines. He saw him as a human instrument by whom conditions under which people lived could be vastly improved.

Adams proved to be an energetic and able evangelist of town planning in this country and before long the Town Planning Institute of Canada came into existence on an informal basis. Not surprisingly Canadian surveyors, through the Association of Dominion Land Surveyors, played an influential part in bringing about the formation of this important agency. In 1918 the surveyors were joined by members of the Engineering Institute of Canada and of the Architectural Association of Canada to promote the creation of the Institute. This was a natural alliance for the purpose, involving as it did the abilities of all three professions.

Surveyor General Deville as well as D. H. Nelles became charter members of the new organization. In 1921, Deville, a vice-president, was named chairman of the editorial committee responsible for the contents of the Institute Journal. The main objective of the new Institute, formally incorporated in 1923, was to promote the scientific and artistic development of town and country on the basis of these joint contributions. The architect's concern would be in groupings of buildings and in the compositions of entire districts of a town or city rather than with the appearance and utility of any individual structure. The municipal engineer's function in planning would be to examine, in particular, the problems of transportation in the community. The surveyor, in Adams' view, ought to be interested in the best use of land, not just in the accurate measurement of it.[5]

During the mid-1920s a number of land surveyors provided important leadership in town planning activities in various parts of Canada. Horace Llewellyn Seymour (1882-1940), commissioned a Dominion land surveyor in Ottawa in 1906 and an Alberta land surveyor five years later, contributed an address, entitled *Town Planning and the Surveyor,* to the 1915 annual meeting of the Alberta Land Surveyors' Association. In that same year Seymour, who had also won surveyor's commissions in Quebec, Ontario and Saskatchewan, withdrew from the practice of surveying and entered upon a career in town planning. Ten years later Seymour drew the special attention of surveyors to the far-sighted town planning projects being launched at that time in Waterloo County, Ontario, and in the city of Kitchener. In the latter community zoning by-laws determined the height, set-back and area of occupancy of buildings but no authority existed to exercise control over construction just beyond the limits of the city. Steps were being taken, even then, to obtain the cooperation of the nearby town of Waterloo in the preparation of zoning by-laws there that would match those of Kitchener.[6]

Seymour was one of the first Canadians to emphasize the indispensability of mapping to effective town planning. In the Waterloo experiment a part of the township had been mapped and contours shown. Thomas Adams, in his report on the planning of Kitchener, also declared that it would be of immense service to the city and township authorities if a map of the whole county could be produced on a scale of 2,000 feet to the inch, showing topographical features, railways, highways and some of the most important levels. Seymour, a president of the Town Planning Institute of Canada, advocated that Waterloo township demand the production of an improved thematic map of the county.

Dominion land surveyor Joseph Edwin Underwood, who was also a Saskatchewan land surveyor, took a keen interest in town planning from the time of its earliest applications in Canada and was, in fact, elected an alderman in Saskatoon in 1927 on a platform advocating the adoption of such planning procedures in that community. Another member of both those organizations of land surveyors, Stewart Young of Regina, became Director of Community Planning for the province of Saskatchewan in 1924. A distinguished graduate of the School of Practical Science, then affiliated with the University of Toronto, Young began his career as a surveyor in 1912 when he was assigned by Surveyor General Deville to a survey party operating in British Columbia under M. P. Bridgland. Young, in common with Adams and Seymour, stressed at all times the importance of mapping to town planning. He firmly believed that the rights of individual property owners as well as the interests of the community as a whole would be well guarded by the appointment of trained engineers to a permanent town planning board.[7]

The views of Stewart Young in this field helped bring about the passage of an improved Saskatchewan Town Planning Act in 1928, a measure that replaced the Town

FIGURE 108. Horace L. Seymour.

FIGURE 109. Stewart Young.

Planning and Rural Development measure passed in that province eleven years earlier. Other prominent Dominion land surveyors who took an active interest in town planning during this formative period were J. E. Umbach, C. H. Taggart, J. W. Pierce, and Carl Engler.

As early as 1919 the Association of Dominion Land Surveyors had established a committee on town planning under the chairmanship of Seymour. Its other members were J. D. Craig, W. H. Norrish and E. J. Wight. This body decided that the subject was important enough to bring before the Association executive.[8] The committee's report was submitted to the annual meeting of the organization in 1920 by Albert Howard Hawkins, who also served at the time as secretary of the Town Planning Institute of Canada. The report stressed the usefulness of maps in any intelligent planning of future urban development, with special reference to population distribution, placement of buildings, lines of transportation, public utilities, schools and parks as well as in relation to taxation and assessment patterns.[9]

In 1921 the Geodetic Survey of Canada published a study by Dominion land surveyor Douglas Henry Nelles, a publication that won wide interest in the United States as well as in Canada. The author was fulsome in his tribute to the part played by mapping in town planning generally. "An accurate topographical map", he wrote, "helps to solve all the fundamental problems in the life of a community which arise in trying to establish a higher standard in the health, education and happiness of the people. It is a basic element in all scientific town planning. It is the Bible of the working departments of the municipal governments." Nelles also pointed out that in addition to their functions in relation to various engineering projects within a community, maps were essential in classifying land for residential, commercial, or industrial purposes, for assessment work and in the planning of local improvements. "No town planning scheme", the author asserted, "or engineering work of any size can be carried out efficiently without the aid of topographical maps. A large-scale topographical map of a city and the country in its vicinity shows the conditions . . . at the time of the survey, the relation between the natural and artificial features expressed in distances and elevations, from which much can be calculated . . . The general accuracy of the map will ultimately depend on the accuracy of the framework which . . . will consist of primary points fixed by primary or secondary triangulation."[10]

In 1924, the year of Deville's death, editorial comment in *The Canadian Surveyor* supported the creation in Ottawa of a post-graduate school of town planning to serve, in part, to educate practising surveyors in the principles of urban and rural planning. "Modern development of town planning", the editor declared, "which has evolved from the necessities of solving the slum problem and which brought to our understanding the relations which street widths and heights of buildings bear to the access of light and air . . . is the great sociological achievement of the age. The surveyor has, in the nature of things . . . much influence upon subdividing and a heavy moral responsibility in the ultimate sociological results of his planning . . . The future of surveying would seem to hold great opportunities in replanning for the better disposition of people upon rural land no less than for adjusting them within city limits."[11]

The 1927 report of the committee cited some noteworthy examples of town planning then under way in Canada. Mention was made of the development along planned lines of university endowment lands in the Point Grey district of Vancouver. A zoning scheme for Canada's capital, prepared by its Town Planning Commission, was under consideration at the time by Ottawa's city council. A land-use map was being prepared in Victoria, British Columbia, in anticipation of the passage of a zoning ordinance in that city. The Aluminum Company of Canada had undertaken extensive town planning work in preparing the layout of the community at Arvida, Quebec, designed to accommodate company employees. Kitchener, as already mentioned, was ahead of most large Canadian urban centres in the adoption of planning procedures. It was noted in the report, in conclusion, that in those parts of Europe and the United States where town planning had made the greatest headway, it had expanded into regional planning.[12]

The committee's 1928 report posed a perceptive question — "Cannot the resources of science, so effectively employed for purposes of wartime destruction, be devoted in times of peace to the building of more interesting, orderly, efficient and beautiful towns and cities?"[13] The abolition of the federal town planning office, established in 1914, was noted with regret. In the general discussion following the report, mention was made for the first time of the possibility of employing aerial photography as an aid in effective town planning. Application for two memberships in the Town Planning Institute, which had continued to function effectively, was made at this time by the Association of Dominion Land Surveyors.

The evolution of Toronto from its beginnings provides an example typical, in certain salient respects, of the development of town planning in Canada. Even before the arrival in this country of John Graves Simcoe, the Governor in Chief, Lord Dorchester, had taken steps to prepare for the building of a town on the site of Toronto. In 1788 Deputy Surveyor Alexander Aitkin had been instructed to lay out such a townsite. His plan placed the proposed settlement, in the main, in the area now bounded by Spadina Avenue and Toronto Street and extending northward from the waterfront almost to Gerrard Street. The town was to be surrounded by a commons about a half-mile in width and by a belt of government reserve land beyond. Subsequent pre-Simcoe planning for this townsite was based on the initial Aitkin pattern but the site was enlarged to a mile and a quarter square.[14]

In 1788 also Capt. Gother Mann of the Royal Engineers drew up a town plan for a settlement on the site of present-day Toronto. This plan was based on both Aitkin's design and a map of Toronto Harbour made by John Collins earlier in the year. Deputy Surveyor General Collins of the province of Quebec had been authorized by Lord Dorchester to investigate and submit a report to him on military posts along the Great Lakes. Mann's plan, accompanying that report, represented an area of one square mile, divided into 121 lots.[15] Six lots were set apart for use as public squares or for the erection of public buildings. Bordering a central common were township lots described as town parks. These early plans reflected the thinking of that period concerning layout of towns in newly-opened territories and placed the townsite some distance east of the Humber River and close to the route of the Toronto Passage. This route followed river valleys leading northward from Lake Ontario and offering the shortest approach to the Upper Lakes.

Two years later, in 1790, Deputy Surveyor Philip Frey received instructions from Quebec to lay out the front line of a range of eleven townships, extending from the mouth of the Trent River westerly to a mile or so beyond Toronto Harbour. The most westerly of these townships was named Dublin. As Frey happened to be occupied elsewhere these instructions had to be renewed in the following year, Deputy Surveyor Adolphus Jones being entrusted with the township survey task. The instructions to Jones involved only the measurement and marking of a single line across the front of each township. His line across Scarborough Township, named Glasgow at that time, ended about three and a half miles north of Lake Ontario. Before pressing on, Jones ran the boundary between Glasgow and Dublin townships south to the lake, then continued across Dublin Township on the line of present-day Queen Street, Toronto. The system of subdivision was that which is found even today in Scarborough and townships farther east, namely, lots 20 chains wide by 100 chains deep, with a side road every other lot and each township 35 lots, or about 9 miles wide.[16] Within a few years the name Dublin Township vanished from official use, to be replaced by Toronto Township. Before Jones had measured off 35 lots along what is now Queen Street he reached Lake Ontario at present-day Sunnyside and had to offset his line to the north to complete the survey of the entire township boundary. The western boundary of Dublin Township, as established by him, was not far from the centre of today's High Park.

About this time certain surveys were being made of Toronto's harbor. In 1792 the commander of British naval forces on the Great Lakes requested data on the depth of water in the harbor and it is likely that Plan 14 in the Surveys Branch, Government of Ontario, the work of Adolphus Jones and entitled "Plan of the Front Line of Dublin with the Harbour and Soundings" was the result of that request. A more detailed survey of the harbor was made either late in 1792 or early 1793 by Joseph Bouchette. During 1793, after the town of York survey plan had been completed, Alexander Aitkin was ordered by Simcoe to make another survey of the harbor. His plan was, in fact, quite detailed, showing lagoons at Toronto Island, creeks on the mainland, harbor soundings and the sites of the town and the garrison.[17] Not until 1818 did another survey of the harbor take place, when Lieut. H. W. Bayfield, R.N., performed the task for the British Admiralty.

But Toronto as a community of importance began its career in 1793. It was in the summer of that year that Lieut.-Governor Simcoe sailed from Niagara-on-the-Lake to Toronto Bay and set up temporary headquarters on its shore. He was accompanied by deputy surveyors Aitkin and Jones as well as by men of the Queen's Rangers and some artisans. The soldiers and skilled workmen not only erected a fort but also, within a few years, built homes, mills, wharves and warehouses. On June 26, 1793, instructions were given to Aitkin and Jones "to survey the southerly part of the Township of York" and to lay out a small townsite on the north shore of the bay.

Apparently Aitkin was mainly responsible for laying out the townsite as the diary kept by Jones indicates that the latter was occupied during most of the field season in surveying concession and side roads in York. From the harbor plan produced by Aitkin it is known that the original plan of the town of York consisted of 10 blocks, each containing lots 66 feet in width by 132 feet in depth. The town plot was in the form of a parallelogram, bounded on the north by Duchess (now north Adelaide) Street, on the south by Front Street (East), on the east by Ontario Street and on the west by George Street.[18]

A scramble to obtain town lots took place among prospective settlers in early September, 1793, but there was a definite effort made by the authorities to discourage real estate speculators. Lots of 100 acres in size were allotted to members of Simcoe's official and personal entourage. Most of the new owners cleared the lots for farming purposes. As for the smaller lots of the townsite the total of 80 seemed, in comparison with the recently surveyed towns of Kingston and Newark, quite modest. For Simcoe's purposes, however, the establishment of a garrison was the prime consideration. Completion of the townsite survey task marked the beginnings, then, of the "old town of York" as it came to be called. The original fort and other structures of those early times have long since vanished from the scene but the posts planted by the surveyors remain the foundation of property ownership based on that ancient townsite.

Zoning regulations appeared in the earliest years of the new settlement at York, a fact borne out by a letter written by Hon. Richard Cartwright to a friend in which he states "You will smile perhaps when I tell you that even at York a town lot is to be granted in the front street only on condition that you shall build a house of not less than 47 feet front, two storeys high, and after a certain order of architecture . . ."[19]

It was Simcoe's idea that a military road should be built running due north to Lake Simcoe and designed primarily to carry trade to the North West. Out of this conception Yonge Street evolved. This highway was surveyed by Jones, assisted by John Stegman, during the field seasons of 1794 to 1796 and it developed into a key transportation artery that profoundly affected the long-term growth of Toronto. This road replaced the old trail bordering the Humber River and by-passed the site selected in 1788.

Poorly drained clay soils, responsible for the appellation "Muddy York" as well as malaria-infested swamps mitigated against the selection of such a site for settlement and prompted Col. Thomas Talbot to refer to the area as being "better calculated for a frog pond, or beaver meadow, than for the residence of human beings."[20]

What, then, were the principal factors leading to the choice made by Simcoe in 1793? Along the north shore of Lake Ontario there were other well-sheltered harbors, some of which commanded large streams leading even farther inland than those draining into the bay at Toronto. But Simcoe, judging from his letters, concluded that what is now central Toronto's waterfront constituted the best harbor on the Canadian side of the lake and described the location as a "natural arsenal of Lake Ontario, affording easy access overland to Lake Huron".[21] Collins, too, described the harbor as "safe, commodious and well-sheltered".

Simcoe's plan to link defensive advantages with commercial possibilities came to a natural focus at the site he selected. The fact that it provided entrance to a good route overland to the Upper Lakes, through the Toronto Passage, proved to be a determining factor in the making of this choice. In fact it was only after his examination of the Passage during the summer of 1793, which disclosed to him the excellent harbor on Georgian Bay at the northern terminus of the Passage, that the firm decision was made to build at what is now Toronto.

The founding of York was a bold move. The nearest white settlements, at the time, were Niagara and Kingston. In those early days York seemed to be "off the beaten track" in the existing pattern of communications. Despite the fact that, later on, the main trading route to the North West side-tracked the new town, its emergence as capital of Upper Canada made the site a focus for a number of roads in that strategic region. The location, in turn, enabled the settlement to become a leading centre for distribution of goods and services. The growth of the town was also stimulated, in the passage of time, by its proximity to a part of Canada rich in agricultural possibilities. But when the community first emerged, farming in the areas tributary to it was still in its infancy.

The shape and pattern of development of early Toronto were predominantly determined by government policies and planning. The old town of York, for instance, was a compact settlement, planned in its entirety by the authorities. Because the properties on the site were government-owned, expansion of the community was carefully organized as a unit and sensibly integrated with the original layout. The "new town of York" was laid out in 1797 in the area now bounded on the north by Queen Street and extending between present-day Yonge and Peter streets. The plan made provision for several large squares and the blocks of lots were generally of larger dimensions than those of the old town. But the blocks were not uniform in size. An 1850 map shows lots 150 feet deep along the east side of the school square. The church square was reduced by the grant of two acres to private individuals. This piecemeal system of land disposal accounts for the irregular street pattern that exists to this day between Yonge and Jarvis streets, south of Queen Street.[22]

In preparing York for the seat of government of Upper Canada, Simcoe made preparations to have additional lots surveyed and added to the townsite. Before his plan could be implemented Simcoe had to leave the province because of ill health. Peter Russell (1733-1808) was at that time President of the Executive Council and acting Administrator of the province. He had come to America from England in 1776 as an assistant to the British general, Sir Henry Clinton, during the Revolutionary War. Incidentally, Major Samuel Holland, Surveyor General of Quebec, had been attached also to Sir Henry's staff at that time.

In 1796 Russell instructed William Chewitt, the surveyor, to make surveys for an extension of the town westward on government-owned land. However, he experienced difficulty in locating lines of the original town plot. Indications of the problem he faced are found in the text of a public notice posted by Acting Surveyor General D. W. Smith on the order of Peter Russell, dated November 8, 1796. "No person is to presume in future", the notice proclaimed, "to lay down a House of Frame on any Lot in the Town of York until the surveyor who may be stationed there examines the spot and declares it agreeable to the Regulations of Council. Whoever shall attempt to move or to throw down any Boundary will be prosecuted with as much vigor as the Law permits — and if any person throws down a Boundary by accident in clearing his lot, he is to make immediate application to the surveyor's office there to have it fixed in its proper place; paying all reasonable expenses."[23]

In retrospect one consequence of these early Toronto surveys remains particularly impressive — the permanence of road and street lines laid out by the pioneer surveyors. Churches, houses, mills and taverns of the 18th century have vanished; gullies, streams and swamplands have disappeared; the shore has advanced into the bay by hundreds of yards with the reclamation of land from the lake. Yet, almost without exception, the streets of York laid out by Aitkin and Jones carry the traffic of today and the street lines defined by successors of those early measurers are nearly identical to the lines fixed on the heavily-wooded shores of Toronto Bay in Governor Simcoe's day. On incorporation of the City of Toronto in 1834 the name York was dropped.

One of the most interesting features of early Toronto surveys is the Windmill Line, first established in 1833 along the waterfront. This governing line is mentioned in many of the property deeds signed by William Chewitt and was usually described in such documents as a line produced "from the point near the site of the late French Fort west of Toronto Garrison to Gooderham's Windmill." The old French fort mentioned was Fort Rouille, destroyed in 1759. Within less than another century the Gooderham structure had been demolished. But for many years this line formed the southern boundary of all wharf structures and water lots. The windmill, built about 1832, seems to have been a very prominent feature of the east end of the harbor and stood near what is now Trinity Street. In 1893, by Order in Council the Windmill Line was extended 644 feet between York and Princess streets.[24]

Not all Ontario surveyors of the late 19th century were convinced of the authenticity of the Windmill Line. Alexander Niven remarked in 1887 that he had heard a Chief Justice interrupt a surveyor who was giving evidence in court and who had offered the opinion that "no one can say where the Windmill Line was located". The Chief Justice, to Niven's admitted surprise, declared that the Windmill Line was as well known as King Street. "I studied in Toronto", commented Niven, "and claim to know that the so-called Windmill Line was almost a myth. It existed theoretically but practically I believe no surveyor could define it!"[25]

Despite Niven's misgivings the City of Toronto in 1893 employed Ontario land surveyor Charles Unwin to retrace the Windmill Line. He ran the line through to Spadina Avenue on the ice. A plan in the office of the Director of Surveys, City Hall, Toronto, shows the line in relation to the then existing wharves and docks. When resurveyed in 1913, by Ontario land surveyor Norman D. Wilson, the Windmill Line had become the centre of the city's waterfront commercial life, cutting through buildings, docksheds and warehouses.

In the beginning of settlement of Toronto's core area the land extending north to Bloor Street between Parliament Street and the Don River was a government reserve and came to be known as The Park. When a piecemeal subdivision of this area began to take place south of Queen Street, then north of it, many small houses were crowded into the blocks, especially in what came to be known as Cabbage Town. This was an area, not marked by that name on maps or official surveys, in which English and Irish immigrants had settled in the period of cobblestone streets and gaslit shops. A century

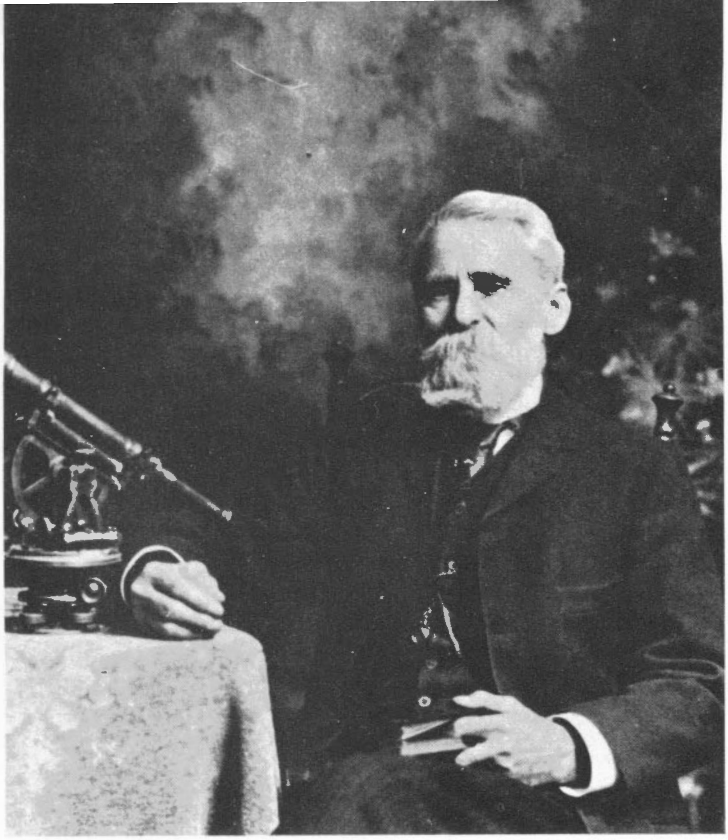


FIGURE 110
Charles Unwin.

later the Toronto newspaper columnist, J. V. McAree, son of a pioneer Dominion topographical surveyor, John McAree, wrote a book entitled *Cabbage Town Store*, published by The Ryerson Press in 1953 and in which life in that district of the early city was vividly described.

The advent of railways in the 19th century, with a number of lines radiating from Toronto, contributed substantially to its progress as a community. Investment of large sums in railway construction created new and expanding industrial activity and by 1851 Toronto's population had risen to 30,000. By that time residential expansion north of Queen Street had become necessary. Properties near Yonge Street developed first of all, a tendency that became more pronounced during the steady growth northward in the second half of the 19th century. For the most part, streets were projected on a north-south alignment along 100-acre lots. East-west connections remained poorly integrated. As early as 1853 locomotives were being built in the city. When a Toronto company built sections of the Grand Trunk Railway, enough capital was accumulated to enable Gzowski and MacPherson to establish, in 1860, the Toronto Rolling Mills. In addition to attracting line-building and line-maintenance workers to the expanding community, railway companies stimulated the establishment of machine and metal-making industries. By 1881 the city's population had climbed to about 85,000.

In southern Ontario the typical farm unit had been laid out in the form of a rectangle, its orientation being dependent upon the direction of the base line of the original survey. When such a farm was taken over for urban development the street system imposed upon it was generally prescribed by the rectangular grid. Any lack of uniformity in existing street patterns in Toronto reflects differences in the primary survey systems.

FIGURE 111. Urban developm

West of Yonge Street, between Bloor and Eglinton arteries and as far west as Keele Street, the dominant orientation of streets is a slight deviation from due north-south (N. 16°W. and N. 74°E.). West of Yonge and north of Eglinton as well as east of Yonge Street, north of Rosedale, the trend of thoroughfares is generally east-west. In short, these street patterns testify to the process of farm-by-farm expansion that has featured Toronto's growth to this day. An unhappy result of this process is the considerable number of jogs found in many of the city's thoroughfares. Most such discontinuities originate in the piecemeal subdivision of farms. Other jogs, especially those occurring in main traffic arteries, arose out of inaccurate surveys. In some cases elimination of these jogs, in order to facilitate the flow of increasing traffic, has been costly.

Don Mills, Ontario: 1952 and 1967.

At the turn of the century Toronto, unlike its pioneer nucleus York, was a community built without any over-all planning and with a minimum of government direction or interference. Its appearance, on the whole, reflected the almost random nature of its land-subdivision activities. By the mid-20th century, after several false starts, town planning had been definitely accepted as an instrument of enlightened administrative policy. Its application came not a moment too soon. During the 16 years following the end of the Second World War more land had been developed for urban uses in the Toronto metropolitan area than during the entire history of the city up to that time.[26] The phenomenally increased use of the automobile served to alter the face of most large cities of the continent. The increased mobility that resulted made possible, if it did not actually dictate, the mushroom-like growth of suburbs and of satellite communities not only in the Toronto area but in most important urban centres of Canada, the United States and Mexico.

During the First World War and most of the 1920s town planning as a tool of civic government continued to lie largely unused. From 1912 to 1930 all such planning within urban Toronto was entrusted to the City Surveyor's office, a branch of the municipal assessment department. By 1929, however, an Advisory City Planning Commission had come into existence. During the 1930s, following rejection by public ballotting of suggestions proffered by the Commission, town planning activity receded. At the beginning of that decade the City Surveyor's office was expanded and became the Department of City Planning and Surveying, continuing as such until 1954. But the planning work of the Department consisted mainly of approvals and layouts of subdivisions, planning of streets and traffic engineering generally, together with the establishment of all legal surveys for the municipality.

Not until early in the Second World War, when post-war reconstruction and expansion were under consideration, were demands for town planning measures vigorously reviewed. On June 1, 1942, the Toronto City Planning Board was established and all planning submissions came under the purview of the City Surveyor, for presentation to the Board. Although this body was advisory only in function, its recommendations had very far-reaching effects upon the development of post-war Toronto. Its report, in fact, was the first comprehensive proposal for town planning for the metropolitan area, from greenbelts and a civic centre to land-use maps within the city proper and the establishment of zoning standards. In 1947 the City of Toronto and 12 suburban communities,

FIGURE 112. Mouth of Don River, Toronto.

totalling 250 square miles, developed and undeveloped, containing more than one million inhabitants, were formed into a planning area under the jurisdiction of the Toronto and Suburban Planning Board. This forward step was taken under the authority of a statute of the provincial legislature.[27] In the previous year planning boards in Ontario had been empowered by the legislature to investigate and survey the physical, social and economic conditions in their planning area and to prepare maps, drawings and other documentation essential to the study and solution of problems affecting their orderly development.[28] By 1949 an official plan for the metropolis had been prepared and a comprehensive zoning by-law passed by city council. At this stage Toronto's population approached 850,000.

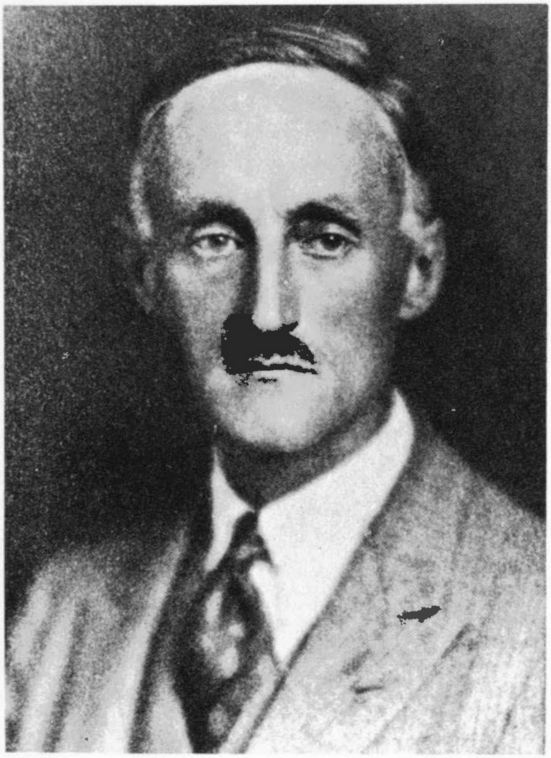


FIGURE 113. Tracy D. leMay.

From the early 1930s the English-born City Surveyor for Toronto, Tracy Deavin leMay, who had been awarded his Ontario land surveyor commission in 1909, developed a profound technical knowledge in all fields related to the planning, growth, and development of communities in general and of Toronto in particular. In this work he enjoyed the active support of A. Douglas Ford and W. J. Gordon Wadsworth, O.L.S., who became, in time and in succession, City Surveyor, and Director of Surveys, City of Toronto, respectively. The appointment of leMay as vice-president of the Town Planning Institute of Canada in 1953 crowned a long period of close and highly useful association with the work of that organization.

FIGURE 114. University Avenue, Toronto, looking south to waterfront.

Toronto inherited from surveying activities of the 19th century a broad grid of cross-town traffic arteries at 1¼-mile intervals, based on the location of original concession roads and side roads. From the outset certain old travelled roads failed to conform to the general survey pattern. Davenport Road, Dundas Street, Weston Road and Kingston Road, for example, cut irregularly across the prevailing survey grid. Actually these were highways used to reach the town of York before surveyed roads had been opened. Some of these roads may have followed the course of Indian trails. Later on streets within the subdivision grid of roads were joined to form additional cross-town arteries. College Street and Bay Street are examples of this type of development. A 1912 enactment authorized city authorities to widen to 86 feet, concession and side roads outside the existing city limits in advance of subdivision projects.

FIGURE 115. Toronto Island.

From the turn of the century, plans were made to improve the grid pattern by the construction of a system of impressive boulevards. In the 1929 report of the Advisory City Planning Commission it was proposed that University Avenue, which has become the bright jewel of central Toronto's thoroughfares, be extended as part of an over-all plan for the improvement of the downtown street pattern. It was recommended that the avenue be extended southward, then projected southeasterly to Front Street. The commission also recommended that all buildings to be constructed along University Avenue be made subject to reasonably high architectural standards. This declaration was the first clear echo to be heard in 20th-century Toronto of Governor Simcoe's town planning proclamations, issued in the earliest days of the settlement at York.

Downtown a large-scale program of street-widening, of rapid-transit construction and of expressway building became imperative. The construction of the first stage of an ambitiously designed subway system, a 4½-mile stretch along Yonge Street and extending from Eglinton Avenue to the Union (Railway) Station on Front Street, was commenced. In addition, for the first time in Metropolitan Toronto, a planning organization had created a framework of traffic arteries to expedite the rapid movement of motor vehicles. Lake Shore Boulevard, linking Queen Elizabeth Way with Kingston Road, was supplemented by the Gardiner Expressway. Highway 401 to the north, Highway 27 to the west, also provided access to the inner city, as did the Don Valley Parkway and Bayview Avenue extension. By the judicious placement of new expressways through ravines, much of this type of landscape was retained for park purposes. High Park, laid out at an early stage of the city's growth, on hilly terrain just east of the Humber River, continues to be outstanding among all parks in the city. Revolutionary changes in transportation routes and facilities foreshadowed a new distribution, within the city proper, of high-rise office and apartment buildings. This tendency toward decentralization of such structures soon became evident near the Bloor-Yonge, Yonge-St. Clair, and Eglinton-Yonge intersections.

In the decade following the end of the Second World War the most impressive feature of Metropolitan Toronto's growth was its large-scale suburban expansion, involving the rapid appropriation of large blocks of rural properties for urban uses. Open country continued to recede at an astonishing rate. The traditional grid system continued to form the basic pattern of growth. In time, serious efforts were made to establish less conventional and more attractive and cohesive communities within this immense suburban development. In Don Mills, for example, house types of considerable variety were built on unconventional street patterns, centred on a modern shopping and service complex.

Town and rural planning, by the mid-20th century, was receiving steadily increasing attention in all parts of Canada. It was becoming more widely recognized throughout the nation that good subdivision design, in addition to fitting the local topography, should include and ensure the most efficient use of land, permit the most economical installation of municipal services, promote health and safety as well as provide the maximum amenities of living. The land surveyor, in relation to such objectives, was fast becoming a servant of the development of land in our communities in the interests of its inhabitants through the creation of an improved environment for the Canadian way of life.

12

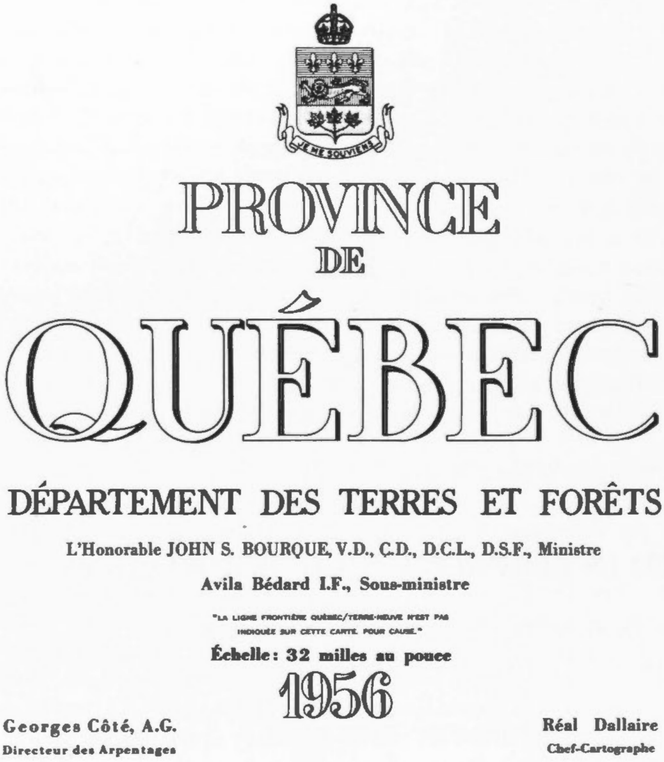
THE UNSURVEYED INTERPROVINCIAL BOUNDARY

"La ligne frontière Quebec/Terre Neuve n'est pas indiquée sur cette carte, pour cause."

—Legend on maps of Quebec issued in 1946 *et seq.* by the Quebec provincial government.

The word "Labrador" began to appear on world maps in the early 16th century and was initially applied to what is now Greenland. Misunderstanding among cartographers of the period over the relative positions of Greenland and northern North America led, in time, to the transfer of the name "Labrador" to its present location. The Wolfenbuttel map, 1534, bears an inscription in Spanish with reference to the east coast of Greenland which reads, in part, "Land of the Labrador . . . discovered by the English of the town of Bristol and because he who gave the direction [the pilot] was a labrador of the Azores, they gave it that name."[1] The original meaning of "labrador" is not clear but the word, at that time, may have signified a farmer or laborer. By the time of the Sanson map of North America, 1696, the name was firmly attached to the mammoth peninsula between Hudson Bay and the Strait of Belle Isle.

The interprovincial boundary line between Quebec and Newfoundland in the Labrador peninsula, although legally defined, remains completely unsurveyed and unmarked on the ground. The roots of this paradox reach back more than three centuries into a period when fishing was the principal, perhaps only, industry of the region. Today, with large-scale water power developments, timber production, and intensive mining of high-grade iron ore as major economic activities in areas adjacent to the interprovincial border and, occasionally, astride it, the need to establish agreement on the actual course of the boundary as well as its definition on the ground, is more urgently needed than ever before.



PROVINCE
DE
QUÉBEC

DÉPARTEMENT DES TERRES ET FORÊTS

L'Honorable JOHN S. BOURQUE, V.D., C.D., D.C.L., D.S.F., Ministre

Avila Bédard I.F., Sous-ministre

"LA LIGNE FRONTIÈRE QUÉBEC/TERRE-NEUVE N'EST PAS
INDIQUÉE SUR CETTE CARTE POUR CAUSE."

Échelle: 32 milles au pouce

1956

Georges Côté, A.G.
Directeur des Arpentages

Réal Dallaire
Chef-Cartographe

FIGURE 116
Title, with explanatory clause, typical of maps of the province issued by the government of Quebec after 1945.

The boundary in Labrador between Quebec and Newfoundland, shown on maps published by the Canadian and Newfoundland governments during the past forty years, reflects the 1927 decision of the Judicial Committee of the Privy Council, London. It is over the validity of this judgment of British law lords, presided over by the then Lord Chancellor, Viscount Cave, that recent governments of Quebec have expressed reservations.

Origin of the Boundary Problem

As was demonstrated in the Canada-Alaska boundary dispute, disagreements in debates over location of a border often originate in ambiguously-worded, formal documents as well as in conflicting maps pertaining to the region in question. It is significant to find in the Labrador case, as in that of the Alaska Panhandle, that the term "coast" became the subject of various interpretations. However, the documents mainly involved in the Labrador case were those officially describing administrative responsibilities of governors of Newfoundland who served in that office during the decades immediately following the signing of the Treaty of Paris in 1763. It was in that year of the formal cession of Canada by France to Great Britain that the right to control Labrador fisheries was granted to Newfoundland. But soon thereafter Quebec fishermen, resident in the region, began to protest strongly against exclusion from their traditional fishing areas in the Strait of Belle Isle. As a result of these objections the administration of all Labrador was transferred to Quebec under terms of the Quebec Act, 1774.

From the opposite side complaints began to be made, in subsequent years, that the government of Quebec was not much concerned with Atlantic cod fisheries and that no real governing power was being exercised along the Labrador coast. Accordingly the British government decided to reverse its stand and, by the 1809 Newfoundland Act, it was enacted that parts of the coast of Labrador, from the St. John River to Hudson Strait "annexed to the Government of Newfoundland . . . in 1763, shall be separated from the said Government of Lower Canada and be again re-annexed to the Government of Newfoundland." Sixteen years later, under the (Imperial) 1825 British North America Act on Seigneurial Rights,* a boundary was established between the two jurisdictions with a southerly limit at ". . . a line to be drawn due north and south from the bay or harbour of Anse Sablon . . . ." The remainder of this line, apart from a reference to the 52nd parallel of north latitude, was described in rather general terms. But this Imperial legislation had the effect of transferring back to Lower Canada parts of the Labrador coast, west of the defined line. It marked the final statutory move in the 62-year-long game during which Labrador territory was tossed like a shuttlecock back and forth between jurisdictions.

But documentary evidence, other than treaties and legislative acts, also had a definite bearing on this important issue. Capt. Thomas Graves was Governor of Newfoundland at the time of the cession of Canada to Great Britain. On April 25, 1763, Graves was reappointed by King George III "King's Governor and Commander-in-Chief in and over our said island of Newfoundland *and all of the coasts of Labrador* [author's italics] from the entrance of Hudson Straits to the river St. John's which discharges itself into the sea nearly opposite the west end of the island of Anticosti . . . ." Instructions to Governor Graves under the Royal Sign Manual in accordance with the terms of the appointing Order-in-Council made no distinction between the island of Newfoundland and the coast of Labrador, both being included in identical terms in the territories under the care of the governor. In the various royal commissions issued to governors of Newfoundland succeeding Captain Graves, including Hugh Palliser, the language of the original documents was retained unaltered.[2]

The boundary dispute was revived when a discrepancy arose between the formal description of Newfoundland's jurisdiction in Labrador, as contained in Newfoundland letters of patent dated March 28, 1876, and a map of Labrador, published in 1880 by the federal Department of the Interior. Efforts to negotiate a compromise of this difference failed to produce any results and by the turn of the century the issue had come to a head. A legal confrontation was made inevitable when, in 1902, a pulp and lumber company was licensed by Newfoundland to operate in the Goose Bay area. The right of the company to cut timber in that vicinity was challenged by the government of Quebec. The matter was taken to the courts and in 1907 the governments of Canada and of Newfoundland agreed to refer the boundary question to the Judicial Committee of the Privy Council. The outbreak and duration of the First World War, coupled with an inability to settle on the precise wording of the reference to the court, resulted in additional delay. It was not until the early 1920s that the contending governments asked the law lords "What is the location and definition of the boundary between Canada and Newfoundland under the Statutes, Orders-in-Council and Proclamations?"

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*6 Geo. IV, ch. 59, Term 9.

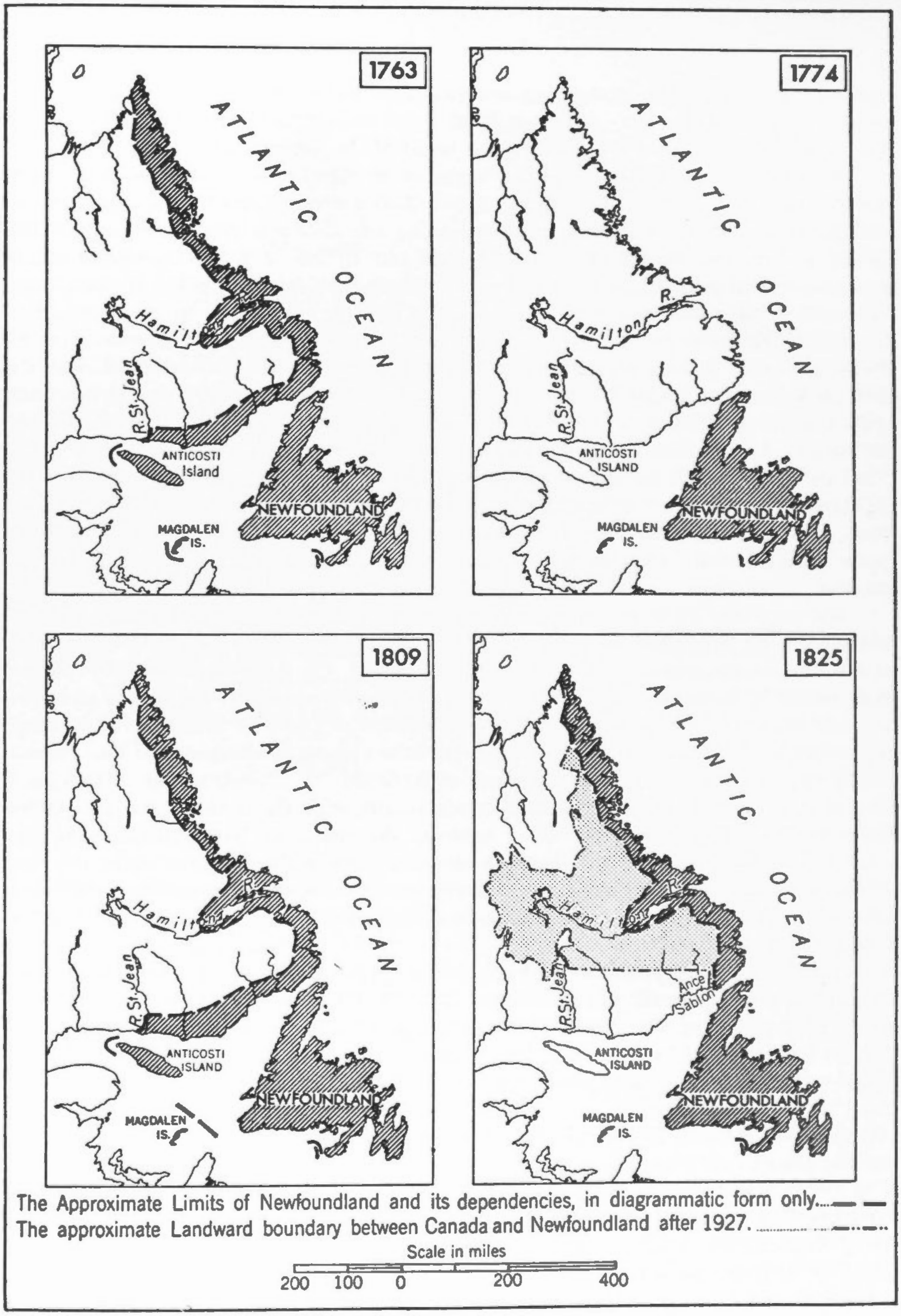

FIGURE 117. Evolution of the boundaries of Newfoundland. Map from *Boundaries of Canada, Its Provinces and Territories,* by N. L. Nicholson. Queen's Printer, Ottawa, 1954. Geographical Memoir No. 2, Department of Mines and Technical Surveys, Ottawa.

The Privy Council Adjudication

The government of Quebec chose not to be represented at the hearing before the Privy Council, arguments at which consumed fourteen days up to November 15, 1926. From the terms of historical documents offered in evidence it was clear that there had never been any distinction made between the island of Newfoundland and the coast of Labrador. The law lords became convinced early in the proceedings that ownership of "the coast of Labrador" had become legally vested in the Colony of Newfoundland. The only question of magnitude left to their decision was that of the island extent of the term "the coast". The arguments of the chief counsel for Canada in this case, Rt. Hon. H. P. Macmillan, K.C., was that Newfoundland received only a coastal strip or fringe area of the Labrador peninsula. Sir John Simon, K.C., counsel-in-chief for Newfoundland in this hearing, contended that the boundary was a line "due north from Anse Sablon as far as the 52nd degree of north latitude . . . thence northwards to Cape Chidley along the crest of the watershed of the rivers flowing into the Atlantic Ocean."

The term "coast", capable as has been indicated of several interpretations, was construed by the law lords in its broader sense, namely, as including the hinterland as well as the shoreline fringe. This view, they pointed out, was consistent with the doctrine of international law by which legal occupation of a seacoast carries with it a right to the whole country drained by the rivers which empty their waters into that coastline. In the 18th and 19th centuries, their lordships pointed out, the word "coast" was used from time to time to denote a region, not merely a shoreline, as in the case of the Gold Coast in Africa.[3] In any event the law lords would have been at a loss to suggest any other boundary between the seacoast and watershed along which any sensible line could be drawn. In addition, the terms of the 1825 act, providing for the re-annexation to Lower Canada of "so much of the . . . coast as lies to the westward of a line to be drawn due north and south from the bay or harbour of Anse Sablon inclusive as far as the 52nd degree of north latitude" indicated that much more than a fringe territory or coastal strip was involved in these boundary transactions. Any narrow construction of the term

FIGURE 118
Levelling operations by members of Geodetic Survey of Canada at Hamilton Inlet, Labrador, prior to the Privy Council decision of 1927.

"coast" appeared inapplicable in view of the known fact that a ribbon of land along the Labrador shore would often consist of high cliffs inaccessible from the sea and therefore of little practical use in the prosecution of the fisheries.

On March 1, 1927, the decision of the Privy Council was made public. In the judgment it was stated that the boundary between Canada and Newfoundland in the Labrador peninsula consisted of "a line drawn due north from the eastern boundary of the bay or harbour of Anse Sablon as far as the fifty-second degree of north latitude, and from thence westward along that parallel until it reaches the Romaine River and then northward along the left or east bank of that river and its headwaters to their source and from thence due north to the crest of the watershed or height of land there and from thence westward and northward along the crest of the watershed of the rivers flowing into the Atlantic Ocean, until it reaches Cape Chidley."

The Geographical Aftermath

The Privy Council definition, commendably simple and concise at first glance, nevertheless soon deposited a heavy burden of precise ascertainment upon surveyors and mappers. Even the names and locations of the terminal points of the boundary line puzzled geographers. The southernmost point, at the mouth of the St. John River, referred to in the Privy Council judgment as "Ance Sablon" (sometimes alluded to in other special documents as "Anse Sablon") was originally christened "Ance au Blanc Sablon". In the Arrowsmith map of 1853 it is entered as "Blanc Sablon" and the place is known as such today. The precise location of Cape Chidley, the northern extremity of the defined boundary, remained in doubt for some years after the decision of the Privy Council. Cape Chidley was named, by John Davis in 1587, after "the worshipfull Mr. John Chidley in the countie of Devon". Chidley, incidentally, commanded in 1589 an expedition from England to the South Seas by way of the Strait of Magellan.[4]

On the Arrowsmith map of North America, issued under the authority of the House of Commons, London, in 1857, the name of the feature appears as "Cape Chudleigh". This spelling occurred occasionally on maps issued as recently as 1889 when, on June 10th of that year, the Canadian federal government geographer, John Johnston*, wrote a memorandum to Deputy Minister A. M. Burgess, Department of the Interior, Ottawa. On a map prepared by Johnston to accompany the memorandum, a sketch based on maps published by Arrowsmith of London and by W. and A. K. Johnston of Edinburgh, the Canadian cartographer followed the custom of marking the boundary of Labrador "southerly from cape Chudleigh [at the ocean entrance to Hudson's strait, along the height of land] to the undefined southern boundary of Lower Canada to Anse Sablon". John Johnston commented that "it does not appear that this line was intended by the geographers to represent the boundary of the territory in Labrador under the jurisdiction of Newfoundland, but most probably the dividing line between Labrador and what was supposed to be Hudson's Bay Company's territory . . . On the maps of the Dominion published from time to time by this department [Interior] the same system of drawing the Labrador line has been followed as on the British maps, but we have invariably taken the precaution to show it in a dotted line, with the word "supposed" or "undefined" applied to it."[5] Canadian government authorities on nomenclature have since ruled that "Cape Chidley" is the correct spelling of that geographical feature.[6]

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*A cartographer and member of the family which owned the well-known Edinburgh map publishing firm. He was brought to Canada by Governor General Lord Dufferin.

MAP 4. Part of the Quebec-Newfoundland boundary to terminus at Cape Chidley.

In 1931, 1932 and 1935 flights were made from Boston to the coast of Labrador in a Fairchild seaplane by a group of explorers sponsored by the American Geographical Society. These flights by Alexander Forbes, C. J. Hubbard, O. M. Miller and colleagues were made in the prosecution of an aerial survey of northern Labrador, initially to test the then new method of producing topographical mapping from oblique aerial photographs. As a result of these efforts the Society published in 1936 Map Sheet No. 1, Cape Chidley, on a scale of 1:100,000. This map showed the cape to be on what is now known as Cabot Island, one of two small islands lying off the northeastern coast of Killinek Island which, in turn, is separated from the Labrador mainland by McLelan Strait.[7]

The publication of this map led to a reference on January 14, 1936, to the Department of Justice, Ottawa (Deputy Minister W. Stuart Edwards) by the Topographical and Survey Bureau, through the parent Department of the Interior (Deputy Minister J. M. Wardle) for a ruling on whether Port Burwell, on the west coast of Killinek Island, was in Newfoundland or in Quebec or in the Northwest Territories. The opinion of the Justice Department was contained in a memorandum dated February 17, 1936, (J. R. 1304/36) in which it was pointed out that the judgment of the Privy Council in 1927 did not profess to determine the location of Cape Chidley. The law lords did, however, include with their judgment a sketch map serving to illustrate the rival claims as to the course of the boundary. On this map Cape Chidley is marked as being on a promontory on the northeastern coast of Killinek Island. This location was confirmed by maps submitted in evidence at the London hearing by both Canada and Newfoundland.

In the Justice Department's memorandum it was also stated that "it is a reasonable assumption that their Lordships intended Cape Chidley, as so depicted, to be taken as the point designated in their judgment as the northern terminus of the boundary; and this notwithstanding that the watershed of the rivers flowing into the Atlantic Ocean northward along whose crest the judgment requires the boundary to be traced until it reaches Cape Chidley, may not be . . . a continuous watershed . . . Upon this view Port Burwell, which is located on the western side of Killinek Island, would be within the Dominion of Canada." After coming to this decision, namely, that Port Burwell was not in Newfoundland, the author of the memorandum concluded that, in the light of the Quebec Boundaries Extension Act* and the Northwest Territories Act† all that part of Killinek Island, including Port Burwell, lying west of the boundary line linking Cape Chidley with the mainland, would be in the Northwest Territories, rather than in the province of Quebec.

In June, 1936, Surveyor General Peters, Ottawa, sent to O.M. Miller in New York City information on the most recent astronomic positions established by the Geodetic Survey of Canada for Port Burwell and nearby Lady Job Harbour. Miller, in acknowledging the data on these determinations, commented that the information "makes the aerial triangulation by oblique aerial photographs between Port Burwell and the astronomic position at the origin of our survey, much more precise."[8] Some cartographers have suggested that the name "Cape Chidley" ought to apply to an area rather than to a mathematically calculated point. The Canadian government ruling, however, is that Cape Chidley is the promontory located on the northeastern coast of Killinek Island at 60°23′ north latitude and 64°27′ west longitude.[9]

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*Statutes of Canada, 1912, ch. 45, sec. 2.
†R.S.C., 1927, ch. 142, sec. 2.

For many years after the London settlement the governments directly affected by the Labrador boundary problem made no attempt to have the boundary officially surveyed and marked on the ground. Possibly this indifference resulted from the fact that so much of the hinterland involved was relatively inaccessible and appeared, at the time, to be of little worth in any significant economic sense. Only after the timber resources of the peninsula began to be exploited by private interests were definite steps taken by public authorities to obtain a judicial ruling in the matter. The loudest reverberations aroused by the 1927 decision had hardly died away when public and private attitudes underwent a convulsive change and for the first time there developed a widespread and acute awareness in Canada of the Privy Council award and its various implications.

There have been few Canadian studies in depth of the Labrador boundary question but one highly authoritative work on the subject is the volume written by Henri Dorion entitled "La Frontière Québec-Terreneuve", published by Les Presses de l'Université Laval in 1963. A considerable number of magazine and newspaper articles have appeared, dealing with various aspects of the subject. Special mention should be made of "The Labrador Frontier" by F. Kenneth Hare in *The Geographical Review*, volume 42, (1952), no. 3; also "La Frontière Canada-Labrador" by Gérard Gardner in *Revue Trimestrielle Canadienne*, volume 24, no. 95, p. 272, published in September, 1938, by École Polytechnique, Montreal; and a recent series of newspaper articles appearing in *Le Devoir*, Montreal.

In a contribution to *Perspectives,* Montreal, no. 43, (October 24, 1964), entitled "Labrador (via Londres) Ou La Frontière Inventée (Labrador, via London, or the Trumped-Up Boundary)" Henri Dorion provides a summary of the situation as well as insights of the Quebecker's point of view. According to the editor's accompanying comment on this article Dorion made his presentation "avec science, mais aussi avec humour". After making reference to "Mother Ottawa" inviting "Grandmother London" to solve the boundary definition problem, Dorion pointed out that the Judicial Committee of the Privy Council became, in effect, at one and the same time, judge of the dispute as well as a party to it. "Ainsi dans cette affaire . . le Conseil Privé de Londres devenait-il, en un sens, à la fois juge et partie." In addition Dorion claimed that Quebec was not formally consulted before the boundary case was placed by Ottawa before the Privy Council. The Labrador question, the writer asserted, as reviewed in London, turned on concepts as well as on facts . . . ". . . a porté sur des concepts autant que sur des faits". Since the outcome of the hearings depended, to an important extent, on the judicial concept of the term "coast" Dorion expressed the conviction that Their Lordships had given an excessively generous meaning to the word. He felt that the ruling on its interpretation was as ludicrous as claiming that a part of Alberta could be said to be on the coast of the Gulf of Mexico. In resolving the question the Privy Council had given to Newfoundland an area three times as large as the island itself, thus permitting "la grenouille de se faire presque aussi grosse que le boeuf (the frog to become nearly as big as the ox)."

Dorion proceeded to state: "Le Canada réclama devant le tribunal toute la péninsule, a l'exception d'une étroite bande côtière d'un mille de profondeur sur toute l'étendue de la côte, ce qui n'etait pas loin de constituer une insulte au bons sens. De son côté, Terreneuve manifestait un appétit considérable, en réclamant des territoires s'enfoncant jusqu'au coeur de continent. Entre ces deux solutions également extrêmes, également illogiques, les juges anglais se fixerènt d'en choisir une, à l'exclusion de tout autre intermédiaire qui aurait mieux servi la logique, le bons sens et peut-être, en même temps, la justice. [Before the tribunal Canada claimed the whole peninsula, with the exception of a narrow, one-mile-deep coastal strip, which was not far from being an insult to common sense. For its part Newfoundland revealed a huge appetite by claiming territories penetrating to the heart of the continent. Between these two equally extreme and equally illogical solutions the English judges decided to choose one, excluding any other compromise which would have better served logic, common sense and, perhaps, justice.]"

Iron Ore and the Boundary

In 1929 a mining firm, New Quebec Company Limited, obtained from the province of Quebec a special exploration licence covering some 2,100 square miles, a huge block of territory situated north of the hinterland region that had been awarded to Newfoundland two years earlier. Soon afterward a second special licence was issued to Richard S. Denning and R. B. Daigle on an adjacent area. Two Canadian geologists, W. F. James and J. E. Gill, completed the first scientific investigation of the 20th century in the region, and Gill made the first important discovery of iron ore near Ruth Lake, not far from Knob Lake. All this activity took place in 1929. Up until that time most prospectors in Labrador had been occupied mainly with the search for gold.

In the meantime consideration was being given in Ottawa to the possibility of carrying out a survey to mark the defined Labrador boundary on the ground as this line, at the time, was not an interprovincial border but a line more in the nature of an international boundary. On October 7, 1931, Richard William Cautley (1873-1953), then Acting Chief of Control Surveys, Topographical Survey of Canada, in a memorandum addressed to Surveyor General Peters, recommended that the cost of a complete survey of the Quebec-Newfoundland boundary in Labrador would be quite prohibitive. "From a survey point of view", Cautley stated, "the delineation of the Labrador boundary will be a tremendous undertaking presenting great difficulties of transportation. In the first place the boundary as indicated on existing maps is more than 1,400 miles long — 320 miles of straight line and 1,120 miles of height of land. In the second place, most of the boundary line is difficult of access . . . approximately half the territory awarded to Newfoundland in Labrador is more than 2,000 feet above sea level, while the Torngat Mountains rise to more than 4,000 feet, which probably means that the rivers flowing to the Atlantic Ocean are comparatively useless for purposes of navigation.

"The most useful and practicable form of complete boundary survey would perhaps be a triangulation tied in to monuments placed at clearly defined points along heights of land, which might be supplemented as to detail by an aerial strip flight. The transportation problems involved in such a survey would be difficult and very expensive . . . Having regard to the uninhabited nature of the country and the little that is known at the present time of the potential value of its natural resources I suggest . . . that all that is really needed is an astronomic determination of various points along the boundary which would enable us to rectify its position on future maps . . ."[10]

In deciding not to proceed with the marking of the boundary on the ground in the 1930s federal authorities passed up the last opportunity to make such a survey on their own initiative. The war years diverted administrative energies at Ottawa to other pressing tasks, and the entry of Newfoundland into Confederation meant that invitations from both provinces concerned constituted a condition precedent to any federal participation in such a project.

The existence of iron deposits in Labrador had been known for some time but the richness and extent of these deposits, until Gill's discovery in 1929, had been only dimly realized. Because of the remoteness of the area from large industrial communities and the onset of the economic depression, private enterprise had shown no interest in the latent opportunities in the region for intensive mineral development. But in the late 1930s and early 1940s fears began to be felt in steel-making circles for the future of the famous Mesabi Range in the United States, a district which, for many years, had been the principal source of iron ore for that American industry. It appeared that at long last the reserves of that Range were beginning to wane and that another North American field of comparable size and richness had to be found and developed quickly.

As early as 1866 Rev. Louis Babel, O.M.I. had made annual visits to the Labrador hinterland. In addition to making sketches of the travel routes he followed, Father Babel compiled a useful map of the region. In view of the imperfection of his instruments the accuracy of his map was truly remarkable. He continued to investigate the entire area until 1870. In 1873 the Department of Crown Lands published a Babel map on which a region had been marked as being "full of iron (abondante en fer)". Unhappily the map was not accompanied by any report although the missionary may have made a written communication on the subject to his ecclesiastical superiors.

A. P. Low of the Geological Survey of Canada, during field seasons from 1892 to 1895 inclusive, conducted expeditions along the principal rivers and lakes of the Labrador Peninsula. In three of those years D. I. V. Eaton acted as assistant and topographer.

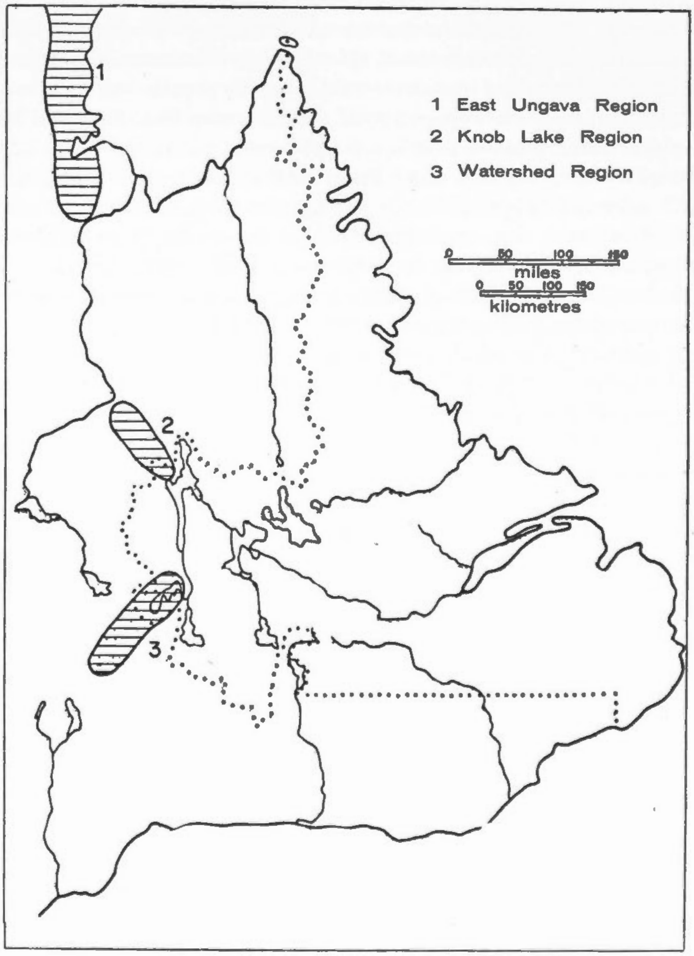

FIGURE 119
Mineral regions of Labrador. Dotted line indicates boundary according to Privy Council decision, 1927. Map from *Mining Activities in Labrador, Ungava*. Graham Humphrys, Montreal, 1959.

Eaton compiled a map to accompany Low's formidable report covering the entire four seasons of investigation. "The immense deposits of magnetite, hematite and siderite in the Cambrian formation, and their widespread distribution, may at some future date be of economic importance, especially those containing a large amount of manganese," Low prophesied. In one locality Low observed that "exposures of iron-bearing rocks are almost continuous and the amount of ore in sight must be reckoned in the hundreds of millions of tons. There is certainly", he added, "an almost inexhaustible supply of high grade ore."[11]

Not many months after the District of Ungava was officially annexed to the province of Quebec in 1912 and became known as New Quebec, a prospector, R. B. Daigle, investigated the watershed region of the Labrador hinterland. Daigle was, in fact, the first prospector to stake mining claims in that part of Quebec.[12] Although he was particularly active in the area in the seasons 1914 and 1915 Daigle continued his probes in subsequent years. Unfortunately written records descriptive of his travels and observations do not appear to exist.

The name of Joseph A. Retty (1904-1961), born at Fort Coulonge, Quebec, will always be associated prominently with the advent of large-scale mining developments in the Labrador wilderness. During the period 1936 to 1938, with the valuable assistance of an Indian trapper, Mathieu André, Retty proved the existence of at least 100 million tons of high-grade iron ore in New Quebec, centred upon an important find at Burnt Creek. The largest of these newly-discovered ore bodies lay directly across the Quebec-Labrador boundary. Retty, as a student, had been associated, from 1924 to 1929 inclusive, with field parties of the Geological Survey of Canada. In the 1930s he was employed by the Quebec Bureau of Mines and wrote several geological reports of importance on areas in that province which were published by that government agency. In 1936 Retty joined the Labrador Mining and Exploration Company as a consultant. Dr. Retty once concisely described the Labrador Trough, in which the richest and most extensive deposits of the metal occur, as assuming a typical corrugated [rock] pattern due to the alternation of northwest-trending ridges and linear lakes, the characteristic topographical expression of folded strata. Retty echoed, incidentally, the grievances of Canadian surveyors and mappers from the days of Samuel de Champlain concerning black flies and mosquitoes, and expressed the conviction that "undoubtedly this [Labrador] region is the source of supply [for these insect pests] for the entire universe."[13] By 1942 Hollinger interests had acquired effective control of mining rights in the areas reported on by Retty. Seven years later these interests, with the M. A. Hanna Company and in conjunction with a group of American steel firms, formed the Iron Ore Company of Canada.

A rapid evolution in forms of civilian transportation, following the Second World War, accompanied the revolution in general attitudes of Canadians and Americans towards Labrador. The canoe route into the hinterland from Sept-Iles up the Moisie River was slow, difficult and, in modern terms, impracticable. Indians of the region required at least one month to negotiate the first 150 miles of this turbulent waterway. Because of this transportation barrier the area remained largely unexamined and underdeveloped for at least three decades after publication of Low's notable report. But the use of aircraft swiftly altered the situation. Planes were particularly useful in freighting from tidewater to inland field parties and contributed greatly to the rapid construction of the Quebec, North Shore and Labrador Railway, a subsidiary of the Iron Ore Company of Canada. This rail line, work on the construction of which began in 1947, crossed 358 miles of difficult terrain from Sept-Iles to Knob Lake. Surveys for the building of this line, the

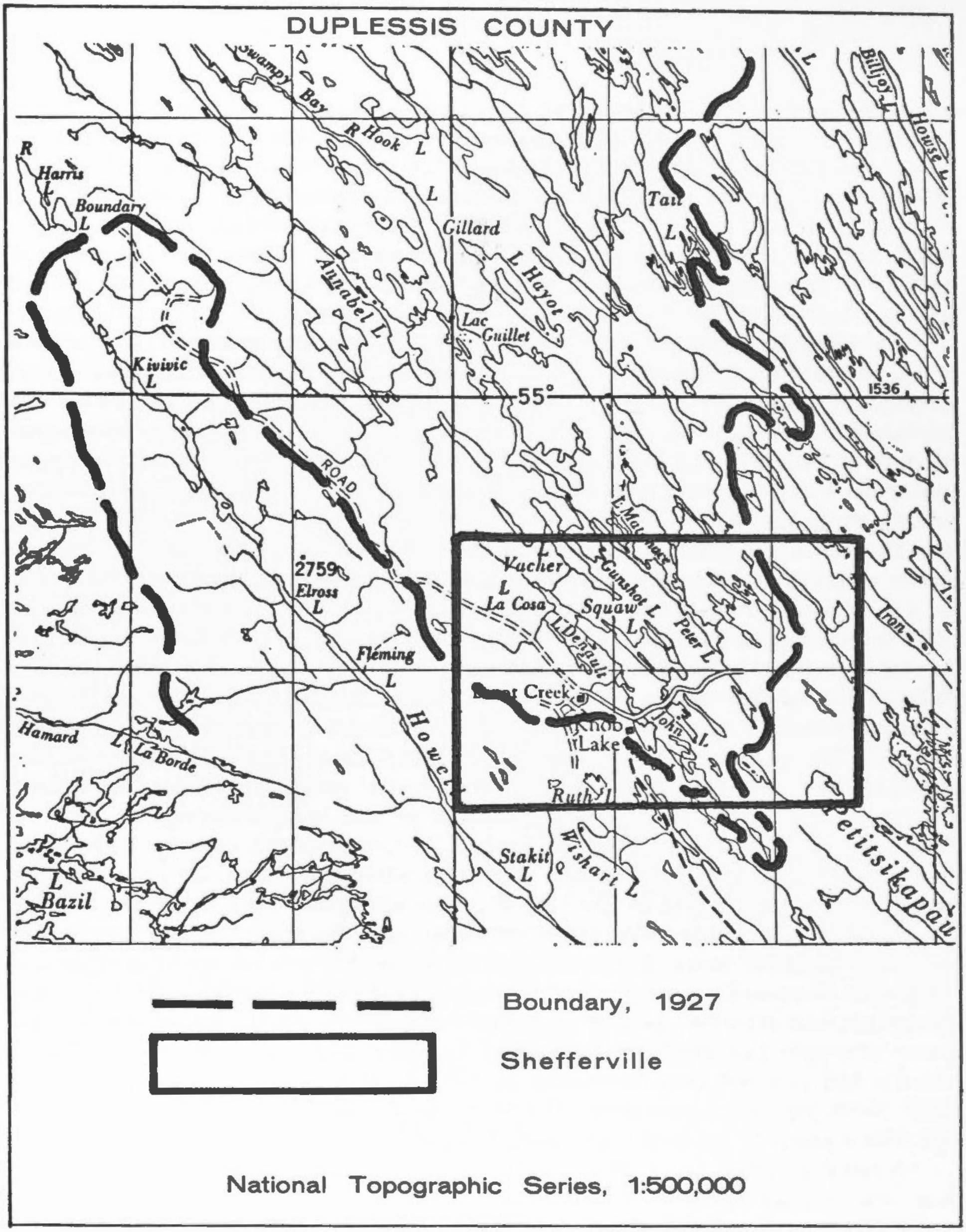

FIGURE 120. Map sketch showing course of boundary line through the Schefferville locality. Map from *La Frontière Quebec–Terreneuve*, Henri Dorion, Laval University Press, 1963.

stretch between Mile 150.8 and Mile 356 being located in Newfoundland Labrador, involved the building of two major bridges, one over the Moisie River the other over the Hamilton River. The first spike in rail construction was driven on November 10, 1950, at Sept-Iles by the then mayor of that community, P. J. Romeril. On February 13, 1954, at a special ceremony at Schefferville, the president of Hollinger Consolidated Gold Mines Limited, Jules R. Timmins, hammered home the golden spike marking the completion of the line.[14] Sept-Iles was 952 miles from Cleveland by water, through the St.

Lawrence Waterway and the Great Lakes. The movement of iron ore, in economic quantities, over this route was dependent upon the completion of the St. Lawrence Seaway. All these engineering tasks coincided with and were spurred by a mounting demand for iron ore by the steel industries of the United States and Canada.

Yet another significant natural resource development in New Quebec-Labrador during the immediate post-war period, foreshadowing the establishment of one of the world's major sources of hydro-electric energy, was the opening in 1954 of the Ste Marguerite Power Company, situated on the river of that name. With other local sources, power for the operation of mineral processing plants and for mining communities was thus made available. In the same year the town of Schefferville, adjacent to Knob Lake, was incorporated. On the surveying and mapping side, much had been accomplished that was basic to this impressive economic expansion. By the end of 1950 nearly 15,000 square miles had been mapped, 40,000 aerial photographs taken, and about $10,000,000.00 spent on exploratory work. In addition, standard geological surveys and geophysical examinations were employed extensively in the search for iron ore. A major function in these operations was the mapping of rock formations and the use of maps as guides in the hunt for iron ore deposits. All types of geological mapping were used in these explorations ranging from rough reconnaissance work to the most refined, detailed cartography.[15]

The story of Quebec's boundaries with other provinces and any account of surveying and mapping in Quebec, fundamental to its progress in mining, would be incomplete without reference to the substantial contribution made in these occupations by Dr. Georges Côté (1894-). After spending several summers with survey parties in wilderness areas of the province Côté, in 1915 and at the age of 21, received a degree in surveying from Laval University. In the same year he entered practice as a Quebec land surveyor and, in 1916, was commissioned a Dominion land surveyor. This vigorous Canadian, whose highly adventurous career was crowned by promotion to a key post in the provincial government service, namely, "Directeur de la division territoriale et commissaire des frontières", narrowly escaped death in the field on several occasions.

In 1918 Côté was the only member of a party of four surveyors to escape drowning in the Megiscane River in the Abitibi country. "Seated in two 18-foot canoes, loaded with several thousand pounds of equipment and provisions," he has recalled, "we were being carried swiftly downstream by a strong current when the first of our two canoes suddenly struck a submerged obstacle and split in two. Both occupants disappeared in

FIGURE 121. Georges Côté.

the turbulent water and were not seen again. The canoe in which I rode was steered partly clear of the wrecked craft but we also overturned. I managed to grasp hold of the canoe which had come to rest against some rocks, injuring my knee and arm. Finally I made it to shore with the utmost difficulty."[16]

On a later occasion in a part of the province, where serious forest fires began all too frequently without much warning in the heat of summer, a survey party of eight persons, including Côté, was crossing a heavily wooded area when all of them were suddenly enveloped in thick clouds of smoke that shut out the sun from their sight. After contriving in some manner to obtain their bearings the hardpressed men finally reached a lake. The body of water provided them with protection until the inferno of flames swept by. On yet another trip several surveyors in the field party became gravely ill from what seemed at the time a highly mysterious ailment. The sickness was traced to nitroglycerine poisoning produced by eating biscuits from a discarded dynamite container. The diagnosis of the trouble was made just in time to avert fatal consequences.

By 1921 young Côté had become a surveys inspector in the provincial government organization and, seven years later, director of surveys in the province. Before long he took another step up the ladder of promotion to the post of superintendent of land surveys, a position he occupied until 1943. Then, at the age of 49, Georges Côté was appointed director of the cadastral service. Since 1963 he has been director of land division and commissioner of boundaries as well as a consistent advocate of Quebec's claim to the Labrador hinterland.

The eastern boundary of Canada created by the Privy Council decision of 1927 remained in force for only 22 years. In 1949 Newfoundland entered Confederation, becoming Canada's tenth province and what had been, in essence, an international boundary became an interprovincial boundary. The Labrador boundary of the newest province, as defined by the Judicial Committee of the Privy Council, was incorporated in the terms of union. This constitutional development gave rise to novel problems, mainly concerning Canada's jurisdiction over territorial waters in the Atlantic Ocean. This, however, is a subject outside the scope of *Men and Meridians*. If the entry of Newfoundland into Confederation created some completely new problems of that nature, it also served to refocus attention on, and give fresh impetus to, the matter of the land boundary separating the new province from Quebec. As already noted, Quebec provincial government maps, from 1946 on, have continued to ignore the existence of the judicially-defined line, each official map sheet including, as part of its legend, the explanatory statement quoted at the head of this chapter.

Federal survey authorities are powerless, under law, to intervene in any boundary line determination in the absence of express invitations to do so from provinces directly concerned. But boundary commissions, including the person of the federal Surveyor General, whether the dispute involved two provinces or a province and a territory, have hardly been rarities in the course of Canada's development. On seven such commissions, including the Ontario-Manitoba Boundary Commission, the Surveyor General of Canada has been a member and it has been customary to name him to act as commission chairman. But, at present, there are no signs indicating a disposition to call in any federal authority to assist in surveying and marking on the ground a line between Quebec and Newfoundland territory in Labrador, a line that has become one of the most important boundaries within Canada.

13

CANADIAN ASTRONOMY: THE STEWART-PLASKETT PERIOD

"Are all celestial bodies but one globe
As is the substance of this centric earth?"
—Marlowe: *Doctor Faustus*

The first stage in the progress of Canadian astronomy, that of isolated astronomical observations used mainly in land surveying, came to an end with the completion and occupation of the Dominion Astronomical Observatory in Ottawa in 1905. During most of the period covered by the second stage in that story, Dr. William Frederick King, as Canada's first director of the Ottawa observatory, remained at the summit of its affairs. It was a period in which Canadian interest, in official circles and on the part of the general public, quickened in matters astronomical as well as in the pursuit of earth studies. In the year in which the Ottawa observatory opened, the annual Gold Medal Award of the Royal Astronomical Society of Canada was established to encourage the study of astronomy in this country. On each occasion the medal was to be presented to the student leading in first-class honors in the astronomy division, University of Toronto, in his or her graduating year. The first recipient of the award was William Edmund Harper (1878-1940), born in Bruce County, Ontario, and educated in Owen Sound before he proceeded to the University of Toronto. Harper, in 1906, was actually the first to graduate in the university's newly-established course in astronomy. Within a few minutes after his graduation Harper accepted an invitation to join the staff of the Dominion Observatory in Ottawa. He began a career in this branch of science, a career that reached its climax in his appointment to the post of director of the Victoria Astrophysical Observatory thirty years later.

At the dawn of this second era in Canada (1905-1918) the study of astronomy at Canadian universities began a new chapter. The science was elevated to the status of a separate department at the University of Toronto with Professor Clarence Augustus Chant (1865-1956) as its head after 1904. It was in this department that most of the astronomers who manned Canadian observatories during the first half of the 20th century, received their early training for this type of work.

The initial years at the Ottawa observatory were mainly occupied with tasks of organizing various aspects of its principal functions. At the outset the divisions established were those of Surveys, Meridian Work and Time Service, Astrophysics and Solar Research as well as Geophysics. In the latter division, Seismology, Terrestrial Magnetism, and Gravity were included. By the close of the second stage in the progress of Canadian astronomy and earth sciences these three activities had become self-contained divisions. Dr. Otto Julius Klotz had, in fact, been placed in charge of Geophysics from the beginning. In 1907 Canadians began to participate in international conferences on seismology. Within a few years, and just as soon as newly-purchased instruments could be put in operating order, the Division of Astrophysics was replaced by Solar Physics, the Fifteen-Inch Equatorial, and Photographic Photometry. An important part of the earlier activities of the observatory staff was the work they performed in the course of surveying Canada's international boundaries. A start was made in this period also in geodetic survey work. Dr. King was named first Superintendent of the Geodetic Survey of Canada in 1909. Boundary-line surveys and the Geodetic Survey remained under Dr. King until his death on April 23, 1916. In 1917 these activities were separated from the observatory and established as separate entities. Thereupon the Dominion Observatory was organized on a seven-division basis: Astronomy of Position, including the Meridian Work and Time Service; Solar Physics; the Fifteen-Inch Equatorial (telescope); Photographic Photometry; Seismology; Terrestrial Magnetism, and Gravity.

For a span of 18 months after the onset of Dr. King's fatal illness the observatory organization remained leaderless and drifting. At the time of King's death the First World War had been taking its awful toll in human life for many months. Canadian casualties had been heavy and patriotic emotions, occasionally exercised in cruel forms, had been deeply stirred in most parts of the country. Undoubtedly there was some hesitation in high government circles in Ottawa to name anyone with such a Teutonic name as Otto Klotz to a position in the civil service of a fairly sensitive wartime nature. Under the circumstances this was an attitude decidedly unfair to a man of the outstanding character, attainments, and record of service of Dr. Klotz, as well as deeply repugnant to one of his proud temperament.

In the 50th year of his faithfully-kept daily diary and, in particular, on May 17, 1917, Klotz records his interview with Sir Thomas White when he approached the Minister of Finance in the Borden government in order to invite him to address the University Club of Ottawa: "As I was leaving I said to Sir Thomas, 'I am somewhat disappointed that I have not yet been appointed as successor to Dr. King at the observatory'. 'Aren't you the head of the observatory?' he asked. 'No', I replied. 'This is the first I have heard of it', he continued . . . I simply said 'it appears my name and name alone — it's German, I know — is the reason' and I bowed myself out."[1]

Early in July Klotz noted that "things at the observatory are in a most unsatisfactory condition, going from bad to worse . . ." By this time he had persuaded the chairman of the Civil Service Commission to bring the deteriorating situation to the attention of the Prime Minister. In the meanwhile Dr. Klotz had been named chairman of the Scientific Committee of the Seismological Society of America. At about this stage of affairs all the members of the scientific staff of the observatory, men such as J. Macoun, W. E. Harper, C. A. French, J. B. Cannon and R. J. McDiarmid, signed a petition to the Minister of the Interior calling for the promotion of Klotz. When Klotz read this document he wrote in his diary that "my heart beat fast — I trust it will be the death knell to chaos at the observatory".

The Klotz Regime

By the end of September, 1917, the long-awaited appointment was made and the *Ottawa Journal,* on October 1st, announced in headlines that "Dr. Otto Klotz, Chief Now at Observatory. Has been with the Dominion Government since 1879." One of the most moving passages in the Klotz diaries was written at this time: "I was alone now in the Director's [my] room. I sat down in the chair of my predecessor, Dr. W. F. King, and a flood of thoughts and memories rushed through my mind. I saw the panorama of the inception of astronomic work in 1885 by me, King joining therein in 1887, and how, by degrees, the work grew. Government recognition of it took shape when Hon. Clifford Sifton gave us the privilege of having an observatory creditable to Canada, in fact one 'beyond our dreams'. King and I were told to select a site on government land. The present site was selected by me. The plan of the observatory is a combination of our ideas. I believe that the 15-inch was our first plan. I went to Pittsburgh and to Cleveland about the dome . . . and to London, England, Troughton and Simms, about the large transit which was ordered by King against my advice . . . and how our work prospered and we built up a reputation in the various branches which we preserved. The panorama of 32 years unfolded itself in clear outline and I felt that the goal of my ambition, or rather the crowning event of a long life of honest endeavor and work, is found in the achievement of the position *Director of the Dominion Astronomical Observatory.*" Little did Dr. Klotz realize at that lofty moment in his lengthy and distinguished career, that not much more than five years of life remained to him.

Something on the lighter side of the new director's methods of operation is revealed in the experience of a post-war recruit to the observatory staff, Russell Glenn Madill (1879-   ). Born in the Kawartha Lakes district of Ontario near Peterborough, Madill — after schooling at Lakefield — entered Queen's University, specializing in mathematics and physics. At the time of his graduation a federal civil service poster came to his attention. It advertised the position of Junior Magnetician, Dominion Observatory, at an annual salary of $1,620. A number of candidates applied for the post and examinations to test their abilities were compiled by Klotz. Madill, years later, recalled that of the three written tests, one paper proved easy for him, one on physics was mildly challenging, but that of the eight questions on the examination on terrestrial magnetism he felt capable of answering only the first four. Grimly resisting the temptation to feign more skill and knowledge than he possessed, Madill wrote frankly but somewhat despairingly on this paper, "Unfortunately for me, I know nothing about these last four questions." Years later the secretary to Dr. Klotz revealed to Madill that the director, in the case of each candidate, had looked only at the responses to the four most baffling questions. Following this scrutiny Klotz rang for his secretary and announced, "This man Madill gets the job. He's the one honest man among those who have written; the remainder are only bluffing!"

Dr. Klotz introduced young Madill to the man who would be his chief in the Terrestrial Magnetism Division, Charles A. French, remarking with a twinkle, "I expect you to teach Madill the ropes as he admits he knows nothing about the work here." Madill has recalled that Klotz, from time to time, would distribute to members of the observatory staff, details of a highly abstract mathematical problem, asking for solutions by an early deadline. To add to the stress Klotz would carefully remove all relevant reference books from the observatory library to his own office. Madill found in the course of these periodic tests that when he submitted solutions punctually these were received non-committally by the director. Accordingly Madill decided, on one such occasion, to pretend complete inability to solve the problem. Klotz brightened immediately. "Let me", he offered with obvious enthusiasm, "show you how it can be done."

Sometimes, in his office on an upper floor of the observatory, Madill would discover that certain half-solved mathematical problems left on top of his desk had been worked out by Klotz on week-ends. In climbing the stairs Klotz ignored strict orders from his doctor not to indulge in such activities. Gradually, and partly because of such efforts, the director's health began to fail. By December, 1923, he was confined to bed but on the fourth day of that month was able to take feeble notice of many congratulatory messages on the attainment by his wife Marie, and himself of their golden wedding anniversary. In his diary (now in the 57th year of its progress) Klotz, on December 6, mentioned C. A. French and assistant magnetician Madill "who is in the wilds adjoining the west coast of Hudson Bay. I have not heard from him for several months but he is due to reach civilization shortly".[2] His final diary note was entered on December 23. Otto Julius Klotz died late in the afternoon of December 28, 1923, in his home at 437 Albert Street, Ottawa. Headlines in the *Ottawa Citizen* of the following day announced "Canada Loses a Noted Scientist and Devoted Public Servant". An ambitious, forceful spirit, interested in promoting not only his scientific interests but the influence of the spoken and written word, Klotz was regarded in Ottawa as the "father of our public library". In his passing Canada lost the services of one of the most eminent seismologists in the Americas and an astronomer and surveyor of international distinction. On behalf of his beloved Canada he had taken an important and very active part in the completion of the first longitude girdle around the world in 1902.

It was during the Klotz period that the Dominion Astrophysical Observatory, with its 72-inch reflecting telescope, was formally opened at Victoria, British Columbia, on July 11, 1918. This telescope, for a brief time, was the world's largest. The giant glass disc, weighing 5,000 pounds, was cast and annealed at Charleroi, Belgium. The task was completed in July, 1914. The mirror was shipped from Antwerp only a week prior to the outbreak of the First World War. Had it not been shipped promptly to North America the mirror, in all probability, would have been destroyed by enemy action. The glass factory at Charleroi was reduced to ruins during military operations in its vicinity.

The Stewart Regime

At the turn of the present century the Astronomical Branch, Department of the Interior, was in its infancy and offered a challenging field for young Canadian scientists of promise. It was not a matter for surprise, then, that Robert Meldrum Stewart (1878-1954), one of the top mathematicians of his day in this country, should have joined the branch, his continuous service in the federal civil service dating from 1903. Stewart's high school training at Jarvis Collegiate, Toronto, and at Lisgar Collegiate, Ottawa, was marked by brilliant scholarship and the winning of nearly all available prizes. At the University of Toronto he graduated with high honors in mathematics and physics and was the university's gold medallist in 1902. As in the case of other Canadians of his generation who studied astronomy, Stewart came under the influence of Professor Chant's guiding spirit. The student's father had exerted an earlier beneficial influence and inspiration by taking his young son on long walks at night, explaining to him something of the movements of the stars and planets.

When Stewart joined the Ottawa organization the staff numbered only a few persons and occupied rooms near the Parliament Buildings. Observing of the heavens was done from a modest frame building on the south bank of the Ottawa River near the end of Cliff Street. In its early days the work of the Astronomical Branch dealt mainly with accurate longitude determinations, work of prime importance to the efficient prosecution of Dominion land surveys and in the construction of transcontinental railways in this country.

All accurate time, ascertained for the regulation of human activities, comes from the stars. In this process a telescope is trained on a selected star as it crosses the meridian in the heavens. This meridian is the north-south line that passes through the north pole of the sky and the point directly overhead, the zenith. The star selected is observed for a short period as it approaches the meridian, then the instrument is reversed and the star is again observed for an equal period after it leaves the meridian. By this procedure collimation errors are eliminated. In order to measure time effectively an astronomical event that repeats itself with perfect regularity and precision is required. The rotation of the earth on its axis is such an event and, in the ultimate analysis, is the measurer of all varieties of time — sidereal, solar, mean solar time and standard solar time. Sidereal time depends upon the position of the earth in reference to the meridian of the vernal equinox, a slowly changing point in the sky where the sun annually crosses the equator in the spring of the year.[3]

An international conference in Washington, D.C. in 1884, convened for the purpose of fixing a prime meridian on the earth's surface and the establishment of a universal day, resulted in the adoption of standard time throughout the world. The conference recommended that all nations adopt a single prime meridian in place of the then existing multiplicity of meridians governing time services, the zero meridian of longitude to be that which passes through the centre of the transit instrument at Greenwich Observatory, London. Prior to that conference, mainly through the efforts of Sandford Fleming, agreement was reached among the railway companies of Canada and the United States concerning the establishment of time zones. With the adoption of a prime meridian it was logical to divide the globe into 24 time zones, each covering 15 degrees of longitude. Canada has seven such time zones, with Yukon Standard Time nine hours behind Greenwich Mean Time.

One of Stewart's first functions with the branch and a task he attacked with great zeal was to inaugurate and develop a national time service. In 1904 a federal appropriation of $5,000 was made to provide for the installation of electric clocks in various government buildings in Ottawa. The clocks were to be serviced and controlled for accuracy by the new Dominion Astronomical Observatory. Stewart was appointed superintendent of the time service in 1905 and it was in this sphere of work and in positional astronomy that he made his most enduring scientific contributions. The first major improvement in the time service, which had its origin in the Ottawa observatory's longitude program, came with the acquisition by that institution of the 6-inch meridian circle telescope, a special type of transit used to determine positions of stars. Stewart supervised the installation of this instrument. The first extensive program at the observatory for fixing the accurate positions of stars was completed in 1923. Observations with the meridian circle telescope formed the basis for determination of accurate time until 1935. The availability of this service, particularly for the correction of the chronometers of field parties, marked an important advance in Canadian surveying.

When the longitude program was extended to stations in Canada lacking telegraphic communications Stewart devised the system of determining longitude by the use of wireless time signals. The first station occupied in this manner was at Quinze Dam, in Quebec province, in 1914. In 1923 the observatory discontinued longitude work in its relation to surveying but maintained its active interest in scientific aspects of the problem. Under Stewart's direction Canada participated in 1926, and again in 1933, in the establishment of longitude networks encircling the globe.

Demands began to mount for the distribution of accurate time to many parts of Canada. Time impulses had been sent by the observatory to local telegraph offices as early as 1905 but the first wireless transmission over local broadcasting stations did not occur until 1923. Four years later radio broadcasts of correct time began to emanate directly from the observatory through the use of short-wave facilities. It was then that Stewart conceived the idea of a time signal machine and supervised its construction, a task completed in 1938. Control of the workings of the instrument was provided by the governing Shortt pendulum clock. When a crystal clock was installed four years later it became the controlling apparatus. Service supplied by this machine included the noontime broadcast of correct time over the network of the Canadian Broadcasting Corporation, an announcement now familiar to listeners across Canada: "From Ottawa, the Dominion Observatory time signal — the beginning of the long dash, following ten seconds of silence, indicates exactly one p.m." Also provided were continuous shortwave time signals and the synchronization by direct wire of some 800 clocks in a score of federal government buildings in the nation's capital, the best known of which is the clock in the Peace Tower on Parliament Hill. Dominion Observatory time was declared by the federal government as the time to be used for official purposes throughout Canada.*

Among Canadian scientists prominent in the field of astronomy during Stewart's regime was William S. McClenahan (1892-1968), Ontario-born graduate of the University of Toronto in 1914, who joined the staff of the Dominion Observatory in Ottawa that same year. He served continuously, except for leave of absence during the First World War, until his retirement in 1957. At that time he was chief of the Positional Astronomy Division. McClenahan's contributions to science were many-sided. During his active career he made many thousands of transit observations. No other member of the Ottawa organization has been known to reverse the meridian circle instrument, as McClenahan did on one occasion, after a three-hour stint of observing and then continue on to obtain a second set of observations. The publication, following Stewart's regime, of three catalogues of thousands of stars observed from the Ottawa observatory was due to his efforts. During the greater part of McClenahan's service at Ottawa the pendulum performed as master timekeeper. He saw it replaced in 1957 by a quartz clock and also lived to witness the transition from these methods to an atomic standard of time and frequency.

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*O. in C. PC. 6784, Ottawa, August 28, 1941.

FIGURE 122. William S. McClenahan.

FIGURE 123. Malcolm M. Thomson.

Malcolm Macmillan Thomson (1908-   ) joined the Dominion Observatory staff, Ottawa, in 1930, following graduation in arts from the University of Manitoba in the previous year. His special interests in the tasks of the organization have included precise timekeeping and associated studies of variations in earth rotation and variation of latitude. Thomson was destined to become, first, acting head of the Positional Astronomy Division and, five years later, chief of the Astronomy Division. With the exception of three years in the Royal Canadian Air Force during the Second World War, Thomson's connection with the Ottawa observatory has been uninterrupted to date. Awarded a Master of Science degree from Yale University in 1954 Thomson later served a term as President of the Royal Astronomical Society of Canada.

Miriam Seymour Burland, born in St. Lambert, Quebec, graduate in arts at McGill University in 1926, joined the Dominion Observatory staff in Ottawa in the following year. Miss Burland, during her 40-year career as a scientist in that organization, specialized in meteor astronomy as well as along educational lines in making the observatory work better known to the public.

Charles Campbell Smith (1872-1940), born in Brampton, Ontario, came to the Dominion Observatory staff in Ottawa in 1905, following a period of service with the Topographical Survey of Canada as a draughtsman. In 1906 he was awarded his commission as a Dominion land surveyor. At the observatory he joined the Meridian Circle and Time Division (formerly Service), although the meridian circle transit instrument did not come into regular use in that division, as has been noted, until several years later. The untimely death of his wife in 1912 led to Smith's temporary and voluntary separation from the work of the observatory. For a number of years Smith practised land surveying in British Columbia, having been commissioned in that province in 1913.

Returning to the Meridian Circle and Time Division in 1919 Smith made a noteworthy contribution to the upbuilding of the organization. In 1924 he succeeded R. M. Stewart as division head. His participation in programs related to the establishment of the world longitude network was important to its success.[4]

As early as 1927 Smith prophesied the advent of computers, which happened some 40 years later, in the operations of the Dominion Observatory, Ottawa. "The greater ease, speed and accuracy", he wrote, "with which computations in a decimal system can be effected by machines soon impresses itself on any [human] computer . . . In these automatic machines . . . multiplication of 9 figures by 8 figures, or the division of 16 figures by 9 figures, takes 10 seconds. To carry out the multiplications and additions or subtractions in the example . . . for star reductions takes approximately one minute. This is at least three times as fast as it can be done by logarithms and the chance of error is very small."[5] Smith retired from the civil service in 1938, two years before his death.

When the Department of the Interior, as such, came to an end at the close of 1936, its organization under the title Department of Mines and Resources, brought about changes in the administrative structure of the observatory staff. In the process Stewart became the first director of the institution to be invested with the title *Dominion Astronomer.*[6] Special mention should be made here of several men whose scientific work at the observatory was linked with the Stewart regime. Ralph E. Delury, Assistant Director of the Dominion Observatory, Ottawa, for many years up to 1947, made a special study of sun spots as well as making many measurements of differential solar rotation. Judson Pulford Henderson contributed significantly to the development of uses of electronics at the observatory and accomplished much pioneer work on the functioning of radio sets on field surveys. Dr. Peter M. Millman, a gifted publicist and scientist on astronomical topics, became well-known nationally and internationally for his studies in the meteorite field at the observatory before moving to the National Research Council of Canada.

The year 1940 was one in which astronomical science and related studies in Canada suffered a number of grievous losses among its eminent personnel. In addition to C. C. Smith, J. B. Cannon, W. E. Harper and R. M. Motherwell, two former presidents of the Royal Astronomical Society of Canada passed away. One of these, Sir Robert Frederic Stupart (1857-1940) was born in Aurora, Ontario. While a student at Upper Canada College in Toronto he acted as a volunteer computer at the Magnetic Observatory located in that city and, at the age of fifteen years, became a member of its permanent staff. Stupart was noted for his work in meteorology and, in 1894, was appointed head of the Meteorological Service and the Toronto Magnetic Observatory. In 1902 he was elected president of the Royal Astronomical Society of Canada. He was knighted in 1916 for his services to science. Thirteen years later Sir Frederic retired from office.[7]

The second loss from the ranks of former Royal Astronomical Society of Canada presidents in 1940 was another Ontario-born man, Andrew Frederick Hunter (1863-1940). From 1904 to 1908 he had been associated with the Geological Survey of Canada.

John Beattie Cannon (1879-1940), born in Ottawa of Scottish stock, graduated in 1908 from the University of Toronto and joined the Dominion Observatory in the capital. After serving for eleven years on its staff he transferred to the Geodetic Survey of Canada and accomplished a great deal of important work in that organization.[8] Robert Millford Motherwell (1882-1940), Manitoba-born graduate of Perth high school in Ontario and of the University of Toronto, was married to Irene, daughter of Dr. W. F. King. After winning the gold medal of the Royal Astronomical Society of Canada in 1907 Motherwell was recruited for the observatory staff in Ottawa. He excelled in the photography of comets. Motherwell died in the year of his retirement from the civil service.[9]

For a number of years prior to 1940 there had been a steadily growing realization among professional astronomers in Canada of the need for some form of periodic recognition in order to foster interest in astronomy among laymen in this country. Accordingly, in that year, the Chant Silver Medal award was established, named after the then director of the David Dunlap Observatory. This award was to be presented annually to amateur astronomers on the basis of the value of work carried on in astronomy or in any of the closely allied fields of original investigation. The first winner of the medal was B. J. Topham in 1941.[10]

The loss to Canada and the world, by death, of R. M. Stewart was a heavy one. As a writer and lecturer on scientific subjects and as an administrator Stewart had won wide respect. Characteristically he was impatient with vague or inaccurate thinking but gave strong support to subordinates on his staff who could convince him of the value of their ideas. He enjoyed debating and was a gifted critic. Although Stewart was a man of strong feelings, these were normally concealed by the dignity and reserve of his manner. After 43 years with the observatory, nearly half of which he served as its director, Stewart retired in 1946. He died in Ottawa on September 2, 1954. Had he lived a few months longer he would have seen one of his fondest dreams transformed into reality, namely, the construction of an annex building to the observatory. Several times during his tenure of office plans had been formulated for such an extension to accommodate the expanding staff and to provide much-needed laboratory facilities.[11]

The Dominion Astrophysical Observatory

Progress in astronomy by the observatory staff in Ottawa, under Klotz and Stewart, was matched by achievements of the Dominion Astrophysical Observatory in Victoria. The official opening ceremony on June 11, 1918, marked the commencement of the third stage in the growth of Canadian astronomy. Harper had toured Canada searching for the site most suitable for observing the skies. Year-round stability of atmospheric conditions was a prime factor in making his choice. Harper, after much travelling and many careful surveys, selected property on the summit of Little Saanich Mountain. John Stanley Plaskett (1865-1941) was named first director of the observatory, and Harper joined its staff in 1919. Other assistants at the time were Dr. R. K. Young and the director's son, H. H. Plaskett. The total scientific staff numbered 38.

With the establishment of the new organization in Victoria and with the increasingly competent staff of the observatory in Ottawa, Canada at once assumed a prominent place in the international development of astronomy and in the general expansion of the physical sciences. The varied contributions made by these two major organizations of their kind illuminated many star problems and thrust telescopic explorations of our galaxy to new limits. Above all, these advances served to emphasize the basic role of astronomy in the surveying and mapping of a country. In fact it was to cope more effectively with the ever-growing need and demand for astronomically-fixed positions throughout this country, arising in part from the requirements of the Dominion lands surveys, the delineation of Canada's international boundaries, and from the need of coordinates for these and other surveys for cartographic purposes, that the two new Canadian observatories had come into existence during the first 20 years of the twentieth century.

The program of observations, initiated by J. S. Plaskett at Victoria in 1918, was mainly concentrated upon ascertaining the radial velocities of stars of miscellaneous spectral type for which the proper motions were known. This choice of program was a logical consequence of Dr. Plaskett's earlier work in Ottawa. With the aid of Dr. J. A. Pearce, who had joined the staff in Victoria in 1924, Plaskett made the first extensive observational test of the rotation of our galaxy. In fact this team of scientists was able to calculate the period of revolution and distance of the sun from the galactic centre. These results represented a remarkable forward step in man's acquisition of knowledge of the galactic system and formed a solid foundation on which many subsequent investigations have been based. One of the deepest satisfactions of J. S. Plaskett's life was the association he enjoyed with his son, H. H. Plaskett, in astronomical work, especially on the Victoria Observatory staff from 1920 to 1929.[12]

Dr. Harper, after his transfer in 1919 from the observatory in Ottawa to the new observatory in Victoria, served 21 years in all at the West Coast institution, succeeding Dr. Plaskett as director in 1936. Harper's contribution to astronomical science was substantial. His published scientific papers numbered more than 200 and he did much to popularize the study of astronomy in Canada by his writings, lectures and radio talks.

Another brilliant recruit to the staff at Victoria, a man destined to become Dominion Astronomer, was Scottish-born Robert Methven Petrie (1906-1966). As a university student Petrie worked at the Astrophysical Observatory in summer seasons from 1924 to 1929 inclusive. He joined the staff on a regular basis in 1935, specializing in spectral analysis of binary and multiple stars and in studies of our galaxy. During the period when he was a summer student Petrie began investigations of the motions of stars and of the nature of double and multiple stellar systems. It was in this field of effort that Petrie made his most distinguished contributions to science in subsequent years. Petrie also designed instruments for ascertaining displacements of spectral lines, a device that removed considerable drudgery from the measurement of radial velocities of stars. A few years before his death in 1966 Petrie, in association with Pearce, completed observations of the radial velocities of some 600 faint B-type stars, thus pushing the investigation of galactic motion farther into space than had ever been done before.[13]

In 1927 the staff of the Dominion Astrophysical Observatory was considerably strengthened by the arrival of Carlyle Smith Beals (1899-). Born in Canso, Nova Scotia, the son of Rev. F. H. Beals, he received his early schooling in Upper Canard in that province. At Acadia University young Beals specialized in physics and mathematics, graduating in 1919. After a period during which he taught in a one-room, all-grades, rural school, in order to finance his further education, Beals graduated with a Master of Arts degree from London University. In 1926 he returned to Acadia University as an associate professor of physics and, in the following year, joined the observatory staff in Victoria as assistant astronomer. Dr. Beals devoted much attention to the emission of line stars and also interstellar matter while he worked in Victoria. His thesis on the former subject won him a Doctor of Science degree from London University in 1934. During the years of the Second World War he made a special study of gases produced for use in warfare and worked out methods of defending against them. During this period also he designed a microphotometer that registered mechanically the form and total intensity of spectrum lines. In the course of the first 20 years of operation of the telescope at Victoria about 30,000 spectra had been obtained.

In 1946 Beals transferred to the Dominion Observatory at Ottawa, succeeding Stewart as Dominion Astronomer the following year. During his 17 years in that high office Beals guided the Observatories Branch, as it had come to be known, through a period of great expansion of its activities and facilities. This growth involved construction of the new geophysics laboratory, the establishment of ten new field stations across the country, and the extension of geophysical work to Arctic Canada. He directed as well the acquisition of modern astronomical equipment for time determination, solar studies, meteoric astronomy and general astrophysics. Beals engaged personally in studies of ancient meteorite craters in Canada, employing geophysical methods, and establishing an international reputation for his pioneering efforts in this, his second career.

In 1937 an addition of more than ordinary interest was made to the staff of the Victoria Observatory when the noted Dominion land surveyor, Guy H. Blanchet, was appointed as an assistant. Blanchet, who was also a British Columbia land surveyor, had first made known his interest in astronomy in a 1928 issue of the *Journal of the Royal Astronomical Society of Canada* in which he described his field observations of terrestrial magnetism and the aurora near Hudson Bay.[14]

The retirement of Dr. Plaskett in 1935 and that of R. M. Stewart about ten years later marked the end of the third stage in the development of Canadian astronomy. Both men had entered the service of the Dominion Astronomical Observatory in the same year, 1903. Each had headed their respective observatory staffs, as directors, for comparable periods and both had left favorable impressions of an indelible character upon their professional colleagues in Canada and abroad. In 1906 the number of stars whose radial velocities were known to astronomers of the world totalled 400, this information having been gathered, for the most part, by United States' observatories. From 1918 to 1935 that grand total had soared to about 7,000 of which more than 2,000 had been determined at Victoria. As in Ottawa, the Victoria institution had become a steady attraction to members of the general public. Visitors in 1934 totalled 21,608, close to the 27-year annual average, 1919 to 1935 inclusive.

Dr. Plaskett died in Esquimalt in 1941. Three memorial windows, installed as a tribute to Dr. Plaskett's character and works in St. John's Anglican Church in Victoria, are unique in that the gold melted from medals such as those awarded Plaskett by the Royal Society, the Royal Society of Canada, and the American Academy of Arts and Sciences realized a sum sufficient to cover the cost of the design and manufacture of these magnificent windows.[15]

Seismology

In the realm of geophysics the subjects of seismology, terrestrial magnetism, and gravity formed separate divisions of the original Dominion Astronomical Observatory organization and have continued as such to the present. Surveying and mapping activities have continued to play an important part in the progress of all three divisions. The creative interest and work of Klotz in seismology spurred the early growth of this field of study in Canada but from the close of his regime until 1952 the development of seismology in this country was largely the product of the successor to Klotz in this particular field, namely, Ernest Atkinson Hodgson (1886-   ).

In 1917 Hodgson's career at the Ottawa observatory hung precariously in the balance. At that time he was seismological assistant to Klotz but the low rate of pay attached to the position, along with an opportunity to take a teaching post in the Toronto Technical School that was more remunerative, convinced Hodgson that he should move to the Ontario capital. Klotz, however, was determined to keep him on his staff and made urgent representations to Deputy Minister W. W. Cory of the Department of the Interior in the hope of obtaining an increase in salary for his able assistant. In this effort Klotz was successful and the raise in Hodgson's annual pay from $1,600 to $1,800 helped the young scientist to change his mind and to remain with the observatory organization. This decision was noted jubilantly by Klotz in an entry in his diary on October 1, 1917.

In 1905 Klotz placed an order for two components of Bosch photographic seismographs and these were installed in January, 1906. The instruments had been acquired just in time to provide the first Canadian records of the San Francisco earthquake in April of that year. About this time each earthquake recorded by the observatory was given a number in a tabulation that has been carried on ever since. The time of each earth tremor, to within one second, has been entered in each instance and all records carefully filed and indexed. In March, 1912, a Wiechert vertical was obtained and this instrument continued to function well for many years.

Although written accounts exist of a severe earthquake in 1732 in the vicinity of Montreal where 300 houses were damaged and one life lost, the modern history of seismic disturbances in this country begins in 1897. In that year two Milne photographic seismographs were purchased, one for installation in Toronto and one in Victoria. The latter instrument registered 2,384 earth shocks, originating in various parts of the world, up to January, 1923. In that year the recorder was replaced by two Milne-Shaw seismographs. By 1926 seismological apparatus in Toronto was accommodated in a basement room of one of the student residences on the campus of the University of Toronto.

Earthquakes in Canada have occurred, for the most part, on the west coast and along the basins of the St. Lawrence and Ottawa rivers. As a result of instrumental recordings, the circulation of questionnaires, and personal investigations by members of the Ottawa observatory staff, a full report of the St. Lawrence Valley earthquake of February 28, 1925, was published. Following this study efforts were made by Dr. Hodgson to call to the attention of commercial interests in Quebec the need for including the earthquake factor in architectural planning in that province.[16] With the growth of Canadian cities and the construction of high office buildings and apartment complexes, the installation of water mains and lighting systems, the possibility of costly damage to these facilities from earth shocks greatly increased.

The 1925 earthquake also emphasized the importance of the role of the surveyor in relation to seismic disturbances. Lines of precise levelling run between Rivière-du-Loup and Lévis as early as 1915, and re-run soon after the earthquake by the Geodetic Survey of Canada, revealed an upwarping of the east end of the affected area in relation to the west end. This finding confirmed the field work of seismologists and gave validity to their deduction that the movement had occurred along a fault in the rock strata crossed by the St. Lawrence River and that the seaward side of the fault had snapped upward in relation to the landward side.

In the determination, with considerable accuracy, of the location of earthquake epicentres, geodetic surveyors could run branch lines of levels into the area and spread a triangulation net over it. Topographical surveyors could then prepare relief maps of the area. Geological surveyors could then examine the region fully. When any subsequent disturbance of the earth's crust occurred in this vicinity the surveyor would be in a position to reveal whether the crust had risen or fallen and also to disclose the direction of any horizontal shift.

By 1930 five seismological instruments were in operation at the Ottawa Observatory, namely, two Milne-Shaw and two Bosch horizontal instruments as well as one Spindler and Hager vertical. Sheets in these instruments were changed each morning. Each month the Dominion Astronomical Observatory issued a seismological bulletin. Seismological stations were established at Shawinigan Falls and Seven Falls in Quebec, as well as at Halifax and Saskatoon.[17]

A complete study was also made by federal seismologists of the Cornwall-Massena earthquake of September 5, 1944, a disturbance that caused property losses estimated at about $1,000,000. In the town of Cornwall more than 2,000 chimneys were damaged. On June 23, 1946, a quake occurred near the midway point along the east coast of Vancouver Island. Earth tremors, which continued for 30 seconds, wrecked chimneys and broke water mains in Victoria. This seismic shock proved to be one of the most severe of all Canadian earthquakes recorded in modern times and was clearly registered on seismograph instruments in the observatory in Ottawa.[18]

In December, 1951, after serving for several years as Assistant Dominion Astronomer, Dr. Hodgson retired from the public service. He was the last of the observatory staff to hold that title. At the same time he retired as chief of the Seismology Division, a post he had held for more than 30 years and in which he was succeeded by his son, Dr. John H. Hodgson. Beginning with the St. Lawrence earthquake of 1925 E. A. Hodgson carried out detailed field investigations of all major Canadian earthquakes. His 1925 survey was the most complete study of a non-disastrous earthquake made in the world up to that time. For many years he worked in close cooperation with Canadian mining companies in the application of seismic methods to mining problems. He was editor of the Bibliography of Seismology for nearly 30 years and, in 1938, was awarded the Gzowski Medal by the Engineering Institute of Canada. Many years previously he had won the Royal Astronomical Society of Canada Gold Medal. A prolific contributor to the pages of the *Journal of the Royal Astronomical Society of Canada,* Dr. Hodgson had a special facility for communicating with the general public, in his field of science, both by the written and spoken word. Dr. John Hodgson who became, in the course of time, Director of the Observatories Branch, carried on and extended Canadian seismological studies in the tradition so competently established by his dedicated and distinguished father.

Magnetic Surveys

Man has been intrigued, from the dawn of civilization, by the earth's magnetism. The Greeks were aware of the magnetic property of lodestone about 600 B.C., observing that it attracted small pieces of iron and that the same could be transmitted to the metal. But for many centuries they failed to recognize the direction-finding function of the stone. The name "magnet" may have been derived from the name of a place in the ancient world from which it could be obtained, Magnesia, in Asia Minor. In time the Greeks discovered that a suspended lodestone would come to rest in a definite position and that it possessed opposing poles.

The compass, by which practical use was made of the direction-finding ability of a magnet, became known to some Europeans as early as the 12th century. In this respect they lagged far behind the Chinese. Until the 15th century, in the western world, it was assumed that the compass needle pointed to the true, or geographic, north. The early charts of Mediterranean coasts were compiled from compass bearings. Apparent deviations from the north were at first attributed to mechanical imperfections in the construction of the instrument. Some historians credit Columbus with the discovery that declination or deviation was magnetic in origin. In any event, by 1500 it was known that the magnetic compass needle usually did not point true north but was deflected east or west by an angle, the extent of which depended upon the geographical location of the observer. The deviation from true north was described as the *variation* of the compass although magneticians in more recent times have preferred to use the term *declination.*[19]

The science of terrestrial magnetism may be said to have had its beginning in 1600 when the Englishman, William Gilbert (1544-1603) published his great work "De Magnete". Gilbert was the first to advance the concept that the earth itself possessed magnetic properties and that all magnets on its surface are influenced by its magnetic force. He concluded, wrongly, that its magnetic poles coincided with its geographic poles. But Gilbert's work served to dispel the theory previously held that the direction-finding power of the compass was due to some celestial attraction, such as the north star. Most of Gilbert's reasons for regarding the earth as a huge lodestone have been discarded long since but his work, nevertheless, laid the foundation for the development of geomagnetism as a science. By 1634 an English professor of mathematics, Henry Gellibrand, had demonstrated *secular variation* of the compass, that is, that its declination varied slowly in the course of time. This was an important finding because the compass had come into use not only as a navigational instrument but in surveying as well. From observations he made at Deptford, near London Bridge, Gellibrand noted that declination changed about seven degrees between 1580 and 1634. With this discovery land surveyors, who had been using the compass to define boundaries of private properties, could not retrace old surveyed lines without first ascertaining the change in magnetic declination that had occurred since the original survey.

By the 1830s it had become obvious that a complete magnetic survey of the globe, involving the establishment of magnetic observatories in various localities, was imperative. A magnetic survey of the British Isles was carried out during the years 1836 to 1838. Subsequently Great Britain extended this type of survey to her territorial possessions abroad. In Canada the measuring of declination began with the earliest explorers. Magnetic observations were made at the site of Halifax by Samuel de Champlain in 1604. Similar observations began at Quebec in 1642 and at Montreal in 1700. Capt. James Cook made similar observations at Nootka as did Sir John Franklin during his Arctic voyages. Because the compass became indispensable to navigation and the expansion of world trade, charts of ocean areas soon came into existence, portraying the degrees of magnetic declination in various zones. In 1701 a chart was published depicting lines of equal declination traversing the Atlantic Ocean. Maps of land areas were issued later, serving the same purpose as the ocean charts. Such maps are now published at frequent intervals.

Reference has been made previously in "Men and Meridians" to the extensive magnetic surveys made in western Canada by Lefroy from 1842 to 1844. In 1880 the Topographical Survey Branch, Department of the Interior, began to assemble data on magnetic declination as observed at numerous stations across the country. The magnetic division of the Dominion Observatory, Ottawa, formed to promote systematic studies of the electromagnetic force of the earth as applied to Canada, came into existence in 1907. In the field seasons of 1922 and 1923 magnetic data were collected along the Mackenzie, Peace, Athabasca, and Slave rivers as well as in northern Saskatchewan and Manitoba. In the latter province the area covered was from the western boundary to the west coast of Hudson Bay and between The Pas and the 60th parallel of latitude. At each magnetic station established in the course of these surveys the declination was measured, the magnetic meridian determined as well as the astronomic meridian and the angle between the two, giving the extent of declination. The dip or inclination to the earth's magnetic field was measured in the field either by a dip circle or by an earth inductor.

The location and development of deposits of magnetic ore and other investigations by geologists are aided by a knowledge of the behavior of the earth's magnetism and by the use of instruments for measuring it. By 1928 keen interest was being shown in Canada in the use of magnetic methods of surveying mineral claims. Some of the methods employed depended entirely on the effects of the magnetic field of the earth and on natural currents of electricity beneath the surface.

Under directors French and Madill the work of the magnetic division had grown in recognition and importance. By 1947 it was operating four magnetic observatories, namely, at Agincourt, Ontario, and Meanook, Alberta, and two in the Arctic. The Ontario institution was formerly the Toronto Magnetic Observatory, moved to Agincourt in 1898. These observatories have become part of an international network and the results of their Canadian studies are used in world-wide discussions on the nature and effects of the earth's magnetism. By 1947 also the division had established 1,300 field stations in a system extending from Cape Race, Newfoundland, to Triangle Island, British Columbia, and from Canada's southern boundary to the northern tip of Ellesmere Island. At a number of these stations repeated observations are made to ascertain changes in the direction and magnitude of the earth's magnetic field. The division also keeps track of the wanderings of the rather mobile north magnetic pole.[20]

FIGURE 124. Magnetometer in use in the field.

When many observations of this type are made across the nation a magnetic chart is the most convenient method of representing general conditions for any particular period. Isolines shown on such charts are analogous to contours on topographic maps.

Gravity Surveys

Among the most interesting scientific problems concerning the nature of our earth are those related to the direction and intensity of this planet's gravitational force. Galileo, whose experiments demonstrated that heavy objects do not fall faster than light ones, laid the groundwork of the science of mechanics. This science, in turn, led to Newton's law of universal gravitation and his laws of motion. The acceleration of gravity, like the velocity of light, is one of the earth's most important fundamental quantities in physics. In 1902, under the supervision of Dr. Klotz, the Ottawa observatory initiated pendulum measurements of gravity as a contribution to international studies to determine the shape of the earth and to test the theory of isostasy as applied to North America. For somewhat more than 40 years such measurements, totalling about 200, were made throughout Canada. After the Second World War the pendulum was replaced for these purposes by the gravimeter.

Initially in Canada official interest in geophysics lay in its application to the larger problems of the nature of the earth. Soon, however, it became obvious that the earth sciences held interesting possibilities for expediting searches for mineral wealth. Accordingly, in 1928 and during succeeding years, Andrew Howard Miller (1886-1962), then chief of the gravity division, Dominion Astronomical Observatory, carried out original investigations, in cooperation with the Geological Survey of Canada, into basic practical aspects of gravitational and magnetic methods of prospecting for minerals.[21]

A. H. "Joe" Miller, widely recognized as a pioneer of Canadian geophysics, was born in Manitoba and received his elementary and secondary education in Winnipeg. He was awarded a degree in mathematics and was named a Rhodes Scholar from Manitoba. He graduated from Oxford University as a Bachelor of Arts in 1910 and as a Master of Arts in 1919. In the intervening years he lectured at the University of Wisconsin after which he served with Canadian forces in France during the First World War. On returning to Canada in 1920 Miller joined the Dominion Observatory in Ottawa and remained on its staff until his retirement in 1951.

Miller was mainly responsible for the initiation of systematic gravity surveys in this country. The early surveys carried out by him testify to his scientific ingenuity and physical endurance. Travelling in the Canadian wilderness by barge, wagon train, pack horse, and on foot, while transporting more than two tons of equipment and provisions, Miller made two memorable trips to the lower reaches of the Mackenzie River during the field seasons of 1921 and 1922. En route he made pendulum observations and established gravity values at points considerably north of the Arctic Circle. On these ventures Miller provided the first significant information concerning the variation of gravity with latitude in Canada.

Throughout the 1920s Miller concentrated on isostasy studies. By careful observation and by prodigious mathematical industry he demonstrated that the large part of Canada covered by his measurements was in a condition of isostatic equilibrium. Thereafter Miller became interested in what were, at the time, revolutionary methods of applying physics to problems of structural geology and to prospecting for minerals.

During the Second World War he put to use his skill and knowledge in the promotion of Canada's war effort. For three years he assisted at the National Research Council of Canada in the establishment and maintenance of a standard gauge-testing laboratory for use by war industries of this country.[22]

In 1922 the first torsion balance instruments were brought to Canada by the Dominion Observatory, Ottawa. The torsion balance was a remarkably sensitive device capable of measuring the gradient of gravity in a horizontal direction. Because of some defects in its manufacture initial use of the instrument in this country was not made until seven years later. By 1928 general interest in geophysical methods of prospecting had been aroused across Canada, mainly as a result of the introduction of electronic methods of detecting sulphide orebodies.[23] The torsion balance, for example, was used in a gravity survey in 1934 of the Malagash salt deposit in Nova Scotia. The resulting gravity map outlined the area in which a deficiency of mass occurred owing to the presence of salt. The precise dimensions of the deposit were not known until this survey was completed. Tests carried out in 1947 by the Dominion Observatory over mines in western Quebec proved that gravity measurements could be made of surface orebodies, even when completely covered by overburden. The orebody was clearly outlined by the gravity contours.

Between 1944 and 1955 reconnaissance surveys with periodic gravity measurements were carried out through southern Canada by automobile, and in northern Canada by light aircraft. During this period some 10,000 regional measurements were obtained, providing data for the first edition of the Gravity Map of Canada, 1956.

Miller's retirement occurred in the middle of this transitional period. He was succeeded as chief of the gravity division by Dr. Morris J. S. Innes, graduate of the University of Saskatchewan and the University of Toronto. The final phase of Miller's scientific career was associated with a radical change in both the speed and accuracy of gravity measurement through the use of highly portable gravimeters. These new instruments, which revolutionized gravity studies throughout the world, became generally available after the end of the Second World War. Miller was quick to realize their advantages and concentrated on the development and standardizing of field procedures involving the use of gravimeters. In field seasons from 1945 to 1951 he established by his personal efforts some 5,000 gravimeter stations along the highways of southern Canada from the Atlantic Ocean to the Rocky Mountains.

Miller won international recognition for his investigations of isostasy and for his work in establishing gravity ties between national reference stations for gravity in Europe and North America. His output of some 30 scientific papers form an enduring contribution to the knowledge of earth physics.

The David Dunlap Observatory

In May, 1921, three years after the opening of the major observatory in Victoria, a casual incident occurred at a public lecture in Toronto, a happening that had an important bearing on the future development of Canadian astronomy. In the audience being addressed by Professor Clarence Augustus Chant on the topic of Winnecke's Comet, was David Alexander Dunlap (1863-1924), a Vice-President and Treasurer of the Hollinger Consolidated Gold Mining Company, Limited. After the lecture Dunlap made himself and his keen interest in astronomy known to the professor. They became

FIGURE 125. Dr. C. A. Chant.

fast friends and, later in that same year, Dunlap was elected to membership in the Royal Astronomical Society of Canada. It was this initial meeting of Chant and Dunlap that led to the erection, 14 years later, of the important observatory at Richmond Hill, north of Toronto, on the 70th birthday anniversary of its most earnest and persistent advocate, Dr. Chant.[24]

Dunlap's death in 1924 was a heavy blow to Chant but, fortunately for the future of Canadian astronomy, Mrs. Dunlap revealed her own deep interest in the subject and in Chant's long-cherished dream of the creation of a major observatory connected with the University of Toronto. Accordingly she authorized Dr. Chant to proceed with plans for the construction and operation of such an observatory near Toronto. Years later, at the formal opening of the observatory building Chant told how the Richmond Hill site was selected. "My colleague, Dr. R. K. Young, and I would study a large-scale contour map of the country within fifty miles of Toronto and would then explore the places we had selected. When we found a possible site Mrs. Dunlap would inspect it. Well do I remember driving up yonder lane on a sunny afternoon in June, 1928, and parking the car near the old barn, clambering through a barbed-wire fence and, walking to the top of the hill. 'This is the site', she said."[25]

At the largely-attended opening ceremony on May 31, 1935, Mrs. Dunlap formally presented the University of Toronto with the splendid new observatory, housing a 74-inch telescope, the mirror of which had been cast in Corning, New York. This was the second largest telescope in the world at the time. Many dignitaries were present, including Prime Minister Mackenzie King. A number of honorary degrees were awarded on the occasion, including doctorates to C. A. Chant and W. E. Harper. In his remarks Dr. Harper stressed the importance of the application of astronomy to the tasks of precise surveying.

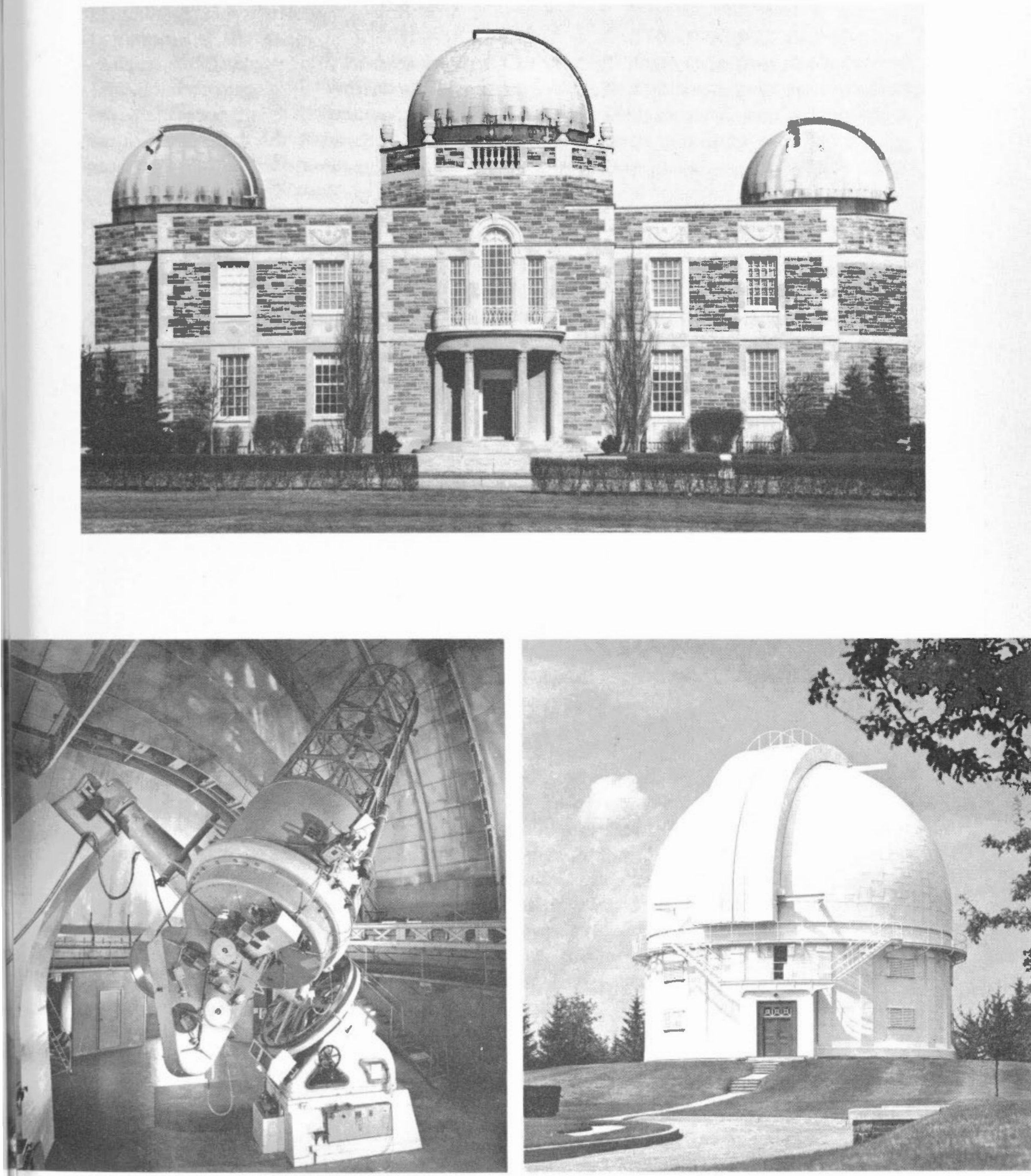


FIGURE 126. David Dunlap Observatory, Richmond Hill, Ontario.

Dr. Young had earlier in the ceremonial proceedings made reference to planned improvements to the observatory grounds. "It is intended to make the [surrounding] land into a park to be known as the David Dunlap Park, and it is very desirable to plant trees over the area as soon as possible. The reason for having the ground covered with a growth of trees is to shield it from the sun on warm days. On an open plain the ground becomes quite hot during the day; and when, at sunset, this heat is given off again, the warm air flowing upwards creates an unsteady atmosphere which interferes with the use of the telescope."[26]

The David Dunlap Observatory was also a monument to the ambitious and persevering efforts of Dr. Chant over many years. He graduated in mathematics and physics at the University of Toronto in 1890 and in the following year was appointed to the university teaching staff in the department of physics. He taught continuously until his retirement in 1935, a period of 45 years that constituted a momentous period in the history of Canadian astronomy. In 1904 a sub-department of astrophysics was formed, under his leadership and a graduate course in astronomy was added to the curriculum. From this point on, and for nearly half a century, Chant's overriding purpose in life was to promote the study of astronomy. In his career he had trained most of Canada's astronomers of the period, among them five men who became directors of important Canadian observatories. As early as 1912 he began a campaign for the acquisition by the university of a large telescope to facilitate major research in the science.

One of the foremost astronomers in Canada in the period under review in this book, and who became a member of the staff of David Dunlap Observatory, is Dr. Helen Sawyer Hogg, whose wide-ranging mind has been engaged in a number of branches of the science and who is particularly well-known for her studies of globular star clusters. Born and educated in Massachusetts, Mrs. Hogg graduated from Radcliffe College, now part of Harvard University. There she met Frank S. Hogg. They were married and she came with him to Canada. He served as director of the David Dunlap Observatory from 1946 until his death in 1950.

Dr. Chant wrote several books, including *Our Wonderful Universe,* a classic yet simple exposition of basic astronomy. For fifty years he served as editor of the *Journal of the Royal Astronomical Society of Canada.* In research his wide interests ranged from early experiments with Hertzian waves to the Einstein Effect at total solar eclipses. His activity in the latter field took him, along with his colleague Dr. Young, to Australia in 1922 where they obtained early verification of the Einstein theory of gravitation, through the observed deflection of starlight by the mass of the sun.[27]

On November 18, 1956, at the age of 91, Dr. Chant died at Observatory House, Richmond Hill. The example of his devoted efforts over the years in the realm of astronomy inspired the construction of a number of non-government Canadian observatories in the 1940s. Although these institutions are considerably smaller than the Richmond Hill Observatory they continue to contribute helpfully to the general advancement of astronomy in this country. The Hume Cronyn Observatory was formally opened at the University of Western Ontario in London on October 25, 1940; the Ville Marie Observatory opened in Montreal in 1941; the University of Alberta Observatory opened in Edmonton in 1943; the Quebec City Observatory in 1944 and, shortly after, the Oak Bay Observatory began operations in Victoria.

The Royal Astronomical Society of Canada

In 1890 the Astronomical and Physical Society of Toronto, originally known as the Toronto Astronomical Club (1868) was incorporated. Thirteen years later its name was changed to the Royal Astronomical Society of Canada, complete with constitution and a motto *"Quo ducit Urania* — Whither thou leadest, Goddess of the Heavens." The purpose of the organization was "to study astronomy and astrophysics and such cognate subjects . . ." The Society was federalized through a constitutional provision for the creation of branches or centres from coast to coast. In addition to the unit in Toronto other centres were established in subsequent years in all of Canada's principal cities, although not all of these centres of the Society have survived. The organization's Gold Medal and Chant Silver Medal awards have helped to stimulate the spirit of enterprise and research among professional and amateur astronomers throughout Canada.

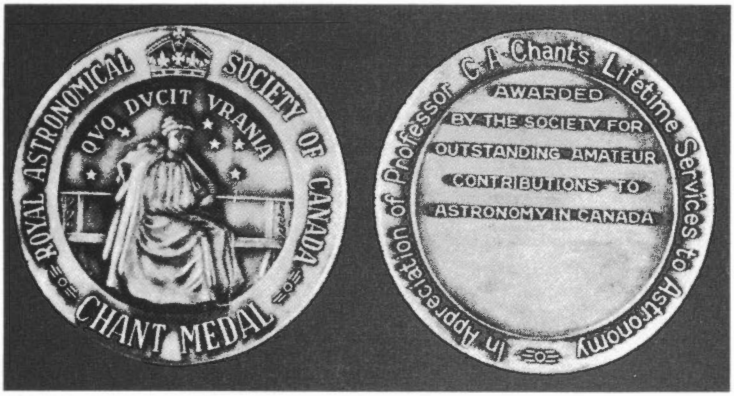


FIGURE 127
Chant Silver Medal.

From the time of the observations of stars made by early French explorers of the 17th century practical applications of astronomy have held the attention and inspired the investigations of many Canadians. But progress in the science has been generally slow and uneven in this country until relatively recent times. Probably the most noteworthy work in surveying and mapping the heavens from anywhere on the northern half of North America was accomplished by Canada's first Surveyor General, Samuel Holland. During his years in office, 1764 to 1801, Holland contributed four papers on astronomy to the Royal Society in England. The first of these described his observations from the islands of St. John (Prince Edward Island) and Cape Breton in order to ascertain the latitudes and longitudes of those places. The second concerned astronomical observations made in 1769. The third paper related to eclipses of Jupiter's satellites as observed near Quebec City in 1774, and the fourth described Holland's astronomical observations in Canada in 1774.[28]

Despite the giant forward strides taken by this country in the realm of astronomy during the Stewart-Plaskett period, the war years with their aftermath of unsettlement brought about a steady decline in Canada's international standing in this area of science.

In telescopic power, for instance, Canada fell from second to eleventh place among the nations between 1935 and 1965. During that 30-year span, during which general interest in studies of the universe greatly increased, no large telescope was established in this country. In the mid-1960s, however, the Dominion Radio Astrophysical Observatory began to function near Penticton, British Columbia, with a research program designed to promote a survey of galactic background radiation as well as the measurement of intensities of brighter radio sources in our galactic system.

Under a plan now pending the federal government has agreed to turn over to a corporate entity composed of a group of western Canadian universities, certain assets already developed for the Mount Kobau (B.C.) telescope project. This consortium consists of three universities in Alberta and three in British Columbia. Cooperation with those institutions of a team of experts from the Dominion Astrophysical Observatory forms one of the important assets involved in this arrangement. The telescope, the mirror of which measures 157 inches in diameter, when erected will be one of the most powerful in the world.

GLOSSARY

Astronomy: the science dealing with celestial bodies, especially their positions, magnitudes, motions, mutual relations and distances.

Astrophysics: a branch of astronomy dealing mainly with the physical and chemical nature of celestial bodies as well as their origin and evolution.

Binary Stars: a form of double star in which the two members are relatively near to each other and revolve around a common centre of gravity.

Epicentre: a point from which earthquake waves seem to radiate, and situated directly above the true centre of disturbance.

Fifteen-inch Equatorial: a type of viewing telescope with object glass measuring 15 inches across, and the main axis of which is parallel to the axis of earth.

Galaxy: our galaxy is the Milky Way. Similar formations are to be found in great numbers beyond our Milky Way and are referred to as external galaxies.

Geophysics: the science dealing with the relationships between the features of the earth and the agencies that produce them.

Gravimeter: a sensitive spring balance instrument that measures changes in the earth's gravity as small as two parts in 100,000,000.

Isostasy: the equilibrium of the earth's crust, a condition in forces tending to elevate, balance those tending to depress.

Photographic Photometry: the measurement of the luminosity of stars from their images on photographic plates.

Radial Velocity: velocity of a star directly in the line of sight as it recedes from, or approaches, the observer who is in a fixed position.

Sidereal: pertaining to, or as determined by, the stars. Sidereal time, for example, is time measured by the apparent daily motion of the stars.

Spectrum Lines: the distinctive lines that appear in the rainbow-like pattern produced when a light source is passed through a prism or reflected from a grating. These lines identify the chemical composition of the source of light, such as a star.

14

THEMATIC MAPS IN CANADA

> *"No study is realistic that treats humanity as if it lived suspended in empty space instead of treading a world of minerals, forests, climates and soils."*
>
> —Isaiah Bowman

Topographical maps, particularly large-scale representations, may be said to depict conventionalized landscape within the constraints of a general system of cartographic techniques. They show the location of things that most people can recognize at sight. There is, however, another major class of maps which are not devoted essentially to the depiction of landscape but which serve to analyze total environment. Until fairly recent times these cartographic productions were known by various terms such as topical, economic, subject, or special-purpose maps or, in the military sphere, as intelligence maps. The term *thematic* is now frequently applied to describe maps of this classification.[1] Thematic maps portray the distribution and characteristics of classes of things which may appear on topographical maps, usually one subject to one thematic map and in addition, deal with many specific environmental factors, such as climate, not directly expressed on any topographical map. For these special purposes thematic maps employ cartographical techniques bearing only an incidental similarity to those used in producing topographical maps. Only a relatively small proportion of thematic maps are made available for direct distribution to the public in separate sheet form. The audience reached by such maps through the medium of atlases is, however, very large.[2]

It should be borne in mind that in the cartographic domain the distinction between maps that are thematic and those that are topographical has not yet been rigorously defined. Many of these special-purpose maps require general outlines of land areas or contoured bases depicting drainage features or elevations, either in simple or complex form. The thematic map, in presenting special information, may utilize topography as a component without emphasizing it.

Thematic maps are used to complement statistical information. The production of thematic maps involves the possession and use of intimate knowledge of the specific topic as well as of the supporting data being used to illustrate that topic in cartographic form. Thematic maps, generally, are of the small-scale variety. Types of diagrams employed to portray specific themes include line, track, or arrow symbols of the sort featured in flow maps to indicate the direction of traffic or trade; histograms, horizontal bars, and pie graphs to provide a comparison of differing sizes, illustrating the scope of a subject in its totality; or the use of sectors of circles to denote proportions of component parts of the whole.[3] The range of symbolization is, in fact, unlimited.

Discussion of thematic maps may be approached by considering the types of distributions and phenomena with which thematic maps deal. The types of distribution may be classified as follows: (a) distribution occurring at points (places) but not between points as, for example, the population of a city or the production of an oil well; (b) distribution along lines but not between lines, such as the volume of flow of a river or volume of traffic flow along a railway; (c) distribution continuous across an area as, for example, atmospheric pressure at the surface of the earth or the extent of population within a settled area larger than a single community.

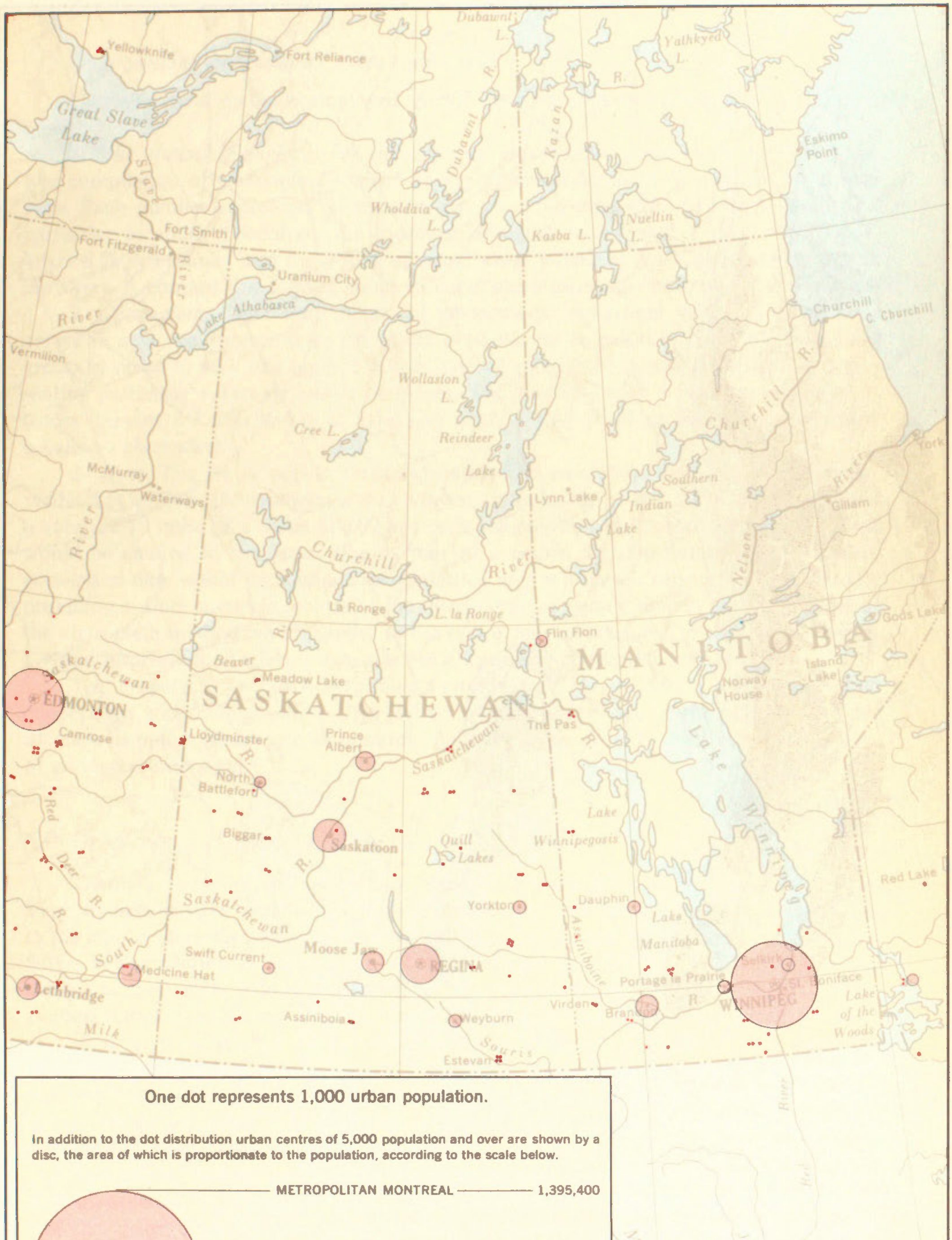
Some kinds of phenomena may be expressed as qualitative types, such as soil or forest classifications. Each type is assigned a color and the resulting map is a composition of area colors. Maps of this kind are sometimes described as *chorochromatic*. In the cartographical expression of quantitative data, such as population distribution or industrial production, the symoblism used is rather diversified and relatively complex. A description of various techniques used in the presentation of such data are considered under the three main headings already mentioned.

(a) Distribution at points but not between points

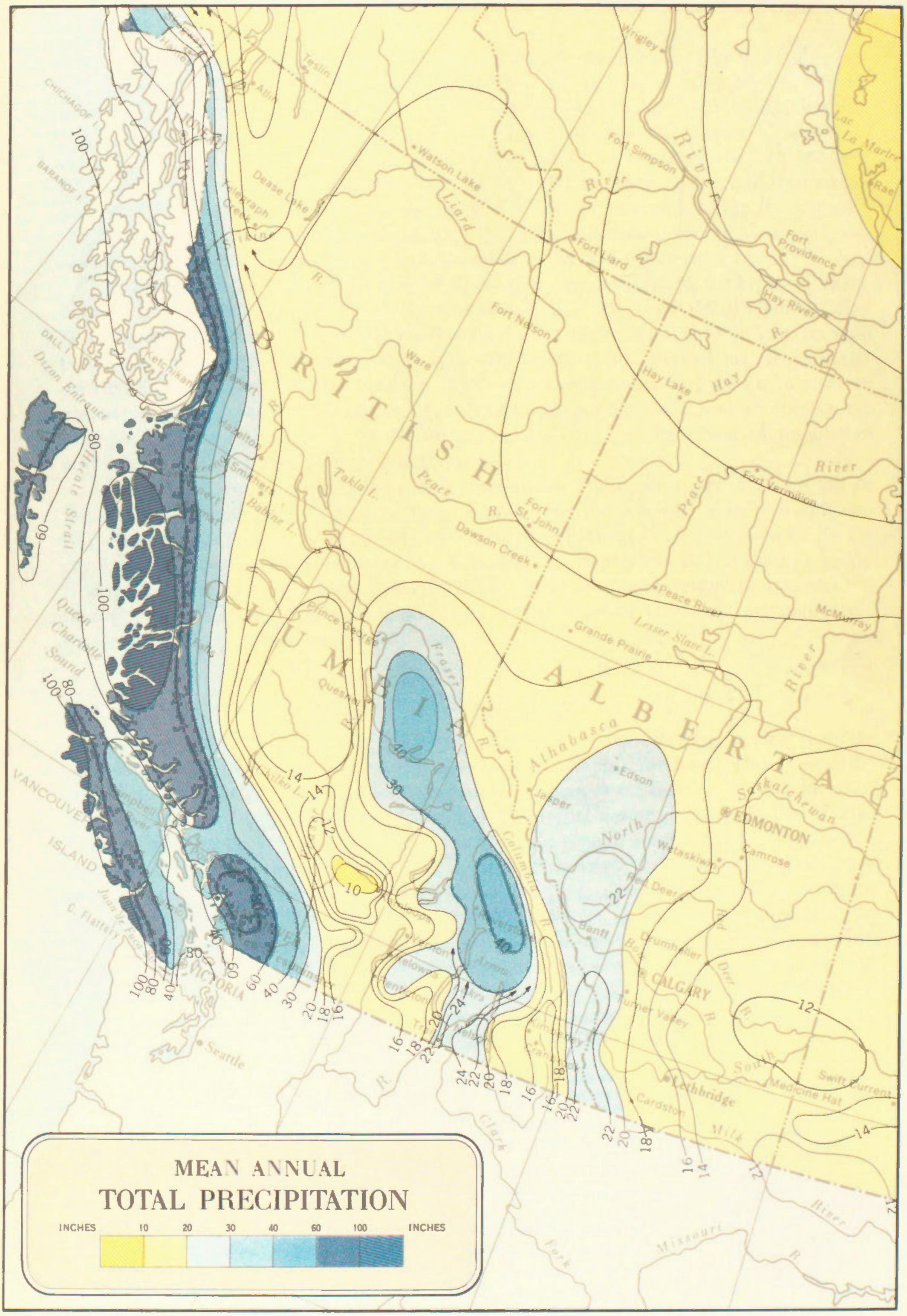
The object of thematic mapping in this category as, for example, portrayal of the population of a city, is to express the quantities by graphic methods. This is done by assigning quantitative values to symbols and by placing these in their correct location. Symbols may be different in shape, size, color or internal design or there may be a combination of some or of all of these characteristics. Any point symbol expressing quantity may be described as a volumetric point symbol. Any plane or solid geometrical form may be used for the purpose. These are of three main types: proportional circles or proportional squares in which the quantity expressed is in proportion to the area of the circle or square; secondly, proportional spheres in which shading is used to give the impression of a sphere; thirdly, proportional cubes in which line work or shading is used to create the impression of a cube. In the cases of cubes and spheres the depicted volume of the symbol is in proportion to the quantitative value of the phenomenon under consideration.

(b) Distribution of quantities along lines but not between lines

The method of expressing quantitative phenomena of this nature is basically similar to that used in depicting values that occur at points or places. The values along the line may be expressed by color of line, type of line, e.g., by a broken line, or by width of line where the width is proportional to the value along the line. These symbols are commonly known as flow lines.



MAP 5. Example of use of volumetric symbols, Atlas of Canada, 1957.



MAP 6. Example of use of isarithms, Atlas of Canada, 1957.

(c) Distribution continuous across an area

Cartographical methods employed in this category may be classified in three main types:

1. The statistical surface, for instance, an atmospheric pressure or weather map. The compilation of a statistical surface begins with a distribution of numbers on a base map. Each number represents a measurement, or value otherwise derived, applied to a particular location. Thereupon the locations of equal values with a prescribed value-interval is determined and the points of equal value joined by lines generally known as *isarithms.* A contour line joining points of equal elevation is one example of an isarithm.

2. Choropleths. For some types of phenomena, construed as being continuous across an area, measurements or values are available not at points but only for delineated areas. In order to map this type of distribution of values, colors are designated as representing particular values or ranges of values. The resulting map is a composite of area-colors showing the distribution of values by areas. This type of quantitative area-symbol is called a *choropleth.*

3. Dots. The use of dots in thematic maps offers an alternative to the use of choropleths. Let us take, for example, a map showing population. A dot, let us say, is assigned a value of 10 units. If a value of 100 has been assigned to a delineated area then 10 dots would be entered in that area. If only part of a census division happens to be settled, population dots would be confined to the settled area within the census division, thereby providing a more accurate picture of the distribution of people than is possible by use of the choropleth method which applies to the entire census division. Dots also may convey a visual impression of relative densities not afforded by choropleth colors.

The preparation of such maps constitutes a task for specialists working in close cooperation with cartographers. The former provide knowledge of the purpose and use of maps as policy guides and as research tools; the latter provide skills in the techniques of graphic presentation.[4]

(d) Other types of symbolization on thematic maps

Thematic mappers employ various types of symbols other than those listed above. Type styles and sizes used in the printing process are capable of conveying information to the map reader other than their strict word-meaning as, for example, the use of sloping letters in the naming of large bodies of water. Index numbers or lettering may be employed as well with reference to descriptive or explanatory text. Map legends often contain complex definitions. Graphs, such as those depicting rainfall in a particular place or region, may be entered directly on the map at the location of the station where the record of precipitation was obtained. Frequently thematic maps carry supplementary graphics such as bar graphs expressing data integral to the subject of the map but which appear either bordering it or included within the map outline. Information in tabular form is often handled in the same manner.

In Canada, federal government departments and universities are among the most active producers of thematic maps. Often such maps accompany the publication of scientific papers, particularly those relating to various aspects of the earth sciences. Important repositories of thematic maps in this country are national and provincial government atlases. Canada is second only to Finland in the issuing of an official national atlas. In 1899 Finland entered this field, to be followed by Canada in 1906 when the Atlas of Canada, prepared under the direction of Chief Geographer James White, was published by the Department of the Interior, Ottawa. This collection contained 40 sheets, consisting mainly of thematic maps dealing with geology, communications, precipitation, temperatures, census returns, drainage basins, and the plans of principal cities.

In 1915 a revised edition of the Atlas of Canada, prepared under the direction of Chief Geographer J. E. Chalifour, was published by the Department of the Interior. It contained 80 sheets consisting mainly of thematic maps dealing with the same topics portrayed in the 1906 atlas. Each of these atlases concluded with a series of diagram maps.

The Natural Resources Intelligence Service of that same federal department issued a publication in 1926 entitled *Canada as a National Property.* With the aid of a number of maps this work summarized natural and other resources of the nation and suggested how best these assets could be developed.

Another outstanding example of a federal government publication containing a number of thematic maps, *Canada's New Northwest,* was published by the North Pacific Planning Project in 1947. The maps portrayed the geology, agriculture, forests, water power, precipitation, trade volume and direction as well as the fishing and transportation industries of the region. These maps were compiled by the Drafting and Reproducing Division of the Bureau of Geology and Topography. The cartography was lithographed and printed by the Geographical Section, General Staff, Department of National Defence.

In the predominantly thematic and most recent Atlas of Canada, published in 1957, the foreword is especially illuminating.* Hon. Paul Comtois, then Minister of Mines and Technical Surveys, in an introductory message stated, in part, that "since the last Atlas of Canada appeared in 1915 the economy of Canada has expanded in all directions. The population of the country has doubled. Newfoundland has joined it as the tenth province, and scientific surveys have revealed to an ever-increasing extent the physical nature of its land and water resources. It is, therefore, the purpose of this edition of the Atlas to present, in maps, an outline of the physical background and the economic development of the nation at mid-century and to show how these factors are interwoven to produce the fabric of the life of our people . . ."

The aim of the 1957 Atlas, as described by Norman L. Nicholson, then Director of the Geographical Branch of the department, was to present "to the world at large a selection of authoritative maps of great accuracy . . . [to] indicate the growth of the economy and something of the extent of the social, cultural and other developments in the country." The Atlas of Canada story begins with descriptions of the exploration and early mapping of the northern half of North America. It continues with treatments of the basic aspects of physical environment, such as relief and climate. Then come maps of population origins and distribution. These sheets are followed, in turn, by those dealing with ways in which the natural resources of Canada are used and with transportation and communications networks that have developed as a consequence. A total of more than one hundred map plates was included in the volume, nearly all of which are thematic portrayals of important aspects of the country and its people. In the production of a national atlas, a project generally accomplished at a slow pace, a number of thematic maps are likely to be obviously out of date by the time of publication. This regrettable and, until now, characteristic defect can be remedied only by greatly expediting the processes of map compilation and printing.

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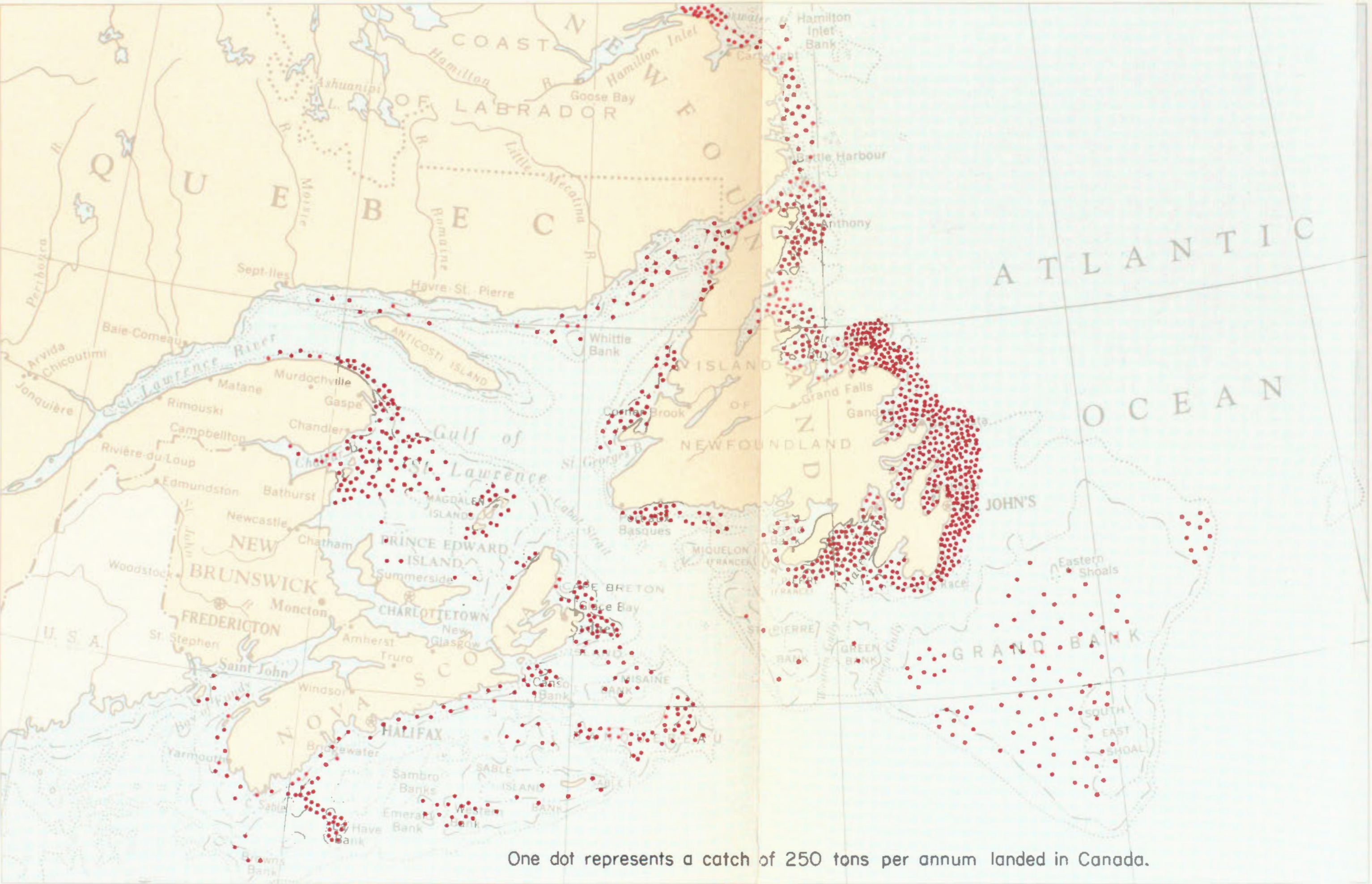
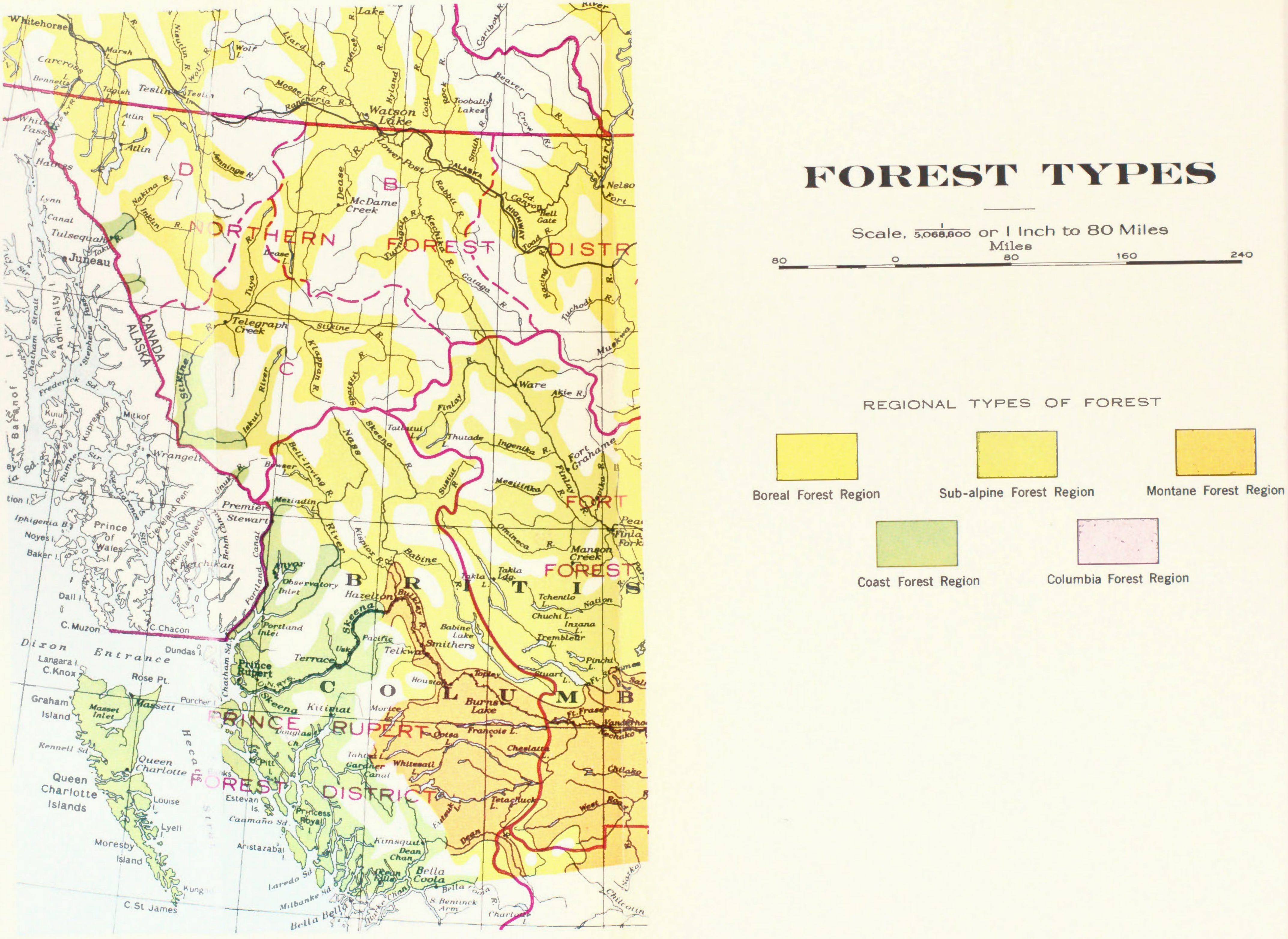
*Occasionally in this chapter atlases and maps therefrom, published after 1947, have been selected to illustrate future trends in Canadian cartography.



One dot represents a catch of 250 tons per annum landed in Canada.

MAP 7. Example of use of dots, Atlas of Canada, 1957.



MAP 8. Part of thematic map produced by North Pacific Planning Project, 1947, showing forest types.

Quebec

The Bureau of Surveys and the Bureau of the Cadaster in the provincial government service of Quebec sponsor the preparation and publication of series of maps. In the case of the former agency, map sheets have been issued covering judicial districts of the province and of Laurentides National Park as well as of seigniory and township lines, without relief, but showing railway lines, and roads. The Cadastral Bureau issues county maps designed to depict municipal boundaries, ranges, and numbered lots of seigniories and townships. Most of these were reprinted from 1935 to 1940. From 1912 on, the Quebec Streams Commission has illustrated its annual reports with river profiles and depths of lakes. The Forestry Service of the province also publishes maps on forest inventories and forest classifications. The Quebec Meteorological Bureau plots data on maps but has not issued sheets except on special request. The Department of Mines of the province, from 1898 on, has issued hundreds of separate geological maps. The Department of Municipal Affairs, Industry and Commerce established an Economic Map Service in 1942, mainly to compile and publish maps designed to accompany soil survey reports, forest inventories, and the Inventory of Natural Resources.[5]

Ontario

In the period under review in this chapter four departments of the government of Ontario carried on mapping and map-making activities. These were Lands and Forests, Mines, Agriculture, and Highways. In the Department of Lands and Forests two branches, Surveys and Forestry, were actively and continuously engaged in collecting data and in making maps. The Department of Mines of the province began to issue maps in 1891. The Department of Highways produced provincial road maps, revised annually. The Department of Agriculture publishes soil maps, patterned after those of the United States Soil Survey. In 1943 a soil erosion and land-use survey report on Durham County was accompanied by a map covering an area of about 22,000 acres in central Ontario. The Ontario Research Foundation, Toronto, is not a department of the provincial government but an endowed body reporting directly to the premier of Ontario. Climatic statistics have been utilized as material for a series of isopleth maps published by the Foundation. Certain soil survey maps of Ontario, on a county basis, are produced by the Department of Chemistry in what is now the University of Guelph in cooperation with the Experimental Farm Service, Ottawa. In 1941 the Forestry Branch produced the Ontario Forest Atlas for use in the schools of the province. This publication contains 14 maps, mostly thematic, concerning forests, forest protection, pulpwood concessions, pulp and paper mills, hydro-electric and mining projects, road and rail transportation in northern Ontario as well as in Crown game preserves.

British Columbia

The British Columbia Atlas of Resources was published in 1956 by the provincial government-supported British Columbia Natural Resources Conference. The provincial Surveyor General and Director of Surveys G. S. Andrews gave assistance in the form of expert advice on the suitability of base maps for this publication and also extended to the project the services of many of his staff. Premier W. A. C. Bennett, in a prefatory statement in the volume, drew attention to the fact that the appearance of the Atlas coincided closely with British Columbia's centennial year. "I wish to congratulate the more than 100 members and associates of the Conference", the premier wrote, "who, over a period of more than two years, turned a magnificent concept into this atlas achievement. The book represents a community of effort in the best Canadian tradition, an original and major accomplishment of a volunteer group whose devotion to the harmonious and integrated development of all our national resources, of men with the land, is well known . . . The fact is recorded here that this atlas is unique in North America, presenting for the first time for any province or state, in colour map form and in associated text and photographs, the story of the people and their resources."

The cartographic editors of this project, in which the University of British Columbia was also actively involved, were A. L. Farley and R. I. Ruggles. Each of the 48 map sheets was prepared specifically for this volume. Thematic maps predominated in this collection and dealt with such topics as meteorology, precipitation, mean daily temperatures, agriculture, fisheries, mining, energy production, recreation, water, distribution of population based on the 1951 federal census returns, explorations and surveys, wildlife, transportation, and manufacturing.

Manitoba

Work proceeded for a number of years on an Economic Atlas of Manitoba under the direction of Professor T. R. Weir of the provincial university. This collection of maps, nearly all thematic, was published by the Manitoba Department of Industry and Commerce. It is composed of 37 map sheets, divided into three categories: Resource Base; Population and Settlement; and Resources Use. The first part or category consisted of maps depicting drainage, geology, glaciation, soil types, temperatures, and precipitation. The second part included maps on rural and urban population, population density, native peoples, and ethnic groups. The third depicted types of farming, crops, and wildlife; also water resources, electric power production, mines and minerals, fishing recreation, transport, and manufacturing.

New Brunswick

Apart from atlas projects some Canadian provinces and some private firms produce, from time to time, separate thematic map sheets. In New Brunswick in the 1940s maps were being made conveying information gathered during forest surveys. In these maps topography was subordinated to types of timber. A map of the province portraying motor roads, railways, and recreational resources was published in 1938 by the New Brunswick Department of Lands and Mines.

Alberta

In Alberta, soil maps were issued by the provincial Department of Agriculture in this period in cooperation with the University of Alberta. In addition, in 1941, Alberta Publicity Director Campbell issued a map showing railways, highways, airports, trails, irrigation canals as well as cities and towns. Information on provincial flora and natural resources was superimposed on a topographic base.

Saskatchewan

In Saskatchewan maps issued by the provincial Department of Agriculture depicted the incidence of hail and grasshopper infestation. The department also issued blueprint dot maps showing distribution in the province of cattle, sheep, horses and hogs, based on 1936 census data. Soil maps were published also. The provincial Department of Natural Resources published maps of Saskatchewan's forests and provincial parks as well as fire-protection maps.

Prince Edward Island

The island province claims the distinction of publishing in 1925 the first of the official provincial atlases to appear in Canada, namely, the Atlas of Province of Prince Edward Island and the World. This publication resembles a county atlas of the type produced in central Canada in fair numbers during the last half of the 19th century and the early years of the 20th century. The cadastral map of each lot of real property in the several counties of the province was reproduced in this collection, showing the owner's name in each case. These sheets also served as population maps.

Northwest·Territories

Under the direction of W. O. Kupsch an atlas of the region was prepared as a working paper for the Advisory Commission on the Development of Government in the Northwest Territories. The results were published in 1966. All maps contained in this collection were draughted by W. Loates and Associates, Ottawa, and included portrayals of mineral resources, Royal Canadian Mounted Police detachment posts, transportation services, forest resources, tundra areas, ice cover, snow cover, temperatures, geology, and wildlife resources.

Thematic maps and thematic map conventions are being used increasingly by many sciences, particularly earth sciences, to communicate information on two- or three-dimensional distributions. In the realm of cartography thematic mapping offers a challenge to all who are interested in the development of more effective methods of communication by graphic media.

When mapping by means of computers becomes common procedure, a development that now appears to be inevitable, there is every prospect that information for all types of thematic maps will be stored in data banks for retrieval and use when required. This process of digitizing cartographic information for the "storing" of maps is certain to lead to the production of a greater number and variety of up-to-date thematic maps.

GLOSSARY

Conventionalized Landscape: The depiction of an area as it is experienced but conventionalized to the degree of including only a standard set of items.

Flow map: One depicting measurement, by the use of lines and bands, of moving phenomena in terms of volume, direction, intensity, etc.

Isogram: An over-all term denoting a large family of cartographic expressions using the prefixes "iso" or "isa" to describe lines involving the factor of equal values.

Isarithm: (isometric line): A line that represents constant value obtained from measurement at a series of points (see Map 6).

Isopleth: A type of isogram, being a line connecting points *assumed* to have equal values.

Qualitative Mapping: Expresses the nature, quality, or type, in a descriptive sense, of the matter being mapped (see Map 8).

Quantitative Mapping: Mapping based on values measured in terms of numerical expressions (see Map 5).

15

THE GEOLOGICAL SURVEY OF CANADA: THIRTY YEARS OF MAPPING, 1917-1947

"*Give me the map there.*"

—*King Lear*, Act 1, Sc. 1.

Three years after the Geological Survey of Canada came into being under Logan the Parliament of the Province of Canada confirmed, in statutory form, that the Survey had been organized "to make an accurate and complete Geological Survey of this Province, and to furnish a full and scientific description of its Rocks, Soils and Minerals which shall be accompanied with proper Maps, Diagrams and Drawings . . ."[1] That was in 1845.

Cartographic functions of the organization were re-emphasized in sections 5 and 8 of the act establishing the Geological Survey *Department* in 1890. In 1907 in the Geology and Mines Act (ch. 29, 6-7 Ed. VII), under which the Department of Mines of Canada was created, these particular duties of the Survey were repeated in section 21, with the italicized words added:

"The Minister may, for the purpose of obtaining a basis for the representation *of the mineral, mining and forestry resources and* of the geological features of any part of Canada, cause such measurements, observations, investigations and physiographic, exploratory, and reconnaissance surveys to be made as are necessary for or in connection with the preparation of *mining,* geological *and forestry* maps, sketches, plans, sections or diagrams." This legal arrangement of words might appear, in the eyes of geologists, to place the cart before the proverbial horse. Such scientists would be more inclined to the view that the functions of cartographic portrayal are subservient to knowledge gained in the field and that mapping is but the means to an end.

A good geological map is much more than an objective depiction of facts. It is, as well, a subjective presentation of interpretations based upon numerous observations as well as on theories regarded as valid at the time the map was made. Although at first glance geological maps appear to be static and timeless, such is not the case. As geological science evolves, so also will geological maps continue to depict developing concepts.[2]

In the preparation of such maps the Canadian geologist, during at least part of the time span under review in this chapter, commenced his task equipped with an accurate topographic map or maps and with air photographs of the area under his investigation. Prior to 1908 the geologist in this country had no alternative but to draw his own topographic base maps. But since that year topographers, organized in a division within the Geological Survey, provided him with this type of cartography. Thus equipped, and before he attempted to convey any geological information on a map, he decided upon the classification by origins of the various rocks coming under his examination. He would make a statistical analysis of hundreds of field observations in order to determine the shape of folds, the positions of faults, or the significance of fossil clusters. Included in his map would be interpretations of geochemical analyses and geophysical measurements. The geologist also selected map symbols along with a general scheme of presentation to enable the map user to peer deeply into the mapped structure and to visualize the distribution and relationship of rocks beneath the surface of the earth. All these tasks were accomplished within the statutory reference provided for the guidance of the embryo organization.

By the time of the First World War, seventy years after the Geological Survey's original guidelines had been given legislative expression, its mapping and related functions had resulted in the establishment of several new divisions within the organization. In addition to the Topographical Division in charge of W. H. Boyd, a Geographical and Draughting Division and a Photographic Division were in operation. In order to reduce possibilities of confusion in the minds of readers, the topographical survey work of the Geological Survey will be identified in this chapter as T.S.G.S. in order to help distinguish this organization from other federal topographic mapping agencies, such as those of the departments of the Interior (under the Surveyor General) and of National Defence. But it should be kept constantly in mind that three distinct stages of cartography are involved in geological field work and its aftermath, namely, the provision of base maps by the T.S.G.S., geological mapping by the geologist himself, and, thirdly, map draughting and reproduction by or through the division of that name functioning within the Geological Survey.

On occasion mapping in the field was adventuresome to the point of extreme danger. K. G. Chipman, for instance, was fortunate to survive an encounter with a grizzly bear in British Columbia. Chipman was chief at the time of a T.S.G.S. party that had camped one evening on the bank of Mineral Creek. He had started out to examine the mountainside at the rear of the tents in order to discover the most feasible way to scale the steep slope on the following day. After a while the topographer sat on a log to rest himself when, without warning, a bear charged savagely toward him out of some nearby bushes.

As Chipman rose to his feet he caught sight of a pair of bear cubs to one side and behind him. Unwittingly he had placed himself between a female grizzly and her young. Firing one shot from his rifle at the onrushing animal the mapper turned and raced down the steep mountainside. The bear followed at such speed that she rushed past him before she could check herself. Instantly Chipman turned and ran back up the hill. Because a bear can climb a steep slope with relative ease the grizzly soon caught Chipman and began to shake him as a terrier would a rodent. Luckily the fierce shaking motion caused the enraged animal to lose its footing and both bear and man rolled together some distance downhill before coming to rest.

At this point Chipman displayed commendable presence of mind. On being stopped by a bush he lay perfectly still, feigning death. The grizzly sniffed him thoroughly and then, apparently satisfied that he was dead, ambled off to join her cubs. Members of the party carried their injured chief to camp and made him as comfortable as possible. A doctor was brought to the campsite after some difficulty and delay. He found that the leather leggings worn by Chipman had saved from serious injury his right leg below the knee. The knee of the left leg, however, and the part above the knee was painfully ripped and inflamed. Otherwise, except for minor scratches and torn clothing, Chipman remained in one piece. Several of his party worked hard to cut a trail through timber in order that the injured man could be carried to a hospital. There Chipman recovered fully from the effects of the vicious mauling he had received.[8]

In 1916, in order to make possible closer supervision of geological parties in the field, Canada was divided from coast to coast into seven administrative districts. Each of these districts, for purposes of geological investigation, was placed under a member of the Geological Survey staff in the following arrangement: Nova Scotia (E. R. Faribault); Eastern Quebec and New Brunswick (G. A. Young); Precambrian Ontario and Quebec (W. H. Collins); Great Plains (D. B. Dowling); Northern Exploration (C. Camsell); British Columbia (O. E. LeRoy); and Northern British Columbia and the Yukon (D. D. Cairnes).

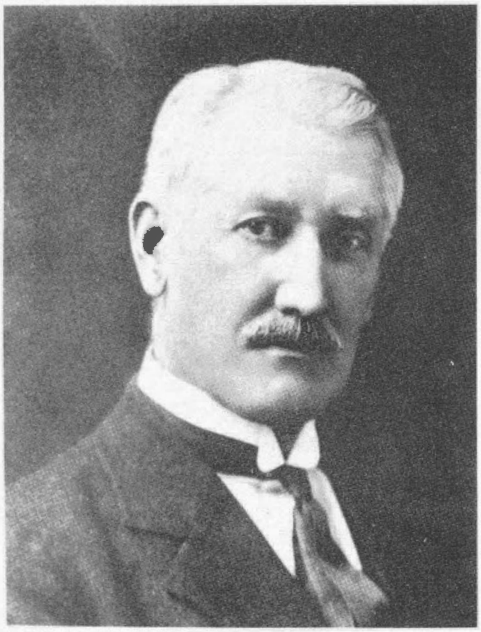


FIGURE 128. D. B. Dowling.

This was a wise, constructive and forward-looking step but, in general, the regime of William McInnes (1858-1925), who had succeeded Reginald Walter Brock in 1914 as Director of the Geological Survey, was marked by disruptions which he could not avoid but which he did his best to mitigate. His special abilities as a leader were brought into full play as he began his six-year term as director in the early days of the First World War. The staff of the Survey was depleted in two ways at this stage of its history.

Not only did the Survey lose a number of experienced members by enlistment in the armed services, many university graduates in geology also enlisted instead of commencing their careers as members of summer field survey parties. When the war ended most of the former staffers returned to the Survey. But the losses were profoundly felt. Major W. E. Lawson, a senior topographer, had been killed in France. Capt. O. E. LeRoy, who had been in charge of field work under Brock, was lost at Passchendaele. J. D. MacKenzie worked for a few seasons in the field following active service overseas but died in 1922 as a result of war wounds; he had just completed detailed geological mapping and study of structures in the northern part of the coal basin in the vicinity of Nanaimo on Vancouver Island.

A wartime catastrophe within Canada also hampered, for a time, the work of the Survey. After the destruction by fire of the Parliament Buildings in Ottawa on the night of February 3-4, 1916, it became necessary to provide, without delay, suitable accommodation for both houses of Parliament then in session. The Victoria Memorial Museum was considered to be the best available building in the capital for that purpose. But as the structure was fully occupied by administrative offices of the Department of Mines as well as by the offices and museum of the Geological Survey, a rapid, large-scale transfer operation became imperative. On the morning of February 4 the moving of staff and equipment began. The House of Commons met in the auditorium of the Museum building in the afternoon of that day. The swiftness of the transformation was made possible by the willing cooperation of all on the Geological Survey staff and of Mines Department officials. With only a few exceptions the Survey organization made its new home in government-owned premises on the north side of Wellington Street, west of Bank Street.[4]

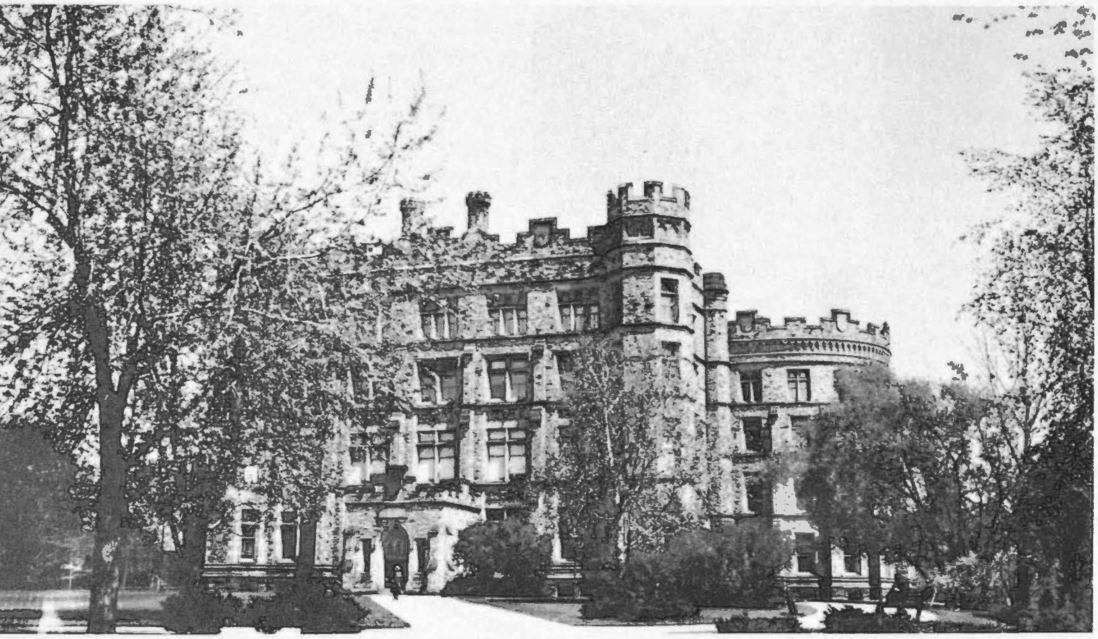


FIGURE 129. Victoria Memorial Museum, Ottawa.

FIGURE 130. William McInnes.

In the immediate post-war years McInnes faced formidable personnel problems. Salary increases came but slowly in the civil service in those days. At the same time offers of more lucrative rewards were being made to federal geologists by universities and mining companies. In a number of cases these attractive opportunities were accepted. Despite such set-backs the Geological Survey program for the summer season of 1919 covered a wide range of investigations. For example, E. M. Kindle continued field work in the Mackenzie River basin, giving particular attention to the stratigraphy of the area in which indications of petroleum had just been discovered by the Imperial Oil Company. F. J. Alcock spent the season collecting data essential to the geological mapping of a part of northern Manitoba. W. H. Collins continued his study of iron formations in the Michipicotin district of Ontario. He gathered sufficient geological and geographical information, including a survey of canoe routes in the area, to construct a map covering 500 square miles on a scale of one mile to the inch. This cartography proved to be quite suitable for prospecting and other exploratory needs.[5]

Clovis-Omer Senécal, Chief Draughtsman of the Geological Survey, reported that 41 new geological maps had been published during 1919 and that 19 other maps were in the hands of the King's Printer for engraving, lithographing and printing.* In addition, 35 other maps were in various stages of progress. A large number of sketches, diagrams and figures for illustrating various publications of the Survey had been prepared as well.

Early in 1920 parliamentarians returned to the Hill where a magnificent new edifice had been constructed. The staff of the Geological Survey then moved back to quarters in the Victoria Memorial Museum. In May of that year a young Manitoban and former pilot in the Royal Air Force, who had served as a student assistant on Geological Survey field parties from 1913 to 1917, joined the permanent staff as assistant geologist. He was Dr. George Hanson (1891-1967), destined to become head of the organization in 1943.

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*The King's Printer did not print maps on his Ottawa premises but distributed such work, under contract, to commercial firms in Canada.

The year 1920 also marked the addition of Dr. George Sherwood Hume (1893-1965) to the Survey staff. Dr. Hume also developed into a leader in this field. In June, 1920, Charles Camsell was promoted from the staff of the Geological Survey to the position of Deputy Minister of Mines. In November of that year William Henry Collins (1878-1937) became Director of the Geological Survey. McInnes was placed in charge of the organization's new museum and also functioned as chief editor, Department of Mines, occupying this dual role until his death on March 10, 1925. During nearly 45 years of service to Canada McInnes had seen the Geological Survey's displays and collections, which formed the core and basis of the Victoria Memorial Museum in Ottawa, grow from very small proportions into an agency of special importance in the educational and scientific circles of this country.

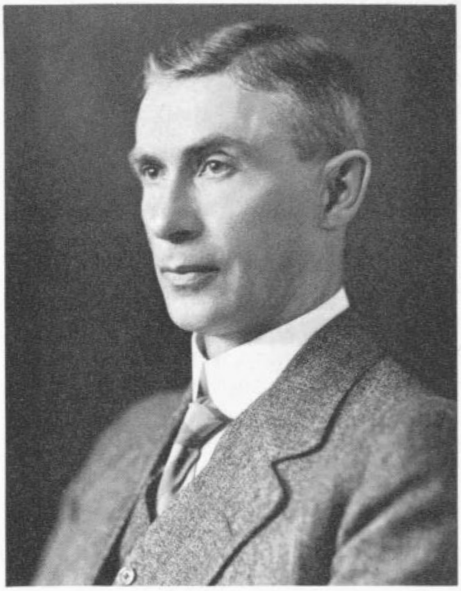
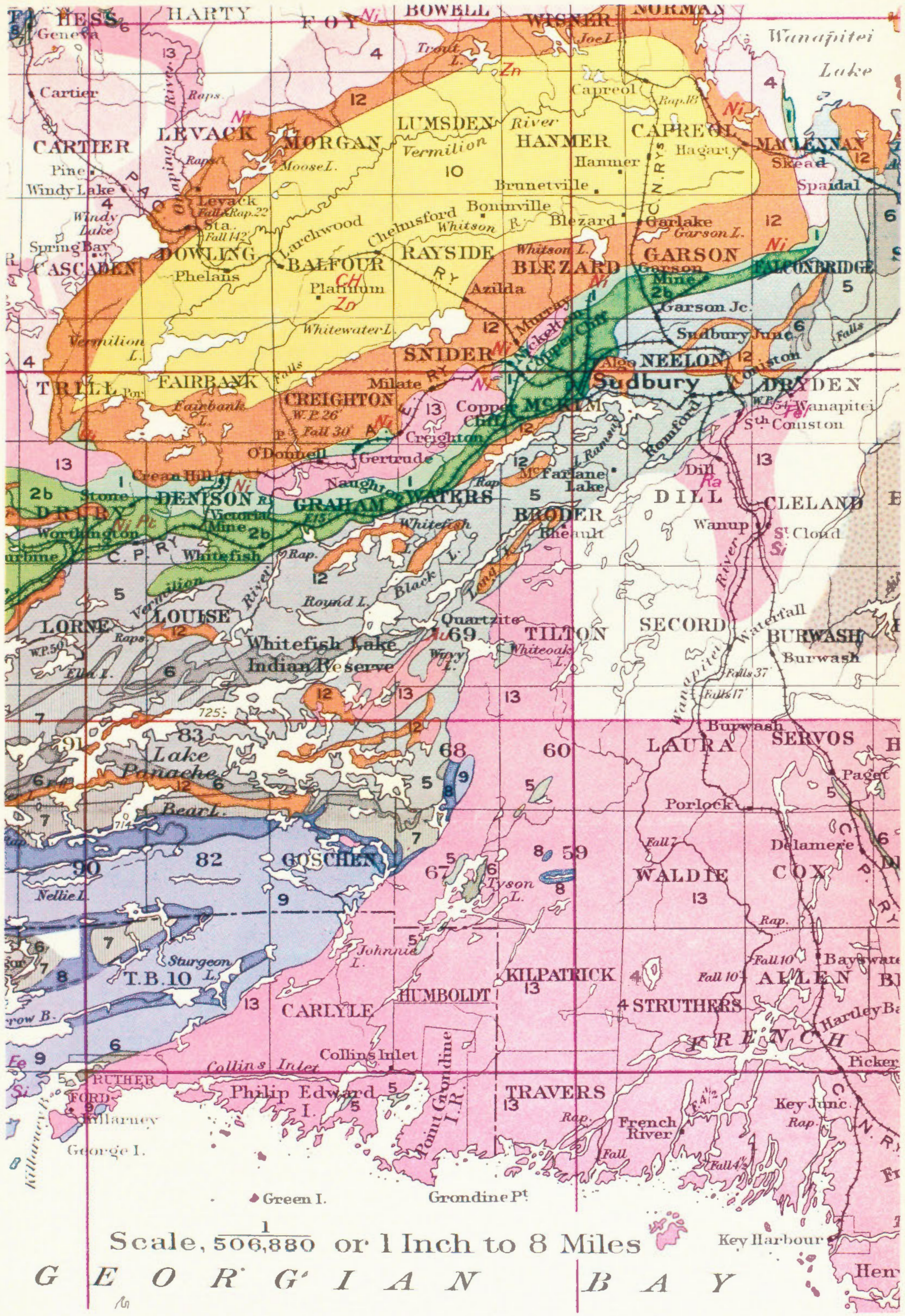


FIGURE 131. W. H. Collins.

Between 1915 and 1920, when the energies of so many Canadians on the home front were concentrated more upon production from known resources than upon the discovery and development of new sources, operations of the Geological Survey became restricted largely to problems of mineral output in districts within easy reach of transportation facilities. Exploratory work was almost completely suspended. With the return of more normal economic conditions in the early 1920s public attention was directed once again to the search for mineral deposits. In keeping with this change in emphasis the Geological Survey resumed its exploratory operations and related mapping activities.[6]

For some years the Geological Survey had been handicapped by a lack of accurate, large-scale topographic maps, a type of aid indispensable to effective geological field work. Gradually, however, the T.S.G.S. recovered its pre-war strength of personnel and vitality. This resurgence brought about a marked increase in work output along with renewed hopes for continuing expansion. In the Survey's annual report for the 1922 field season the comment was made that "the topographical parties, while engaged in preparing base maps for geological use, mainly in areas containing mineral deposits, are producing



KILLARNEAN BATHOLITHIC INTRUSIVES

13 *Granite, gneiss and pegmatite rich in potash.*
Recrystallized sedimentary inclusions usually abundant.

KEWEENAWAN (?)

12 *Mostly sills and dykes of quar ıbase and quartz norite.*
Included with these are variou er intrusive types and
some basic lava flows of unce Huronian ages.

HURONIAN

WHITEWATER

10 CHELMSFORD, *gray feldspat uartzite.*
ONWATIN, *dark gray to black c naceous slate.*
ONAPING, *agglomerate and co to fine tuffs,*
in ascending order.

COBALT

9 UPPER WHITE QUARTZITE
BANDED CHERTY QUARTZITE *ricoloured*
thin-bedded silty and calcare quartzite.
LORRAIN, *impure to pure white artzite; quartz*
and red jasper conglomerate.

8 GOWGANDA, *a variable assemblage of boulder*
conglomerate, greywacke and impure quartzite of
glacial or frigid-climate origin.

BRUCE

7 SERPENT, *white feldspathic quartzite.*

6 ESPANOLA, *recrystallized calcareous silt and magnesian*
limestone thinly interbedded in varying proportions.
BRUCE CONGLOMERATE, *boulder conglomerate and some greywacke.*

5 MISSISSAGI, *mostly feldspathic white quartzite with rare*
lenses of quartz conglomerate; some argillite members.
RAMSAY LAKE, *boulder conglomerate and arkose.*

PRE-HURONIAN

BATHOLITHIC INTRUSIVES

4 *Granite, gneiss and pegmatite poor in potash.*
Evidently includes a group (ALGOMAN) *younger than* (2), *and*
another (LAURENTIAN) *group o er than* (2), *but not separable.*

3 *A complex of igneous granite a gneiss and recrystallized*
sediments (quartzite, paragneis nd crystalline limestone)
of Grenville-like appearance. H rto believed contemporaneous
with (4), *but probably the igne ortion is partly or altogether*
equivalent to (13).

SEDIMENTS

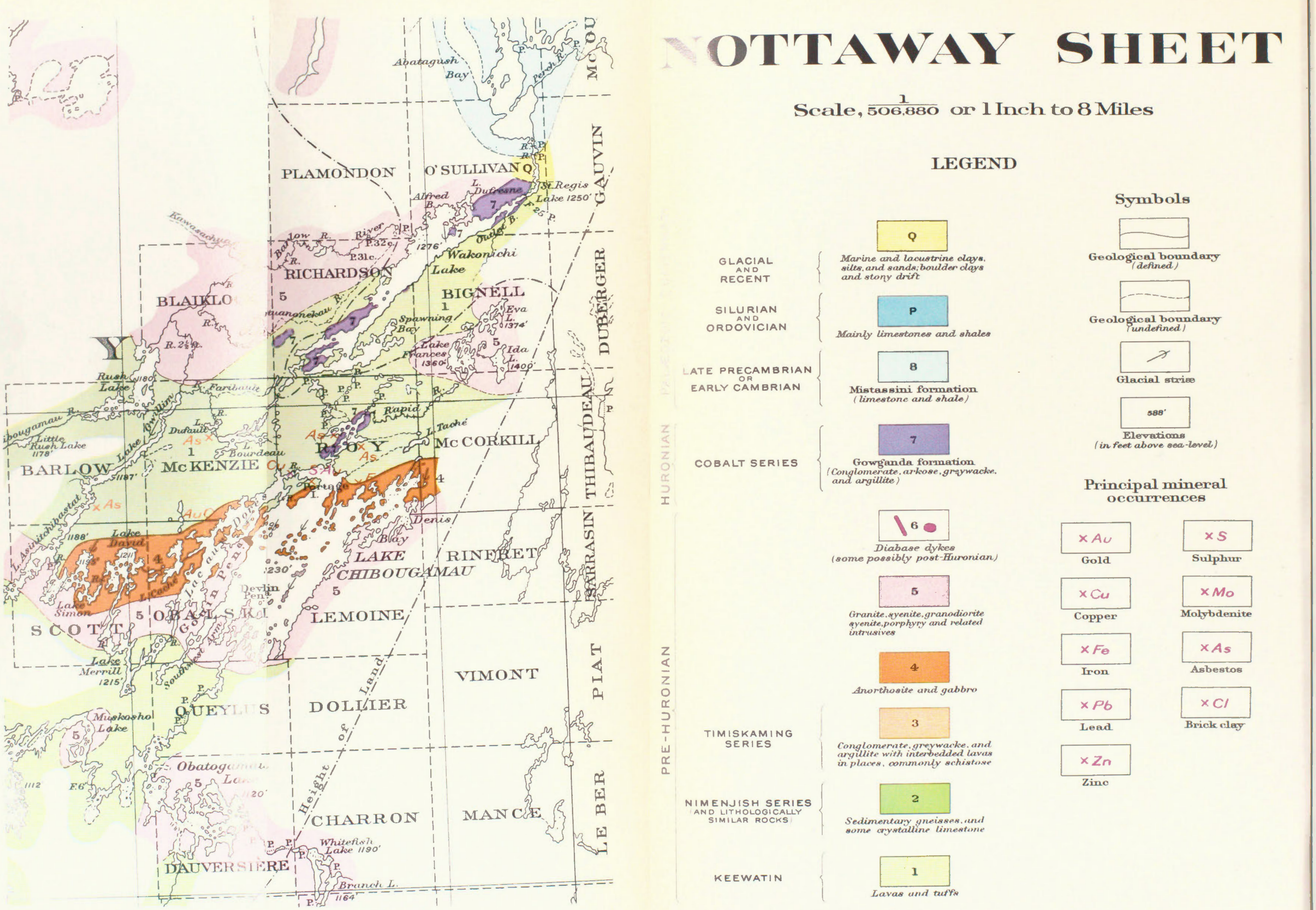
2 DORÉ SERIES (2a), SUDBURY SERIES (2b), TIMISKAMING SERIE (2
BATCHAWANA, RIDOUT, KIASK l *other series* (2).
Clastic assemblages consisting some or all) boulder conglomerat
greywacke, impure quartzite an olcanics. These series occur at
different horizons in (1), *and ar dently not of the same age.*

VOLCANIC COMPLEX (KEEWATI

— - *Iron formations, or local depos f banded silica*
carbonate and sulphides that r throughout (1).

1 *A schisted complex, mainly of s but including*
local sedimentary deposits.

MAP 9. Part of Lake Huron sheet, Map 155A, pu lished by the Geological Survey of Canada, 1933.



MAP 10. Part of Nottaway sheet (Quebec), Map 109A, published by the Geological Survey of Canada, 1927.

these maps on scales and according to standards which make them contributory to the systematic primary mapping of the country."

In 1921 the Survey staff was augmented, in its map reproduction work, by a unit of four copperplate map engravers transferred from the Printing Bureau. This action had been taken following a government decision to distribute its copperplate engravers among the principal map-making departments in Ottawa. Although continuing as nominal employees of the Department of Public Printing and Stationery, Robert Veitch, J. W. Tuttle, A. Stewart and W. W. Arnold were placed with the Geological Survey and exercised their special craft as part of its staff. By early 1922 this unit, with Veitch in charge, had completed the engraving of a series of postal maps for the Post Office Department as well as a chart for the Hydrographic Survey of Canada. About this time the Geological Survey was divided, in its map-making functions, into a Geographical and Draughting Division with Omer Senécal as chief, and a Map Engraving Division under Veitch.

Over a number of years a gradual change had taken place in the nature of the principal activities of the Geological Survey. For a prolonged period following its formation the Survey, although essentially geological in character, was the only government or other organization in Canada engaged in the task of assembling reliable information on the natural resources of this country. Later on, various federal and provincial government agencies began to function in resource fields. Accordingly the Geological Survey of Canada turned from its initial concern with the broader picture to a steadily growing preoccupation with the needs of a prosperous, vigorous and rapidly developing mineral industry. Also it was becoming more deeply involved in the maintenance of a working liaison between numerous federal and provincial authorities sharing responsibilities in geological and related matters. This liaison came to include formal notification each year to the provinces of the nature of, and detailed description of, field operations contemplated by the Geological Survey.

A quick backward glance at this stage was sufficient to reveal the extent of the progress made. In 1843, in the first active full year of its history the Survey consisted of its director, Logan, and one geologist, Murray. By the field season of 1923, eighty years later, the staff of the organization totalled 94 persons. Another example of its growth is found in the realm of photography. From the production of pioneer Canadian photographs made during a field trip in 1860 by James Richardson of the Geological Survey, that organization's collection of photographs had expanded to a total of 56,000, covering a remarkable range of topics and containing many original pictures rich in historical interest and value.

The relentless expansion of demands upon the Geological Survey in post-war years was reflected in the increase in the number of its field parties from 39 in the 1922 season to 47 two years later and to 54 in the season of 1925. This latter level of activity was maintained, on the whole, until the onset of the world-wide economic depression. During the 1920s about two-thirds of all parties in the field were carrying out geological investigation work. Other groups performed various related functions including exploratory activities and surveys preliminary to the construction of topographic maps.

In 1921, a peak year in the production of maps by the Geological Survey, Senécal reported a total of 79 maps published, 15 in the hands of the King's Printers, and 34 others in various stages of compilation. Subsequently the annual output of maps by this organization settled down to a level of about 20 sheets. Among those of special significance being compiled in the 1920s was the copper-engraved, 8-mile-to-the-inch, Lake

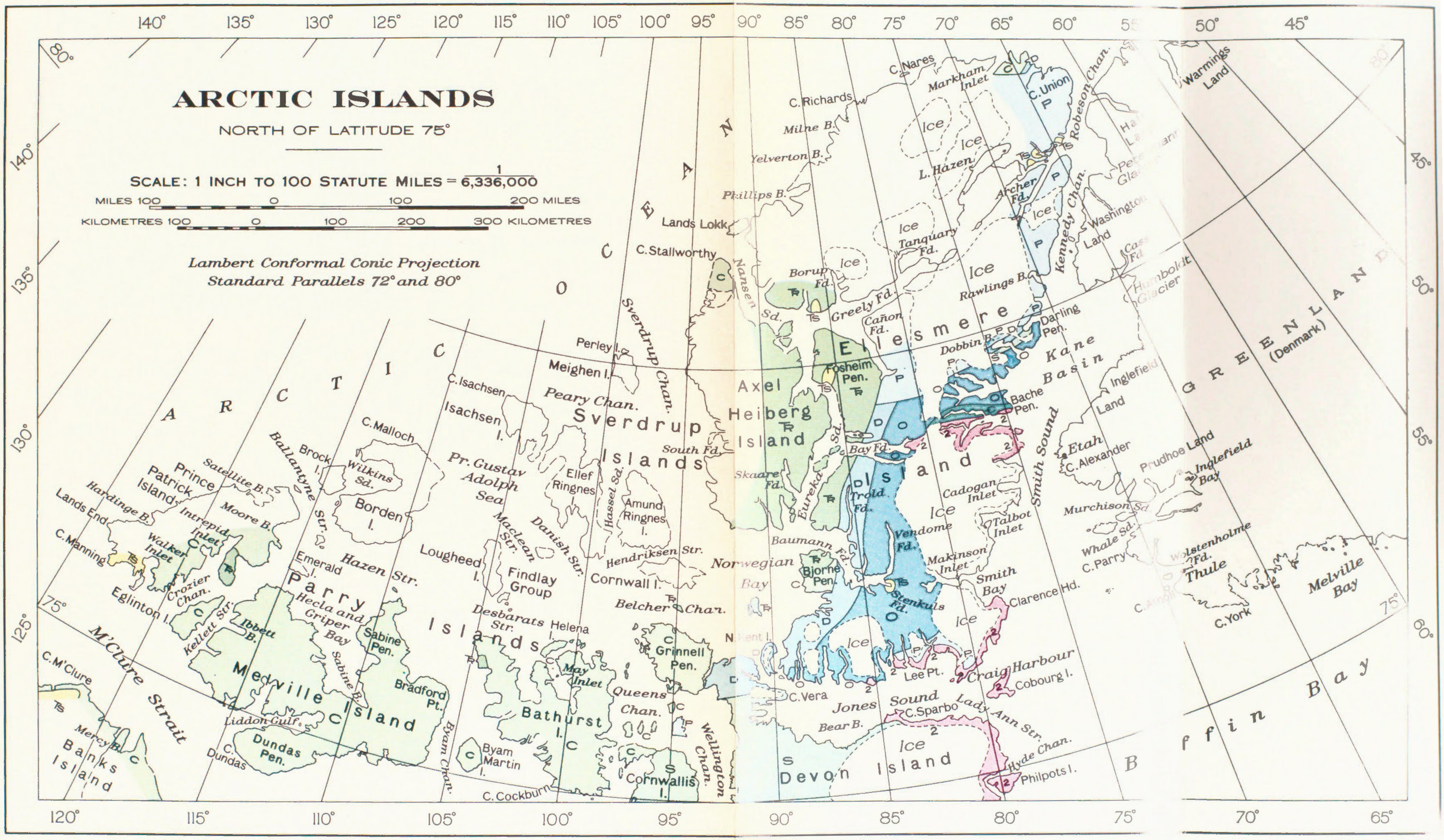
Huron sheet, issued in 1933. This geological map, now out of print, depicted an area from the Ontario-Quebec boundary westward to Lake Superior and extended from Lake Huron northward to latitude 50° North, covering about 90,000 square miles. Another geological map of prime importance in this series was the Nottaway sheet (Quebec Province), published in 1927, depicting the northwestern part of that province adjacent to the area portrayed by the Lake Huron sheet. The Nottaway map represented an area of about 140,000 square miles, extending between latitudes 48° North and 52° North, and from near Lake St. John on the east to the Quebec-Ontario boundary on the west.[7]

Collins, in his annual report for 1926-27 observed that since 1842 the Geological Survey had issued regularly reports and maps and that its total cartographic output during that period exceeded 1,000 maps. There was mention in the department's reports of the cooperation of the Royal Canadian Air Force during the 1926 field season in the task of completing approximately 4,000 square miles of vertical photography in the Rouyn mining district of Quebec. These photographs were produced to be used by the Geological Survey organization as well as by the Topographical Survey Branch, Department of the Interior, in the preparation of maps for publication. It was observed that the photographs afforded a more accurate delineation of rocky areas and drift-covered areas than had been possible otherwise, a distinction of much practical value to prospectors.

In 1926 Senécal was promoted and given the title "Geographer".[8] Dickison succeeded him as Chief Map Draughtsman and in the annual report of the Department of Mines for that year Senécal and Dickison began to issue, jointly, annual work summaries on behalf of the Geographical and Draughting Division. Robert Veitch remained in charge of the Map Engraving Division. "Mapping and map publication", Senécal and Dickison reported, "constitute an important phase of the work of the Geological Survey . . . reports and bulletins are illustrated by maps, plans, and diagrams. As well, separate topographical sheets are published for distribution." In the year following this innovation, the two divisions were merged to form the Geographical, Draughting and Engraving Division. A year later, 1922, Senécal's work entitled *Transverse Polyconic Projection for General Maps of Canada* was published as a Museum Bulletin. After 41 years of uninterrupted and distinguished service with the Geological Survey, Senécal retired on August 24, 1931. He had succeeded James White in 1899 as Chief Draughtsman, Department of the Interior. Senécal made a number of highly useful contributions to the advancement of cartography in this country, including the development by him of a process of color lithography used in printing Canadian geological maps of the period. For many years he was a highly valued member of the Geographical Board of Canada.

By 1927 Alexander Dickison (1880-1957) had been made chief of the Draughting and Reproducing Division in succession to Senécal. Dickison began his training as an apprentice map draughtsman at John Bartholomew and Son, the world-famous map-making firm in Edinburgh, Dickison's birthplace. Following war service with the Royal Scots in South Africa, Dickison returned to Bartholomew's and completed his training. After association for a time with the topographical section of the intelligence division of the War Office in London, Dickison came to Canada in 1905. In May of that year he was appointed to the staff of the Geological Survey, Ottawa, as a map draughtsman.

A tall, wide-shouldered, splendidly built man, Dickison was very much the perfectionist in his work. His qualities of leadership, including a firm belief in strong discipline, soon became apparent. By 1912 his name began to appear in the regular published annual reports of the Survey and by 1919 he had been made Supervisor of Map



MAP 11. Arctic Islands, inset shown on geological map of Canada, Map 820A, published in Ottawa, 1945.

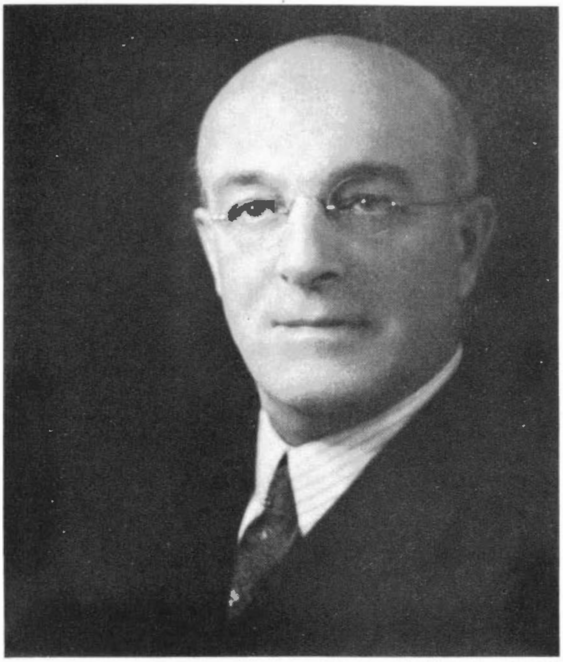


FIGURE 132. Alexander Dickison.

Preparation and Reproduction. In January, 1930, he succeeded Senécal on the Geographic Board of Canada and, in time, became its chairman. By 1936 he was in charge of a staff of 34 skilled craftsmen in the employ of the Geological Survey.

When Dickison retired in 1945 his office associates presented him with a framed, illuminated message expressing admiration "of your accomplishments in the pursuit of your ideals for geological and topographical mapping to the desired perfection, culminating in the production of the Geological Map of Canada." Dickison took special pride in this cartographic accomplishment which he regarded as the crowning achievement of his forty years in the federal civil service. It was published in 1945 as Map 820A in the catalogue of the Geological Survey. This monumental production was issued in an east sheet and a west sheet, the scale being 60 miles to the inch. It is unique as a Canadian-made map in as much as, for the first time, the Arctic islands were included separately in an inset on the same projection as the mainland of Canada (Lambert Conformal Conical) so that the distortion of our northern territories that normally occurs was eliminated to a marked extent. The region portrayed in the inset was drawn on the basis of its own two standard parallels. S. C. McLean, a topographical engineer and expert in the application of projections to mapping problems, gave valuable assistance in the drawing of this remarkable map.

The year 1935 was an epochal one for the Geological Survey. Parliament was asked by the federal government to vote a very substantial increase to the Survey for its field work program in that year. The legislators were quick to respond to the opportunity and this favorable development brought about a considerable expansion of activity both in the field and in the acquisition of new equipment. The rather abrupt revival in the fortunes of the organization was partly the result of a government effort to enlarge employment opportunities in Canada in a useful, constructive manner. Included among more than 1,000 direct beneficiaries of this expansive policy in the 1935 season were a number of geological and mining students then attending Canadian universities. In all, 188 parties were placed in the field by the Geological Survey on 65 separate projects.

This activity was largely concentrated in gold-producing, petroleum, natural gas and asbestos areas.

Collins retired as Director of the Geological Survey in 1936 and was succeeded by George Albert Young, who served as Chief Geologist until 1943.

FIGURE 133. G. A. Young.

At this stage in its progress a Bureau of Economic Geology was formed with Francis Christopher Chisholm Lynch (1884-1963) in charge. Lynch had entered the federal civil service in 1906, joining the Department of the Interior under Robert Evans Young, a land surveyor of eminence in western Canada who had been appointed superintendent of the Railway and Swamp Lands Branch of that department. Lynch soon became assistant superintendent of the branch and, at the age of 27, succeeded Young in 1911. About 1915 the Department of the Interior created the Natural Resources Development Bureau. Five years later this organization was renamed the National Development Board. In each case Lynch was in charge.

Following the transfer of natural resources from Canada to the western provinces in 1930 the National Development Board was disbanded. By 1934 Lynch was in charge, actually as well as nominally, of the Bureau of Economic Geology in the Department of Mines. This bureau was one formed to promote public awareness of the benefits flowing to the nation as a whole from geological work. In the language of the annual report of the department at the time the move was described as "a reorganization of the Geological Survey effected to develop a more fully coordinated machine in the Survey to hasten the publication of maps and reports as well as to give them a more practical character, and generally to intensify the services of the department to the industry."[9]

In 1936 the Department of the Interior disappeared as such and much of its work was carried on by the newly-created Department of Mines and Resources. The Mines and Geology Branch of the new department consisted of the Bureau of Mines, headed by W. B. Timm, and the Bureau of Geology and Topography with Lynch in charge. The latter organization consisted of four divisions, Geological Survey, Topographical Survey, Map Draughting and Reproducing, and Development. Later the National Museum of Canada became a division.

Under the new dispensation within the Bureau the language of annual reports relating to the work of geologists began to appear less technical. "The Geological Survey", according to the Bureau's 1935-36 report, "explores and maps known and potential mineral-bearing regions and ascertains the nature, extent and mineral possibilities of the rocks. From the results of this work the prospector learns where, and where not, to conduct his search . . . Close cooperation is maintained by the Geological Survey with provincial and federal departments in order that field investigations and geological knowledge thereby acquired may be properly coordinated to the greatest benefit of the mining industry.

"The range of the prospector's activities has been greatly extended by reason of the airplane and, as a consequence, an urgent demand for topographic and geologic maps has arisen. The facilities of the Bureau have been strained to cope with this demand but thanks also to the use of the airplane in aerial surveys and the modern science of map making, the prospector has had the satisfaction of obtaining maps of a number of areas that were formerly almost inaccessible." That year the Bureau distributed among the public more than 64,000 map sheets and other publications, a marked increase over the corresponding total for the previous 12-month period.

At this stage a Bureau policy was adopted of issuing preliminary reports and maps shortly after geologists returned to Ottawa from the field so that results of field work would be made available to prospectors at the earliest possible date. These publications replaced Summary Reports that had been issued collectively once each year. In the 1936 summer season 48 geological parties operated in the field. A total of 44 separate maps was published in that year while 67 other map sheets were in various stages of preparation for printing.

Early in 1937 Dr. W. H. Collins died. He had become an authority on North American Precambrian geology and had made an outstanding contribution to geological literature in his studies of the Sudbury nickel-copper deposits. His 16-year term of office as head of the Geological Survey was exceeded in length only by those of Logan and Selwyn. Under Collins the National Air Photographic Library had expanded swiftly and by the time of his retirement nearly 700,000 photographs were on file in that institution.*

The demand for minerals and mineral products suddenly became acute following the outbreak of the Second World War. As hostilities intensified the appetite of the allied powers for strategic minerals, more than ever essential as tools of war in the fight for freedom, proved insatiable. The Geological Survey became responsible for the conduct of intensive surveys of known producing areas and of prospective deposits in Canada. These strategic minerals included graphite, fluorspar, potash, manganese, tungsten and brucite. Tin-bearing deposits in the Yukon, Northwest Territories and Manitoba were also investigated. But this type of activity formed only one aspect of the Geological

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*In 1956, for the first time in formal annual reports of departments the title appears as *National Air Photo Library* although in actual office practice this abbreviated version of the original name was used much earlier.

Survey's wartime program. For a period during the conflict the primary need in this country was to expand Canadian production of gold in order to provide the nation with essential foreign credits. Then the task of supplying large quantities of alloying metals became critically important. In turn this project was followed by an energetic search for new sources within Canada of crude petroleum. Geological structures in the foothills of Alberta, favorable to the accumulation of oil and natural gas, were studied and mapped. Oil production possibilities of a part of the Peace River district, involving air and ground surveys, were also investigated at the request of the Oil Controller for Canada, a wartime official.

Not all the bullet-dodging in the years of world conflict occurred in theatres of war. The experience of A. C. Tuttle during the field season of 1939 is evidence of the unusual hazards faced by topographical surveyors in the course of their work. In that season Tuttle had been engaged in the preparation of base maps of the McQuesten and Mayo areas of the Yukon for use by the Geological Survey. He had crossed the Stewart River and reached the shores of Minto Lake. There he discovered an old cabin but could not find the occupant. Continuing on his way Tuttle walked along a few steps ahead of his cook, both men being followed by their horses. In the meanwhile the occupant of the aforesaid cabin, absorbed in hunting moose, approached along the same trail from the opposite direction. Hearing the sound of horses' hooves the hunter concluded that a moose was near and so raised his rifle to the ready. As Tuttle came into view rather suddenly around a bend in the trail he caught sight of the glint of sunlight on a gun barrel about 100 yards distant. Immediately the surveyor called out loudly and leapt to one side, his cook acting in unison. At that moment the gun was fired and a horse behind the men was killed. Later the hunter claimed that he had mistaken Tuttle's drab shirt for a moose!

In the 1942 season 28 geological parties and 18 topographical survey parties were active in the field. Some 130 maps were published by or through the Draughting and Reproducing Division, including a geological map of southern Quebec Province, issued in three sheets on a scale of 12 miles to the inch. The 1942 season marked the completion by the Geological Survey, the oldest of all federal government scientific services, of 100 years of continuous, constructive activity. To mark this historic accomplishment the Geological Society of America accepted an invitation extended by the government of Canada to hold its 1942 annual meeting in Ottawa. Pressures due to war conditions led to a cancellation of this planned event. But the Canadian achievement did not go unrecognized. Dr. J. B. Tyrrell, formerly of the Geological Survey, presented to the organization a case containing medals and badges won by Sir William Logan, its first director. These included the Gold Medal awarded him by the 1851 London Exhibition, England; the Grand Gold Medal of Honour from the 1855 Paris Exposition; the Wollaston and Royal Medals from the Geological Society of London, England, and badges of the Chevalier and Officer of the Legion of Honour of France. In 1947 proper anniversary amends were made when the Geological Society of America met in Ottawa to observe the 105th birthday of the Geological Survey of Canada as well as the 60th anniversary of its own formation. Nearly 2,000 scientists attended.

For some time prior to the end of hostilities in Europe matters of post-war concern and policy were receiving increasing attention from those in charge of Geological Survey affairs at Ottawa. W. B. Timm reported on the nature of steps that were then under consideration by which its services might be extended to help meet the anticipated peacetime expansion of resources development programs. Plans were revealed that involved an increase of Geological Survey staff, within the space of a few years, to three times its wartime size.[10]

In 1944 Dr. George Hanson, by now Chief Geologist, warned about the immensity of the task facing Canadians in attempting to complete the geological mapping of the nation. In 1936, soon after he had completed his investigations and mapping of parts of British Columbia, mainly from Portland Canal to Babine Lake as well as in the Cariboo and McDame Creek areas, Hanson had been made assistant chief geologist in the federal organization, rising to this senior post in the Survey seven years later. Not long after this latter promotion Hanson wrote that "presently the proportion of Canada mapped adequately for purposes of the Geological Survey is 11 per cent. Mapping by provincial organizations has been mainly detailed and will not probably increase the total by one per cent . . . If it has taken 100 years to cover 11 per cent of Canada, at this rate it will take 800 years to map the other 89 per cent . . . the present staff cannot meet all present demands for detailed investigations and, even cutting some of the less promising of them, few of the staff can be assigned to systematic mapping of the unmapped part of Canada . . ."[11]

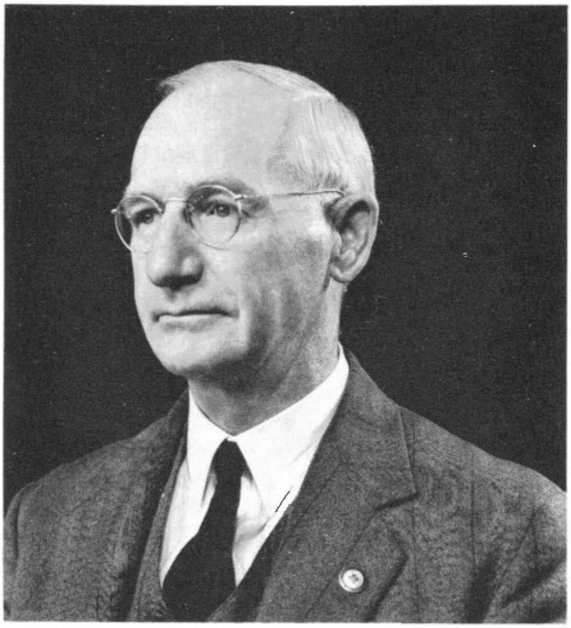

FIGURE 134. George Hanson.

About this time the geological mapping and other field activities of two promising young members of the Survey staff were attracting favorable attention. In the course of events, and in succession, both became directors of the Geological Survey of Canada. James Merritt Harrison (1915-   ) was particularly active in the gold and base metal areas of northern Manitoba. Yves Oscar Fortier (1914-   ) made flights with the magnetic survey party of the Dominion Observatory over Arctic islands and adjacent mainland regions, involving continuous observations of bedrock geology, topographic forms, and land emergences. Fortier later became the first to recognize the oil-bearing potential of the Arctic islands.[12]

Clifford Symington Lord (1908-), who rose to the post of Chief Geologist of the Geological Survey of Canada, conducted important field work in the early 1940s in northern British Columbia and the territories, including a geological reconnaissance along the Alaska Highway between Watson Lake and Teslin River. As a result of lessons learned in the Northwest Territories in the late 1940s he later introduced the helicopter as a means of greatly accelerating geological surveys.

Direct participation by the Geological Survey in federal operations in the atomic energy field began in 1944 when the Eldorado Crown Company acquired the assets of the Eldorado Gold Mining Company. But prior to that year the Survey had made highly important if indirect contributions to the discovery of radioactive minerals in this country. In 1900, for example, an exploratory geological survey party reported an occurrence of cobalt on the east shore of Great Bear Lake. Thirty years later Gilbert LaBine was led by that report to visit the locality. In addition to finding silver, for which he was searching initially, LaBine discovered pitchblende. This find, in turn, brought about the establishment of Eldorado Mine, a world-famous source of uranium. Following the LaBine discovery the Geological Survey made several geological maps in that general region and these proved very useful when uranium production became the centre of official and public interest.

In the development of Canadian sources of uranium Dr. W. H. Collins made an important pioneer contribution. His Blind River sheet (No. 1970, Memoir 143), published in 1925, was a map of the geology of that region that provided major assistance in the staking and subsequent production of the Blind River (uranium) camp. Collins, in the prime of his life, was a tall, lean, muscular type. He was a good packer in the field and an excellent canoeman. His mapping of regions over which he travelled was outstanding. During the whole of his professional life it was his ambition to make the Geological Survey, which he came to head, of special value to his country. With the extension of geological mapping to districts other than Great Bear Lake, prospectors attached to some of the field parties in the Lake Athabasca area uncovered many indications of uranium. These finds, in turn, led to the rapid development of that field. In the ten years following 1944 the Survey produced 19 geological maps of the major uranium districts of Canada.

At the time of Dickison's retirement in 1945 two members of his staff were equally in line, in terms of ability and experience, to succeed him as chief of the draughting division. These men were Arthur Joanes and S. G. Alexander. Joanes won the appointment because of seniority in age and his proximity to automatic retirement. After about two years in that position he was succeeded by Stanley Gordon Alexander. Like Dickison, Alexander had received early training in his craft with the Bartholomew firm of Edinburgh. In 1910, following his arrival in Canada, Alexander joined the Geological Survey staff under Senécal. Enlisting in the Canadian Army in the First World War Alexander saw active service overseas, his military career culminating in his attachment to the staff of Brigadier General McNaughton as a reconnaissance officer. Returning to his work in Ottawa on the conclusion of hostilities Alexander rounded out his lengthy term of service with the Geological Survey's Map Draughting Division as its chief from 1947 until his retirement in 1955. Two men who had been trained under Dickison succeeded Alexander in turn, namely, Arthur E. Hale and Gordon Stephen Daughtry.

Without fanfare of any kind 15 men gathered in Ottawa soon after the conclusion of the Second World War in a meeting the conclusions of which had a highly important influence on the post-war future of Canadian surveying and mapping. The meeting was held in the afternoon of December 17, 1945, in the Council Chamber of the National Research Council. The gathering was composed, for the most part, of surveyors prominent in the federal government service. K. G. Chipman, who had succeeded Boyd as Chief Topographical Engineer, and G. W. H. Norman of the Geological Survey were in attendance. Those present discussed the application of radar to survey work and the meeting learned that two Canadian Army officers, Major J. I. Thompson and Major L. Trorey had recently joined the staff of the Directorate of Operational Research (Army). These officers, it was made known, were available to carry on any desired experimental work that the committee might consider of value. The unanimous decision of that meeting to make use of the special experience of Thompson and Trorey marked the beginning of a new era in surveying and mapping in this country, including the adoption of the highly useful application of the shoran principle.

In the reorganization of the Department of Mines and Resources in November, 1947, the Bureau of Geology and Topography lost one of its three divisions, namely, the Topographical Survey, to a newly-formed Surveys and Mapping Bureau. This latter agency had been established within the Mines, Forests and Scientific Services Branch of the Department of Mines and Resources. This reorganization involved the *physical* separation of topographical surveyors from the Geological Survey of Canada through a transfer of such mappers from the National Museum building in Ottawa to No. 8 Temporary Building in the same city.

In effect, however, the *actual* separation had occurred at the time that the Department of the Interior, as such, passed out of existence in 1936. When the Department of Mines and Resources was formed to take over the Interior Department's functions a merger of nearly all civilian topographical surveyors in the federal government service was brought about. A number of these men, employed in the Air Survey Section under R. B. McKay, moved from the Labelle Building in downtown Ottawa to the National Museum Building, along with a few men not directly associated with the work of that section. All these joined Boyd's staff, operating within the Bureau of Geology and Topography. At this time, therefore, the responsibility for the activities of civilian topographical surveying in Canada was vested in the Chief Topographical Engineer.[13] Division chief Boyd summoned all members of the expanded organization to a meeting partly for the purpose of welcoming newcomers to his staff. "From now on", he declared, "you are the Topographical Survey of Canada." His statement carried the implication that henceforth the new unit was no longer limited to topographical surveying work for the Geological Survey but that it would be responsible for most, if not all, topographical surveying in this country. In other words, the T.S.G.S. had been superseded by the T.S. of C. (The term "Topographical Survey *of Canada*" was used as a unit description by the Department of the Interior in its annual reports from 1922 to 1925 only.)

Following the administrative rearrangements of 1936 some topographical surveyors remained under the Surveyor General of Canada as part of the Hydrographic and Map Service, an organization within the Surveys and Engineering Branch of Mines and Resources. Members of this staff compiled electoral maps, air navigation charts, railway maps, natural resources maps as well as general maps of Canada, mostly derived from existing base maps or maps already published. Generally their cartographic functions were exercised in the interests of *production*, the issue of sheets in printed form, whereas Boyd's staff was active on topographic field surveys and in the preparation of map manuscripts up to the final draughting stage. By 1946 the Hydrographic and Map Service had become the largest single producer of map sheets in Canada. By 1950 that

FIGURE 135. R. B. McKay.

FIGURE 136. G. S. Hume.

Service had been absorbed, along with all of Boyd's staff, in the Surveys and Mapping Branch, Department of Mines and Technical Surveys.

In 1947 Lynch retired as chief of the Bureau of Geology and Topography and was succeeded by Dr. G. S. Hume. Lynch's career in the public service of Canada had extended over more than 40 years. For a number of years he carried on the duties of secretary-treasurer of the Ottawa Branch, Engineering Institute of Canada.

The Geological Survey *of Canada,* with Dr. Hume as its chief, embarked on a new stage of development. In its official annual reports and in its 105th anniversary year the organization resumed use of the full title under which it had been so widely and favorably known during the first 65 years of its career. With Dr. Walter Andrew Bell (1889-1969) as its *director,* the Geological Survey of Canada became a full-fledged branch in the Department of Mines and Technical Surveys.

During three decades in which Canada was affected by two world wars and a severe economic depression, geological mapping continued to expand and advance in this country. Nowhere in the western world in this disruptive period were there more challenging opportunities for mappers and map makers than in this vast country, slowly awakening to its tremendous possibilities. Under such men as Senécal, Lynch, Dickison and Veitch the compilation and production of high-quality maps kept pace with the lively output of field work of the Geological Survey across a span of years extending from about the beginning of the motor age to the dawn of the atomic age.

In Canada, as in the rest of the world, maps are indispensable to orderly, effective geological study and research. "The geological map", in the words of an impressive tribute to this form of cartography, published in 1928, "is an index of the extent and accuracy of geological knowledge at the time of its production and is also the basis of future research. It is the vehicle by which men communicate to one another their discoveries relating to the nature and arrangement of the rocks of the earth's crust and it makes possible the prosecution of further research covering the distribution of rocks, their origin and the evidence of the life of the past which they may contain . . . The geological map may, therefore, be regarded as the dynamic force in geology."[14]

16

MAJOR CHURCH'S SURVEY SCHOOL

In all seasons of the year the people who live in or near Lawrencetown, in famed Annapolis Valley, have become accustomed to the sight of youthful surveyors busy near highways, along the Dominion Atlantic Railway line, and in the fields bordering the community. The instrumentmen and rodmen are readily recognized as surveyors-in-training at the Nova Scotia Land Survey Institute. This happens to be the only vocational school in Canada bearing the description "Land Survey" in its title and *solely* devoted to the training of surveyors, photogrammetrists, and cartographic draughtsmen. The story of the beginnings of this unique institution and of the indispensable part played in its founding by its first chief instructor is a record of exceptional dedication, perseverance and vision.

In 1941 the federal government asked authorities at the Nova Scotia Technical College, Halifax, to establish a program under which army personnel could be taught to function as military surveyors. This attempt failed when it was found that suitable instructors for such courses were unavailable. Two years later a second attempt in this direction proved successful.

Major James Archibald Hepburn Church, D.S.O., M.C., P.L.S. (1883-1967), a veteran of the First World War, had been born in 1883 in India of Scottish parents, William and Marian Church. Graduating from a grammar school in England in 1902 young Church served five years of apprenticeship with a Glasgow mining and engineering firm. Five years later he emigrated to Canada where, in British Columbia and Alberta, he engaged in mining engineering. In August, 1914, at Edmonton, Church enlisted in the 19th Alberta Dragoons and travelled overseas with that unit. Later he was transferred to the 251st Tunnelling Company of the Royal Engineers and for gallantry in action was awarded the Distinguished Service Order and the Military Cross. In 1919 he returned to western Canada and resumed activity there as a mining engineer. In 1931, at the age of 47, Major Church retired from his profession to become a gentleman farmer in Nova Scotia on the fringe of Lawrencetown. The province and locality were selected by Major and Mrs. Church partly because land in the area was somewhat less expensive at the time than land elsewhere in Canada, partly because the major believed that this district of the Annapolis Valley, on the average, enjoyed more hours of sunshine per year than any other district of Nova Scotia.

Coincidence sometimes plays a critically important, if somewhat peculiar, part in the creation and subsequent success of an institution. In this instance its role is particularly remarkable. Three years prior to the arrival of the Alberta couple seeking retirement at Lawrencetown, a local resident had died and left a large, unusual bequest of a capital sum approaching $100,000 "for the founding of a Vocational School in the County of Annapolis." In addition, under terms of the will, provision was made for the application of the annual proceeds from investment of certain other funds "towards the support, maintenance and operation of the said Vocational School." At the time of arrival in their new home Major and Mrs. Church were quite unaware of the bequest. The public-spirited donor, a native of Lawrencetown, was James Barclay Hall (1843-1928), a doctor of philosophy and a principal of the Normal School at Truro. So once again, in that tangled skein of circumstances known as history, the financial substance of

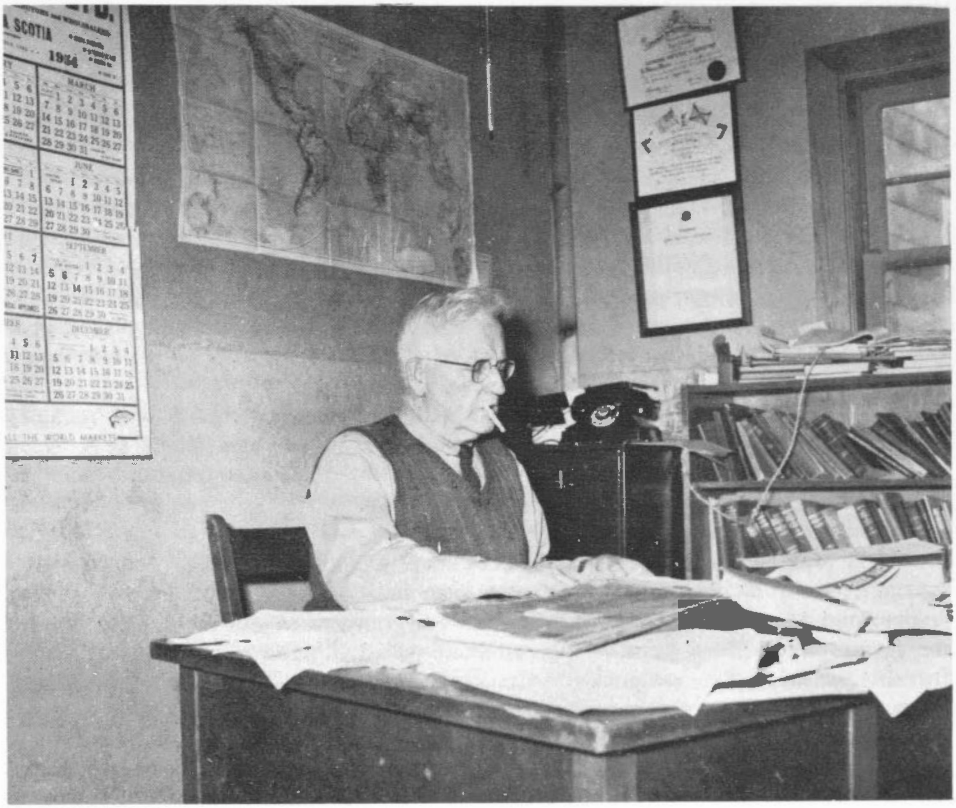

FIGURE 137. Major J. A. H. Church at his desk, Survey School, Lawrencetown, 1954.

one eminent man and the special qualities and abilities of another were joined for effective action, apparently by pure happenstance. In this small Nova Scotian community the combination brought into being a school capable of maintaining a steady flow of men and women graduates into the mainstream of Canadian life, trained in the basic theory and practice of surveying and mapping.[1]

In 1943, the year in which he was commissioned a Provincial land surveyor, Major Church was summoned to serve at Halifax and at nearby Camp Aldershot as a civilian instructor in topographical survey work. In that same year he was requested by the Department of National Defence to organize No. 6 (Army) Vocational Training School, Surveyors Class, at Nova Scotia Technical College so that potential surveyors in the armed forces could be given some training in the craft.[2] At the end of the war one of the classes in land surveying had reached only the half-way point in the required course. In accordance with general instructions governing demobilization Major Church was ordered to terminate the educational venture that had been commenced so ambitiously under his direction. But those in authority failed to reckon with the tenacity, vision and vigor of the resourceful major who pointed out persistently that there was an obligation resting on military agencies to find employment for these trainees. "Why", he asked with considerable force and logic, "should the course be cancelled at the midway mark when this type of training fitted men for useful civilian careers?"

FIGURE 138. Surveyor's class, No. 6 Vocational Training School, Halifax, 1943.

At about this stage in post-war developments a government official, influential in the Maritimes, came to the rescue of the embattled major, strongly supporting him in his struggle to have the training project retained. Dr. F. H. Sexton, director of technical training for the Atlantic provinces, perceived the value of providing educational opportunities in land surveying for war veterans under the federal-provincial Vocational Training Program, administered and financed by the Department of Labour, Ottawa. A syllabus was submitted to government authorities in the maritime provinces in the hope that such a training course, extending over a period of 12 months, would be accepted as qualifying the graduate to sit for the Provincial Land Surveyor examinations in any of the three provinces.

The provinces by the sea approved the proposed syllabus as a basis of such eligibility although Prince Edward Island added a minor condition. Authorities in the island province felt that a graduate of the vocational training course should be required to serve three months with a Prince Edward Island surveyor before qualifying for a certificate to practise in that province.

When the new course was instituted on November 1, 1945, at Halifax the principal aim of those in charge was to develop surveyors who would be well and truly grounded in the requirements of the profession.[3] It was formally declared that not only should trainees gain facility in the use of instruments and in the techniques of surveying but should seek to build reputations for dependability and for the use of good judgment. It was not expected that expert practitioners would be produced in one year of schooling but the hope persisted that this type of student training would enable the trainee to learn from his own experience the limits of survey accuracy possible by use of the level, compass and chain.

The Department of Veteran Affairs moved into the picture and made this venture a rehabilitation training project for veterans of the Second World War. This action enabled those taking the course to receive $60 a month, as a cash grant, along with free tuition and books. When this federal department faded out of this sponsorship at the end of 1948 Major Church, undismayed, brought his special gifts of persuasion to bear upon the Department of Education of Nova Scotia. At this point the mystery of coincidence worked its peculiar magic. Major Church, by now aware of the Hall bequest, proposed to E. K. Ford, director of vocational training, Department of Education, that funds of the bequest be used to promote the advancement of the tiny, struggling 'School'.

During the first years of its development the school led a nomadic type of existence under the supervision, successively, of several provincial government departments. Hampered by lack of suitable open-field training conditions in the capital city, the project was moved from Halifax to Lawrencetown, partly because of the proximity of that site to the home of its chief instructor and partly because of the terms of the Hall bequest. Only temporary accommodation for the school could be found there at the time, however, and it was transferred to the upper floor of store premises in nearby Middleton, just six miles distant. When the branch of the Canadian Legion at Lawrencetown decided to donate property adjoining its hall in that community to accommodate a new Institute building, "Major Church's School" as it had come to be popularly known, returned to Lawrencetown.

In 1958 a great forward stride was taken in the progress of the project when the cramped, single-room Legion structure was replaced by a modern school building of steel, concrete and brick providing space for several large, well-lighted classrooms.* All

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*It was at this juncture that the Institute course was extended from one year to two years.

FIGURE 139
Nova Scotia Land Survey Institute building, Lawrencetown, erected 1958.

this had been made possible mainly by Dr. Hall's bequest. It was at this time that the project was christened "Nova Scotia Land Survey Institute". Major Church continued as chief instructor until 1961 when he was accorded the title of principal of the institution. However, all was not smooth sailing. Plans to base a cadastral survey of the town of Middleton on triangulation and graphic intersection points collapsed when authorities of that town refused the benefits of such a project. Despite this setback a levelling scheme was inaugurated, commencing at a geodetic bench mark located in Middleton and extending to Lawrencetown and return.

Field astronomy exercises also provided the average surveyor with formidable difficulties. It was discovered, however, that once a trainee had grasped the basic principles involved in the transition from plane to spherical trigonometry and had mastered the techniques of making solar and stellar observations with reasonable accuracy, his self-confidence and self-reliance grew remarkably. Field work was divided, naturally enough, into two main categories. The first of these involved retracing old boundary lines originally run by use of the magnetic compass. The second, a general practice course, included all types of surveying from bounding a town lot to a timber berth. When a job opportunity developed in the latter category the student attended the

Land Registry Office and searched the abstracts of title involved in the survey. Then he made his survey on the ground, completing his closure and compiling a complete and correct description of the property. Generally these student surveys were made by use of a transit. If there was any excessive amount of brushwood to be cleared, however, recourse was had to a magnetic compass. In each case the point of beginning of the survey was tied in to some topographical feature.

Ethical conduct in the practice of the profession, as taught at the school, was based upon the principle that a client was entitled to the best service that could be performed for him and that the surveyor, at all times, must carry out his tasks uninfluenced by friendships and unaffected by mercenary considerations. Major Church possessed a

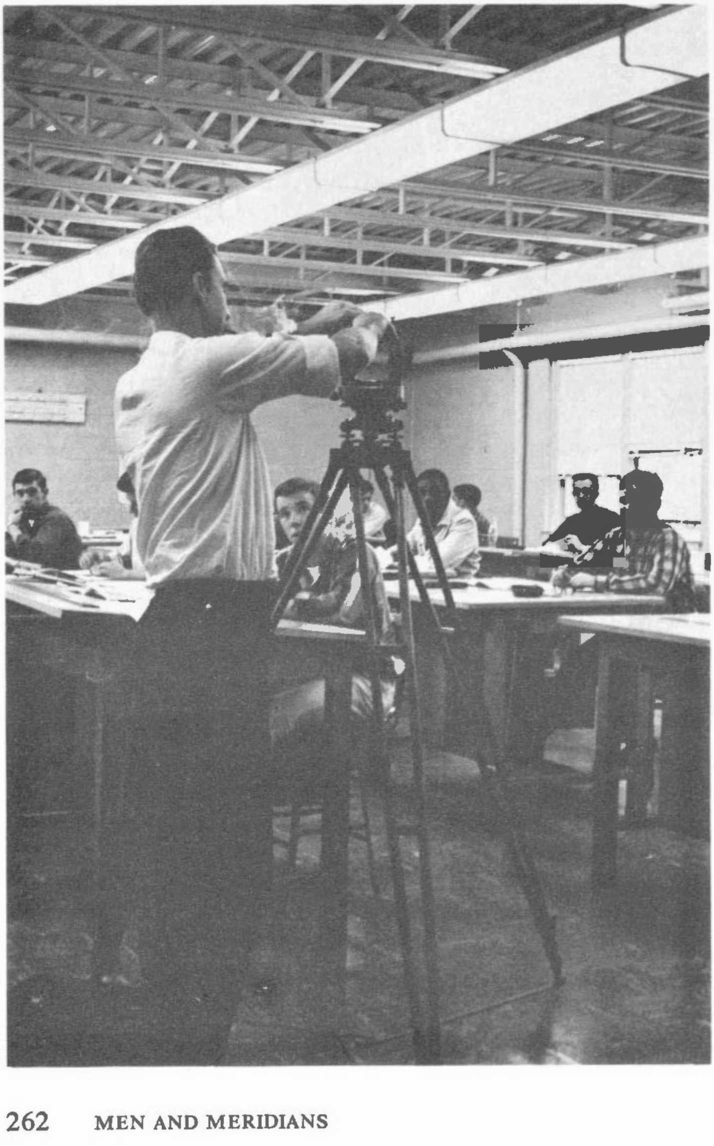

FIGURE 140
Instructor demonstrating theodolite in classroom, Nova Scotia Land Survey Institute.

profound sense of right and wrong and his standards of conduct were communicated effectively to his students by example as well as by precept. Ever forthright and often brusque in manner the major, nevertheless, won and retained the high respect of all officials with whom he had dealings and of those he taught. Major Church never yielded to pressures when he felt his just rights were in jeopardy. His fearlessness became a by-word. In negotiations he did not believe in the subtle diplomacy of "beating around the bush". On one memorable occasion, in a letter to a highly placed government official in which he indignantly complained about the quality of a certain instrument in the school's equipment, he wrote that the appliance was "about as useful as mammary glands on a boar pig".

Major Church was in the habit of bombarding the Nova Scotia Department of Education with proposals advocating the adoption of improved methods and facilities in the teaching of land surveying and related courses. Then, with the aid of the Association of Land Surveyors of Nova Scotia, he brought heavy guns to bear upon the provincial Department of Lands and Forests in an effort to bring about the establishment of higher entrance standards, and certification requirements in connection with these courses. He encouraged his students to strive for the highest possible attainments with the result that many of his graduates proceeded to universities for additional education and to the International Training Course at Delft, Holland. Actually the major became better known for elements of philosophy that he imparted to students rather than for his ability to instruct in the arts of surveying and mapping, unique as it was. His victorious attitude toward life, his stimulation of a worthy response of the whole man to its tests and opportunities, his refusal to be defeated by setbacks, won enduring appreciation and regard from those who trained under his supervision. To a notable extent he succeeded in transforming hardshell war veterans — men convinced, in some instances, that the world owed them a living — into citizens capable of meeting life on its most challenging terms and of contributing in a worthwhile manner to the general progress of society. His was not a namby-pamby approach to problems but rather a "shirtsleeve philosophy" — a good creed to live by and work by.

Major Church was a master in the art of communicating to trainees in their own idiom. Although not by nature given to the careless use of profanity he did not hesitate to swear vigorously and, in some instances, spectacularly, when an occasion seemed to demand emphatic, colorful language. He would never permit an officer or former officer to "pull rank" on those of lesser army rating when in attendance at the Institute. But he would make a point of inviting, in turn, groups of trainees to his home in order, in some cases, to emphasize the importance of good manners on the part of those accepting the hospitality of a gracious and pleasant hearth. All in all, his was a no-nonsense approach to the tasks of shaping civilized men of worth out of the rawest and most unlikely material. Major Church was deeply convinced that every man, however undisciplined or however unfavorable his early environment, possessed a high potential for solid accomplishment. "Give the youth of Canada", he once wrote, "an integrated education system through primary, secondary, and technical schools to universities and you could make the atomic bomb look like a firecracker."[4]

In reply to a letter from S. G. Gamble, Director of the Surveys and Mapping Branch, Ottawa, at the time of his retirement from the office of principal of the Institute in 1963 Major Church, after acknowledging with gratitude the constant interest shown and help given his educational project by the Ottawa organization, commented that "one is truly thankful that our graduates have proved to be of a calibre satisfactory to the higher echelons of the survey profession in Canada, within the limits prescribed by the very inadequate primary and secondary education possessed by these trainees. That is the raw material of Canadian youth, full of hot initiatives but handicapped by this environment." Up to 1948, out of a total of 20 Institute graduates who took the examinations for a Provincial Land Surveyor commission in Nova Scotia, 15 passed on their first attempt, 4 passed on their second attempt, and only one failed completely. This over-all commendable result was achieved despite the fact that these students were unaccustomed to formal written examination procedures. Graduates of the Institute, and of the School that preceded it, may be found in places of special responsibility in Ottawa, in various provinces of Canada, and in other countries. Burton Robertson became director of surveys for Nova Scotia, succeeding J. E. R. March. Walter E. Servant became a leader in Halifax in the land surveying profession. Both of these graduates have served as members of the Advisory Committee of the Institute.

In 1963 in the Lawrencetown Consolidated School auditorium, on the eve of his retirement after more than 20 years as chief instructor and, later, as principal, Major Church attended the graduation ceremony of that year's class of the Institute. Present also on this significant occasion were Hon. E. D. Haliburton, Minister of Lands and Forests for Nova Scotia and W. Darrell Mills, director of vocational education, Nova Scotia Department of Education. Both men paid glowing tributes to the major's leadership and what he had achieved through the Institute that he had done so much to found and to develop. Mills pointed out that "money and property by themselves can never make a school". With the holding of this ceremony the total number of Institute graduates up to that point in its growth exceeded 200. Students had enrolled for its courses from nearly every province in Canada as well as from Africa and from the West Indies.

In the evening the Old Boys of the Institute feted Major Church in Cornwallis Inn, Kentville. He was made an honorary member of the Canadian Institute of Surveying. Al Grant, the School's first student, first graduate and the major's first assistant in the administration of the Institute, made a presentation to the retiring principal on behalf of all in attendance.[5] The Lawrencetown and District Board of Trade, on behalf of residents of the local community and its tributary area, later, in words finely lettered on parchment expressed deep appreciation to Major Church for his "untiring zeal . . . foresight, perspicacity and energy in efforts to enlarge the size and scope of the training courses given at the Institute . . . for years of faithful service to youth . . . we are proud of your good works and honoured by your presence among us." One of the satisfying aspects of the operations of the Institute in Lawrencetown has been the continuing good relations between the staff and students on one hand and citizens of the community at large on the other. Moreover the success of the Institute in Nova Scotia has resulted in a general improvement in the status of surveying and mapping in the entire region comprising the maritime provinces.

The Institute building, with two classrooms on its lower floor for lectures in land surveying and with separate classrooms on its upper floor for instruction, respectively, in map draughting and in photogrammetry, approaches in some aspects the early dreams of its principal founder. There are plaques in the building to commemorate the special gifts of Dr. Hall and of the Canadian Legion. To testify to the genius of Major Church there is not only the structure itself but the program of the Institute which promises to continue producing well-trained technicians and highly desirable recruits for the profession of land surveying.

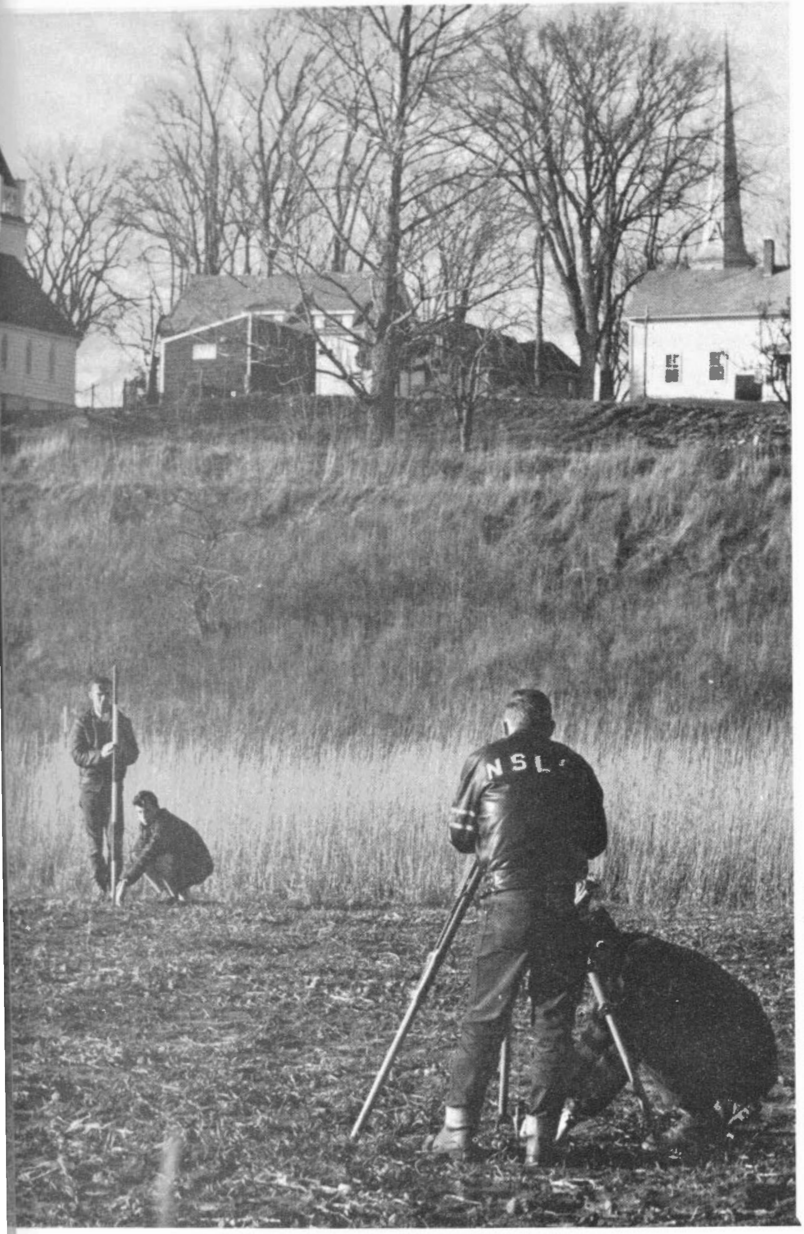

FIGURE 141
Student surveyors on field practice near Lawrencetown.

In Canada as a whole a wide spectrum exists in the means of attaining education in surveying as well as in the level of professional recognition given in each of the eleven principal jurisdictions covering land surveyors and surveying in this country. Three Canadian universities now offer specialized education in surveying. There are now two fully developed degree courses along these lines at Laval University, Quebec, and the

University of New Brunswick. The University of Toronto offers a survey option within its Department of Civil Engineering. At the University of British Columbia optional courses in control surveys and in photogrammetry are available to civil engineering classes.[6]

In addition well-established technician courses in Nova Scotia and Alberta continue to attract young Canadians to the profession. The series of rapid technological developments experienced in Canada during the two decades following the end of the Second World War constituted a most dramatic evolution in survey education. In Calgary the Southern Alberta Institute of Technology is a senior Canadian technical training institution. Programs in survey education, commencing in 1920, developed into a course of two years duration in the early 1930s. By 1945 steps were to be taken to devise a course to meet the requirements of modern surveying as defined by the Alberta Land Surveyors' Association. There was to be an even more explosive growth in survey courses available to technicians and technologists at institutions across the country after passage of the federal Technical and Vocational Training Assistance Act in 1961. As of 1968, the year after the death of Major Church, there were in Canada ten established or proposed 2-year survey technician and technology courses in addition to and following the early example of Nova Scotia and Alberta.[7]

17

REPRESENTATIVE RAILWAY SURVEYS IN CANADA: 1917-1947

The completion in 1885 of Canada's first transcontinental railway, the main line of the Canadian Pacific, ended what may be described as the experimental period in the history of Canadian railway construction. What had appeared to many observers as quite impossible of achievement had, in fact, been accomplished. Critics who had warned that such a railway would soon amount to "two streaks of rust across the prairies" had been confounded and silenced.

The years between 1885 and 1914 may be regarded as years of enthusiastic development, if not over-development, of Canada's rail services. The amalgamation in 1899 of two rail projects in Manitoba heralded the formation of Canada's second transcontinental railway, the Canadian Northern. The Grand Trunk Pacific Railway Company had come into existence to help develop territory farther north than areas served by the other two major companies and to open a port on the Pacific Ocean in a more northerly situation than those located on the Strait of Georgia.

With the growth of population in the western interior and with the resulting upsurge in grain-growing in that region, the development of overseas markets, especially for Canadian hard wheat, became highly important. Europe offered the most attractive market abroad at the time. The transcontinental railways and numerous feeder or branch lines having been built, the attention of western Canadians, particularly in Manitoba and Saskatchewan, turned to the problem of how best to construct the shortest rail line from the high plains to Atlantic tidewater.

Maps clearly demonstrated that such a line would be one connecting the settled parts of Manitoba and Saskatchewan with Hudson Bay. The federal government, in fact, had made an offer to grant land to any responsible party prepared to build such a railway. It was an offer that remained in effect from 1866 to 1908. The Canadian Northern

Railway Company responded to this inducement when it built a line from Hudson Bay Junction to The Pas. The former point, located in Saskatchewan, was east of Melfort and not far from Manitoba's western boundary. This relatively short line was at least a beginning. The land offer was withdrawn in 1908, however, and the federal Department of Railways and Canals appointed one of its engineers to organize appropriate surveys and to report on the cost of building a railway to extend from The Pas to Hudson Bay. In anticipation of a settlement emerging at Churchill the Department of the Interior made surveys of that port in 1908, including the laying out of a townsite there.[1]

In the autumn of 1909 one William Beech was granted a homestead within Churchill townsite, consisting of a rectangle of land enclosing 40 proposed city blocks, including street allowances. In addition to this area of 176 acres C. E. Beech purchased two parcels of land in the vicinity so that the three adjoining areas totalled 300 acres in all, distributed over 1,400 town lots.

In his preliminary report of February, 1909, the federal engineer designated to investigate construction costs mentioned that two ports on Hudson Bay offered rail terminal advantages. These were Churchill and Port Nelson, the latter located near the mouth of the Nelson River. Estimates of the cost of installing suitable port facilities favored Port Nelson by about $4,000,000. By August of that year surveys of both harbors had been completed and from these surveys it appeared that Port Nelson, 510 miles across northeastern Manitoba from The Pas, would be more suitable as a rail terminus on tidewater. In 1909 railway location surveys commenced and in 1910 a contract was awarded for the building of a bridge over the Saskatchewan River at The Pas. In the following year a contract for grading the first 185 miles of the line was let and, late in 1911, the "firm" decision was made to carry the proposed railway to Port Nelson. Contracts for grading the remaining mileage to that port were awarded accordingly.

Early in May, 1913, a location survey party for this project embarked, with gear and supplies, on S.S. *Wolverine* at Selkirk and travelled along the Red River and across Lake Winnipeg to Norway House. Survey work that season began from the point where the railway line was projected to cross the Nelson River at Manitou Rapids. During that field season one man, although a strong swimmer, drowned when a canoe capsized in turbulent water.

Port Nelson entered into a period of lively construction. A man-made island, at which deep-sea vessels could tie up, was built in the estuary of the Nelson River, a 17-span steel bridge, almost two-thirds of a mile long, connected the island with the mainland. A 40-room hotel, a number of houses and certain other installations were erected.[2] Why, one may well ask, with the later adoption of Churchill as the terminus on Hudson Bay, was the initial selection of Port Nelson ever made? Lack of adequate knowledge at the time of decision would appear to be the answer to that question. For example, a 75-mile section of track at the Churchill end of the line would need to be located, if built, over frozen muskeg. It was anticipated that under the hot summer sun the roadbed would soften and be absorbed by the muck. Again, there was every indication of the presence of solid rock in large quantities in the port bottom at Churchill, a fact that would make the cost of any required dredging excessive, if not quite prohibitive. The area for mooring vessels at Churchill also appeared less extensive than at Port Nelson. Finally, the mean annual temperature at Port Nelson was higher than at Churchill. But subsequent investigations disposed of most of these arguments. It was found that substantial quantities of 'gravel fill' over muskeg acted as a heat insulator and prevented weakening of the roadbed's foundation. Test borings at Churchill revealed an area in the harbor free from rock. With the establishment of the channel and deep-water wharf at Churchill, any mooring problem in that harbor would be solved.

In anticipation, however, of the choice of Port Nelson as the Bay terminus a federal departmental engineer was sent to the mouth of the Nelson River to investigate the situation and to recommend a site for the proposed town. In 1911 the Naval Service of Canada had commenced a hydrographic survey of the Nelson River estuary. With the 1912 extensions of Manitoba's boundaries both Churchill and Port Nelson were included within that province.

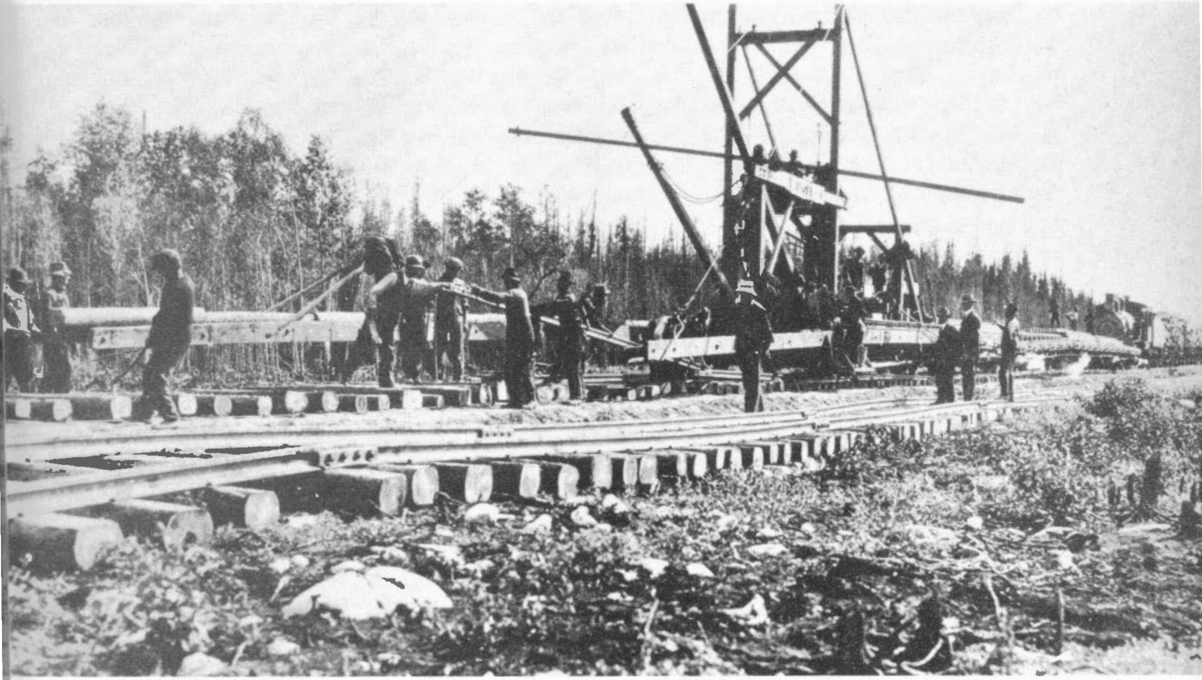

FIGURE 142. Construction work on Hudson Bay Railway about 1915.

But the advent of war in Europe following upon a drastic decline in the prosperity of the Canadian West, brought about in this country the replacement of policies of expansion by policies of contraction. In the realm of Canadian railways the age of optimism gave way to the age of mergers. First, the Canadian Northern lines were absorbed by the Canadian Government Railways, a name which, by 1918, was applied to all rail lines owned and controlled by the federal government.[3] By 1923 the Grand Trunk Pacific had been taken over also by the government of Canada and early in that year all Canadian Government railways were placed under the Canadian National Railways Company (incorporated in 1919) for management and operation.* Other mergers of rail services took place over the next following ten years, including the joint purchase

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*O. in C. P.C. 115, Ottawa, Jan. 20, 1923.

by the Canadian National and Canadian Pacific railways of several lines in Alberta in 1929. These were the Edmonton, Dunvegan and British Columbia Railway, the Central Canada Railway, the Pembina Valley Railway, and the Alberta Great Waterways companies. These four lines were consolidated into one corporation, the Northern Alberta Railways Company, which operated them on behalf of their joint owners.

It was against the background of these and similar developments that railway construction was resumed in Canada in the aftermath of the First World War. In the period between the two world wars a number of branch lines were built in the western interior, the railway to Hudson Bay was completed, the Temiskaming and Northern Ontario Railway (later renamed the Ontario Northland Railway) was extended from Cochrane to Moosonee, and major location surveys made by the Canadian Pacific Railway in mountain passes leading from the Peace River country into central British Columbia.

During the autumn of 1913 location survey work had been completed on the Hudson Bay Railway from The Pas northeastward as far as Kettle Rapids and Mile 332. For purposes of transport after freeze-up dogs were used to haul sleds until open water in the springtime made possible a return to canoes. By the following August the survey line had reached Hudson Bay. The surveyors and their helpers lived in happy comradeship and in good health despite reliance on a diet that lacked fresh vegetables, fruit or eggs and with little fresh meat but with no scarcity of fresh fish. Work advanced at the rate of 10 hours each day during all seasons. Angles were measured, levels taken and distances chained amid clouds of mosquitoes and voracious black flies during the warm months and sometimes in temperatures of 60 degrees below zero during winter months. After evening meals several hours were usually occupied in making calculations and plotting notes, often by candlelight. At the end of 1918 the right-of-way had been surveyed, cleared and graded all the way to Port Nelson, including construction of steel bridges at two crossings of the Nelson River, the second of which was built over Kettle Rapids. Grading operations had been carried out almost entirely by hand. Drainage of extensive belts of muskeg constituted a major accomplishment in making progress. Ditches were cut through layers of permafrost by the use of axes and hand shovels. A limited operational service out of The Pas, over the newly-laid rails, was in effect as far as Mile 214 in that year although by 1918 rails had been laid to Mile 332, just north of the bridge crossing the Nelson River at Kettle Rapids.

Very little money was spent on line maintenance over the operating part of the Hudson Bay Railway in these early years and it was not until 1926 that the task of completing construction to the Bay was actively resumed by the federal Department of Railways and Canals. During the 8-year interlude railway ties had rotted and embankments, in some sections, had fallen in. Frost damage had been extensive and restoration of the entire trackage had to be undertaken by the Canadian National Railways, the corporation authorized to complete the line.

Meantime a new situation had developed. A special committee of the Senate recommended, in 1920, that before additional important expenditures were made on the building of a railway to Port Nelson, an exhaustive examination ought to be made of the relative merits of Port Nelson and Churchill as rail terminals. The federal government called upon (Sir) Frederick Palmer of London, England, an eminent authority on port construction, to conduct a probe of the situation and in August, 1927, along with a bevy of Ottawa officials, Palmer visited both places. As a result of this investigation the abandonment of Port Nelson was recommended and the selection of Churchill approved.

The decisive considerations were that it was possible to make a better harbor at Churchill, the cost of construction would be less than similar work performed at Port Nelson, and could be completed in three years less time. There were unofficial indications also that silt deposited by the Nelson River near its mouth created special problems in the docking of large vessels at the Port Nelson site.

Once the decision was made to develop Churchill, the federal government instituted expropriation proceedings against William and C. E. Beech in order to prevent land speculation at or near the new terminus and to avoid a premature influx of settlers in its vicinity. In relocating the rail line between Mile 332 and Churchill the most economical route was found to follow the Port Nelson line as far as Mile 356. From Amery, a railway station a short distance west of the Second Meridian East, the line turned and headed due north toward Churchill, running somewhat to the west of that meridian, located at 94° West longitude, and generally parallel to it. By April 1, 1929, steel had been laid between Amery and Churchill. Much of the final trackage along this route had to be laid, however, on permanently frozen ground and swampland, without use of ballast. All ballasting was completed by September 14, 1929, in time to permit transportation by rail of timber and other products to the new port before the onset of winter.

It has been found that if due care is taken not to destroy natural surface insulation, roadbed on the more northerly mileage does not require unusual maintenance or costs even after more than 35 years of operation. Favorable grades on the Hudson Bay Railway enable trains of 174 freight cars, 1.6 miles in length and capable of transporting 300,000 bushels on one shipment, to be hauled with a distinct economy of power to tidewater at Churchill.

From Munk's time, early in the 17th century, those who established themselves at the mouth of the Churchill River, including the men responsible for the building and operation of the earliest Hudson's Bay Company posts and Fort Prince of Wales, had chosen the west side of the harbor to locate. But when the time came to select a site for the rail terminus, including railway yards, deep-water wharf and townsite, it was obvious that the east side was more suitable for such developments. No sooner had a temporary wharf been built in the 1928 season than ships began to arrive with timber, coal and other cargoes. As a natural haven from storms Churchill harbor did not need improvements. No matter from what corner strong winds or even gales might blow, the rocky shores beat off the roughest seas. This sheltering effect obtains even with a wind blowing straight through the harbor entrance because the passage is narrow and the harbor channel twists sharply once the entrance is negotiated. Anchorage is available up to 35 feet in depth at low tide. The tidal range for spring tides at this point on Hudson Bay is from 14 to 16 feet. Although shores are rocky it was found by borings that the channel and wharf could be located so that no rock would be encountered at less than 30 feet below low-water level. The expense of dredging in rock was avoided accordingly.

From 1928 to 1935 inclusive, intensive surveys were made by various vessels in Churchill harbor and vicinity to ascertain the arrival dates of the opening and closing of navigation. It was found that over that 8-year span, ice broke up in Churchill harbor between June 7 and June 21. It was also discovered that ice formation ended navigation at Churchill on dates ranging between October 14 and November 3.

The opening of Churchill as a commercial port took place in September, 1931. The ice hazard in the Strait during parts of the open navigation period was sufficiently serious to require an efficient patrolling operation by a powerful icebreaker. To provide this service a new oil-burning icebreaker was launched by the Department of the Marine in 1930 and the vessel was named *N. B. McLean.*

A substantial part of the federally-owned area at Churchill not required for rail terminus development was transferred in 1930 to the Province of Manitoba for the establishment of a townsite.* In the following year a sloping tract of land near the terminus was surveyed in lots and streets.

Aerial Photography and the Railways: 1925-1945

As a result of progress made in the science of aerial photography during the First World War, the airborne survey camera came into considerable use in Canada in the 1920s. For the most part air photography in those days was employed to supplement ground surveys in the mapping of forested and mineralized areas as well as in the revision of old maps and in the preparation of base maps. It would appear, however, that the decade immediately following the conclusion of the war was a period too early in the development of the airborne camera technique for its effective application to railway location work. Nevertheless, during the construction stage of the Hudson Bay Railway, numerous air photographs were taken along its right-of-way as early as 1925.

In the previous year a letter from Henry K. Wicksteed, F.R.G.S., addressed to the Royal Canadian Air Force, Ottawa, was printed as Appendix C of the Air Board Report. In this letter Wicksteed, who had been engaged for some months in 1924 on a preliminary survey and reconnaissance for location of a proposed railway in northwestern Quebec, made extensive comments on the use of aerial photography for that purpose. To study, on foot, the 8,000 square miles in which his employer railway company was interested would be "almost hopeless in our northern forest where the field of view is always restricted . . . ," Wicksteed pointed out. "But", he added, "the aeroplane is swift . . . two or three hundred square miles may be looked over at once, superficially, it is true, but quite often the superficial view is all that is needed to eliminate a portion of the territory from consideration and railway reconnaissance is largely a process of elimination of the impracticable and undesirable. The strong point of the aero-survey is in the mapping . . . far superior to the rough sketches now available . . . We always know that streams or lakes occupy the lowest points in the immediate neighborhood and, as a railway affects low ground, this alone is knowledge of great value to the engineer.

"The functions of the aeroplane are two-fold: (a) to give a wide and comprehensive idea, first by direct vision and, secondly, through the medium of the camera, of a great expanse of country — and (b) to supplement the exact instrumental survey by a vast amount of detailed information, performing these functions with a minimum loss of time and with absolute fidelity. As an aid to the engineer . . . it is difficult to overestimate the value of these photographic documents and plans."

Although some early experiments were carried out in this country using Curtiss HS 2L flying boats, the first aircraft regularly employed for photogrammetric purposes in Canada was the Vickers Viking. This was a relatively low-speed type of flying boat operating under a ceiling of about 5,000 feet but able to land with ease on fairly small bodies of water. The maximum length of a photographic flight in such a plane was 225 miles and, for reasons of safety, orders were issued that the planes were not to be flown at any distance from lakes or rivers (suitable as landing places) exceeding one mile for

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*O. in C. P.C. 537, Ottawa, March 12, 1930.

each 1,000 feet of altitude. In these flying boats, equipped with "pusher" type propulsion, the photographer would stand in the forward cockpit, exposed to wind and weather, taking oblique photographs directly forward and, in turn, at about 45 degrees to each side.

FIGURE 143. Oblique photograph of Pelican Narrows, Saskatchewan, taken at 3,000 feet, 1922. Regarded as the first Canadian air mapping photograph.

Initially the Viking was quite satisfactory for photographic purposes but, in time, its mahogany hull began to absorb water and to become heavier, leading to less efficient performance. Nevertheless these were the pioneer planes by which it was possible to advance Canadian air photographic techniques. The Viking was superseded by the Vedette, a smaller and more efficient craft. The Vedette, as far as can be ascertained, was the first flying boat in Canada on which a vertical camera was mounted inboard. This type of plane, which came into service in the mid-1920s, remained in use for some purposes in this country until the outbreak of the Second World War. Vikings and Vedettes were used to obtain oblique photographs of large areas of Canada for mapping by the grid method.

The pilots of these early aircraft in Canada did not have the benefits of modern aids to air navigation even when their operations extended into the Arctic. Some parts of the coastline of the Arctic Ocean were photographed from Vedettes by crews who, without assistance from meteorological forecasts, radio aids to navigation and other facilities, had to rely solely on their own competence sparked by the spirit of adventure and accomplishment. When flying over large expanses of this country familiarity with the appearance of pine trees of peculiar shapes along the route was a requisite of good airmanship. Any railway line in these remote areas was known to these flyers as an "iron compass".

In 1933 open cockpit flying boats were replaced by high-wing monoplane cabin aircraft which, for most photographic operations, were mounted on floats. These planes had increased range and performance. The earliest of these machines was the Fairchild FC2W. Photographic methods changed with the advent of cabin aircraft. Initially the camera was mounted under the fusilage, pointed aft for oblique photography but this arrangement was soon superseded by a combination of three fixed cameras mounted on a wooden beam inside the cabin. About the end of the Second World War trimetrogon photographs were being taken from Mitchell aircraft. When additional range proved desirable in remote regions the Lancaster bomber, denuded of armament, was adopted. This plane made it possible for the Royal Canadian Air Force, for the first time, to conduct planned and systematic tri-camera or vertical photography over any part of Canada. Other types of aircraft prominent in wartime, such as the Dakota, were also used for vertical photography within limited ranges.[4]

Canadian civil aviation authorities in their 1925 report indicated that the field program that year of the Topographical Survey, Department of the Interior, would include photography covering more than 30,000 square miles in eastern Manitoba and western Ontario, approximately 20,000 square miles in northern Manitoba and, because of public interest in the project, *over the Hudson Bay Railway as far as Port Nelson*[5] [author's italics]. However, the Topographical Survey annual report for the season makes no mention of any photographic flights along that railway. Because of unfavorable weather the two Vickers Viking amphibian flying boats employed to carry out the year's program failed to complete all of the operations planned for that season. Excerpts from the pilot's report on his flights over the railway line are revealing. His working altitude for this project was 5,000 feet.

FIGURE 144. Railway crossing at Kettle Rapids on Nelson River, 1925. Airphoto at 3,000 feet.

"The first flight", he reported, "was carried out on September 3 [1925]. Two previous attempts had been made but were discontinued owing to clouds and haze. Photographs were taken that day on the railway from The Pas to Bowden [Mile 137] where the aircraft refuelled . . . On the 12th the remainder of the railway was photographed though in the vicinity of Kettle Rapids the sky became overcast and two light snow flurries were experienced . . . There is at present no protection for any aircraft landing at Port Nelson and the alternative is to moor in what amounts to open sea conditions or to run up on the shore at hightide and rest in the mud."[6]

FIGURE 145. Oblique photograph, 1929, of port area, Churchill, Manitoba, at 3,000 feet.

More than 1,000 aerial photographs taken during 1929 by the Royal Canadian Air Force along the Hudson Bay Railway to its new terminus, Churchill, are in the possession of the National Air Photo Library, Ottawa. But the report on that year's activities issued by civil aviation officials, as well as the regular annual report of the Topographical Survey covering that season, fail to mention any such photographic project. In any event these flights came too late in the course of this railway venture to have had any connection with survey location work. The planes and pilots employed on these pioneering photographic flights in the 1920s were provided by the Royal Canadian Air Force, a name that was in actual use some months prior to its official adoption on April 1, 1924.

In 1931, however, the Canadian Pacific Railway undertook railway location surveys through the Peace Pass and Monkman Pass routes at a time when the attention of the Canadian public and parliament was fastened upon the need for building a rail line linking the Peace River country with a port on the Pacific Ocean. In commenting on the surveys on the Peace Pass route, covering a distance of 960 miles, Thomas Creighton Macnabb, Engineer of Construction, Canadian Pacific Railway Western Lines, declared that the use of aerial photographs on this project "very greatly speeded up the [location] work and gave a certainty to the conclusions which could not have been reached otherwise. The work was completed in one season; in earlier days it would have taken three years. It was more efficiently done and a decidedly more satisfactory record was obtained."

On this and several similar survey projects conducted by the Canadian Pacific Railway under Macnabb's direction that season, about 30,000 aerial photographs were taken. This accomplishment inspired Macnabb to state further that "the airplane is an unrivalled agent in giving maximum information with minimum expenditure of time and effort. There is the whole science of mapping from the air, using vertical or oblique photographs and interpreting them by means of stereoscopes. For railway locating nothing has ever been so comprehensive as this. But it cannot be used wisely unless the engineer has had a great deal of experience on the ground and is familiar . . . with the type of country to be studied from the air."[7]

The Second World War brought about even more startling advances in this realm of photogrammetry. During 1942, for example, United States and Canadian army engineers, making use of aircraft for transportation, reconnaissance and photography, succeeded in staking the preliminary location, within a period of five months, of a military railway projected to run from Prince George in British Columbia along the Rocky Mountain Trench to Alaska, a distance of some 1,500 miles.[8]

Macnabb's views on the pronounced advantages of the airborne camera in railway location surveys were echoed thirty years later by J. L. Charles, regional chief engineer, Canadian National Railways, Winnipeg, and later consulting engineer to that system. A distinguished veteran of two world wars who rose to the rank of major, Charles pointed out that as a result of scientific advances made during the Second World War it was possible, even by the mid-1940s, for experienced railway surveyors, working on the Alaska Railway project over most difficult Canadian terrain, to determine the most feasible route with great speed and efficiency. In spite of swift rivers flowing through deep canyons, areas of treacherous muskeg, high summits and unstable side-hills of slippery clay, reconnaissance engineers were able to examine, during a relatively short period, several possible routes from the air and to select the most practical one.

Railway Location Survey Procedures: After 1945

The foundation of any successful railway consists, in the planning stages, of adherence to such basic factors as a low rate of ruling gradient, minimum rise and fall, curvature and distance established in relation to sources, classes and volume of traffic on the proposed line and to a reasonable investment in it. Reconnaissance of the territory to be crossed by the railway is therefore the first and by far the most important step in the advancement of the project.

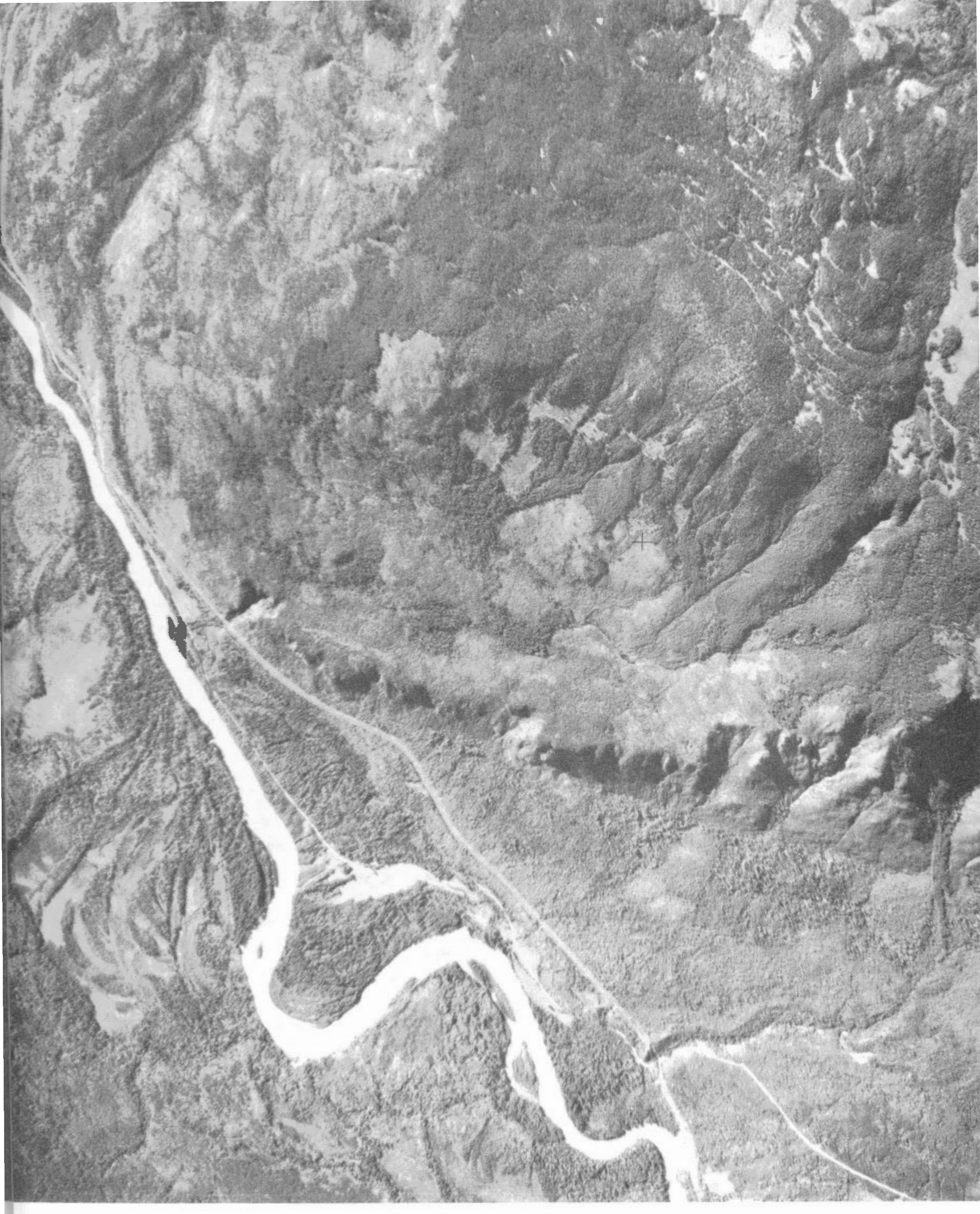


FIGURE 146. Canadian National Railways' Prince Rupert line from the air, 1949, showing route through Bulkley Canyon near Hazelton, B.C.

The time required by the various surveys involved has always been an important consideration in the building of a railway and never more so than in the construction of Canadian lines after the end of the Second World War in order to further develop the country's natural resources. By that stage in our history types of aircraft, advanced equipment and highly precise instruments, including much improved models of airborne cameras, had become available and, in combination, served to reduce very considerably the physical labor and time required to complete location surveys.

Light aircraft and helicopters, camera-equipped and carrying two-way radio apparatus, could be employed for reconnaissance purposes. Air photography produced a series of prints for study in stereo pairs. Subsequent photogrammetric procedures enabled a map to be plotted showing surface features and contours of a strip of territory along the general route of the proposed rail line. A series of such aerial photographs could then be subjected to photo analysis and interpretation in order to disclose the extent of timber growth, the nature of the drainage, depth of overburden, soil types and their suitability for grading operations, muskeg or swamp depths as well as locations of sand and gravel pits required for ballasting operations. Following the accumulation of this information ground controls could be set and distances estimated between defined photo points and respective elevations.

The tasks of measurement had been expedited and the accuracy of results increased by the use of electronic instruments such as the tellurometer. Stereo plotting machines, operated by skilled technicians, produced strip maps of the country along the right-of-way. Such strip maps might cover as much as 2 miles in width and many miles in length. The centre line of the railway could then be projected by an experienced engineer as a "paper location" and the relative cross-section or profile accurately plotted and the grade line set. With the advent of electronic computers, survey engineers were relieved of mass repetitive calculations. Also, by feeding into a computer such data as track, train and motive power characteristics it became possible to simulate expected train performance and to evaluate the merits of alternative routes in the light of total running times and maximum speeds, costs of line maintenance as well as of bridges and other required structures. But more significant than any mechanical devices in the prosecution of railway location surveys is the possession by the reconnaissance engineer of a "good eye for country" and of actual experience in his special field.[9] Finally, comes the staking of the preliminary line, establishment of bench marks, and of profiles "on the ground". The design for the railway can then be completed.

Aerial Photography and the Railways: After 1945

(a) *Quebec North Shore and Labrador Railway*

One of the early Canadian examples of full productive use of air photography in railway location surveys was provided in the case of the Quebec North Shore and Labrador Railway project. This line, beginning at Sept Iles on the north shore of the St. Lawrence River runs almost due north through some of the most rugged terrain in eastern Canada to reach Schefferville, some 356 rail miles away. The completion of this railway, a subsidiary of Iron Ore Company of Canada, made possible the development of rich iron-ore deposits in the Knob Lake region. Transportation of men, supplies and equipment by air was also a vital factor in this impressive undertaking. Within three

FIGURE 147. Knob Lake railway under construction.

years a total of 15 million tons of freight was airlifted in support of the enterprise. Eleven temporary airports were built along the route to facilitate the flow of this type of traffic.

In the summer of 1945 D. A. Livingston, a Vancouver engineer, began air reconnaissance surveys in search of the most feasible route for the railway to follow. Line location surveys continued under his direction from 1947 to 1950 inclusive. At the outset a careful study was made of map sheets published by the Hydrographic and Map Service, Ottawa, on a scale of 8 miles to the inch, each sheet covering 4 degrees of longitude and 2 degrees of latitude. These maps were useful especially in showing the drainage systems of the areas under examination. Employing canoes as well as a Fairchild plane, with Hank Gates as pilot, Livingston completed 20 days of reconnaissance on July 4. Hitch-hiking on one occasion on a Stranraer flying boat that was transporting supplies to a geological surveyor's camp at Hollinger Lake, Livingston found the Moisie River valley in one stretch "a tortuous semi-canyon with sharp bends and requiring much tunnelling, with solid rock predominating."[10] On crossing the height of land the engineer observed that the country was swampy, with low ridges and islands of sand.

Again using canoes and a plane, with Johnny Dart as its pilot, Livingston completed his reconnaissance by exploring, in particular, the height of land area during a further period of 35 days. In timbered parts of the watershed country he found spruce, tamarac, birch and poplar, with spruce predominant. Livingston's initial surveys produced information on elevations of terminal and other strategic points; of grades and summits, passes and lakes. Elevations of streams were obtained at frequent intervals. Stream profiles were plotted.

After reconnaissance of the general area to be crossed by the rail line, the standard railway survey procedure was followed, namely, a preliminary survey was carried out to select the best of the several possible routes determined by the reconnaissance. What appeared to be the most feasible routes were first marked on maps, followed by an examination of each route on the ground. A flight of aerial photographs was taken along what was regarded as the most suitable location of all. Each photograph covered an area approximately 6 miles east-west and 3 miles north-south. Extensive use was made of these photographs in locating the selected route on the ground and in planning subsequent survey operations. Several of the routes under consideration were eliminated at this stage because of their undue length of line or unfavorable grades.

The second, or preliminary survey, stage of the project commenced in the summer of 1947. Two field parties were active on this phase of activities in summer and winter until 1950. Summer crews moved by canoe or boat on the larger lakes and rivers. Winter crews used dog teams. Each party was composed of 18 to 24 men and consisted of a locating engineer, transitman, leveller, draughtsman, two topographers, a head chainman and rear chainman, rodmen, stakemen, two axemen, three canoemen or (in winter) dog drivers, a cook and his helper. A continuous contour plan and profile, revealing all topographical features related to the location line, was maintained on a daily basis.

In regions where lakes predominated, prevailing strong north-west winds often seriously hindered canoe travel. This problem was largely overcome by the building of large, flat-bottom plywood boats, driven by 10-horsepower outboard motors. Such craft were built at Sept Iles in sections and then flown inland. Each field party was equipped with two boats of this type. Survey parties considered that good progress had been made if they covered from one-half a mile to one mile each day. On the Labrador plateau, however, better headway was made and parties averaged 2 miles per day. On location work on this project a total of 1,057 miles of survey line was run.[11]

The maximum elevation on the Quebec North Shore and Labrador Railway is 2,066 feet. The ruling grades, compensated for curvature, run 0.4 per cent against loaded southbound cars and 1.32 per cent against northbound empties. The route follows the natural drainage patterns of the country traversed, crossing the narrow coastal plain just to the north of Sept Iles, rising to the coastal highlands along the valleys of the Moisie, Nipisso, and Wacouno rivers to Mile 130. Then the route follows the Magpie River to the height of land near Mile 150, then enters the Labrador plateau, skirting lakes to Mile 330. Across the remaining distance the line follows the Labrador Trough to Schefferville (Knob Lake) at Mile 356.

(*b*) *Ontario Northland Railway*

In 1921 construction began on the 187-mile extension of the then Temiskaming and Northern Ontario Railway from Cochrane to Moosonee, its James Bay terminus located at 51°20′ north latitude. The undertaking involved a total descent to sea level of 881 feet. Although the railway location survey party lived in light silk tents throughout the winter and, at times, slept in the open in weather 55 degrees below zero, the experience was not all hardship. The quality of rations was good, each man knew his assignment and all worked together as a happy team. Activities were planned systematically well in advance, including provision of a special Christmas dinner along with a gallon of rum. This feast was celebrated near the crossing of the Owl River and, appropriately enough, involved a considerable amount of hooting. During the first winter bridges were built close on the heels of those performing the reconnaissance and location surveys. Piles for these structures were driven into position in permanently frozen ground by the use of steam jets.[12]

Urgency was the watchword of this initial drive northward. In order to bring timely aid to the establishment of a hydro-electric plant in the canyon of the Abitibi River it was necessary to expedite building of 44 miles of line out of Cochrane. The season of 1923 marked the start of construction, consisting of several stages, of railway mileage to Rouyn, Quebec, a point reached four years later. In 1928 location surveys led the way once again to the north, reaching Moosonee in time to permit trackage to reach that terminal in 1932.

(c) *Sherridon-Lynn Lake Extension*

One day in 1941 a prospector, travelling along the shore of Lynn Lake, Manitoba, about 500 miles northwest of Winnipeg, discovered an outcrop of mineralized rock which proved, on assay, to be 6 per cent nickel, a very rich strike of this metal. At Sherridon, Manitoba, upwards of 150 miles to the south, the Sherridon-Gordon Mine was becoming depleted. In order, however, to ship nickel and copper concentrates from the newly-found deposit to a refinery near Edmonton, Alberta, construction of a 144-mile rail extension from Sherridon was considered by the company to be essential to the success of the enterprise. Negotiations between the company and the Canadian National Railways led to the decision of the latter to build a rail line to Lynn Lake. In 1951 the project was authorized by Parliament.[13] A time limit of 32 months was set for completion of the line through country that was virtually uninhabited and unsurveyed.

Topographical features in that part of Canada show a general east-west trend and consist mainly of rocky ridges, numerous lakes and rivers as well as many areas of muskeg. A major waterway, the Churchill River, had to be crossed. Trees in this region were rather small and widely scattered.

In February, 1951, initial surveys of the line commenced and by the end of that year location work had been completed as far north as the point at which the Churchill River was to be bridged. Aircraft was used for reconnaissance purposes as well as for facilitating the movement of men, supplies, and camp equipment.[14] Because of the numerous waterways three major steel spans, one small steel bridge, and some 65 timber bridges as well as more than 500 culverts were required. Following air reconnaissance, examination of principal natural features was made on the ground so that a study might be made of comparative factors such as distances, topographical formations, ruling gradients, curvatures, construction and maintenance of way costs.

After consultation with officials of the Department of Mines and Technical Surveys, Ottawa, it was decided to employ several ground survey parties to be aided by aerial photography and air transport. After examining the air photographs in stereoscopic pairs, preliminary survey lines were run and maps plotted on a scale of 200 feet to the inch and with contours at 5-foot intervals. These maps covered 1,000 feet on each side

of the preliminary line. Location was projected on map sheets and then established on the ground. After additional study, revisions of the line were made wherever improvements in alignment or in the reduction of construction costs, or both, would result.

The length of this railway, upon completion, did not greatly exceed the airline distance of 120 miles between Sherridon and Lynn Lake. By the exercise of careful line-location procedures the percentage of track on muskeg was kept relatively low. Not more than 10 per cent of total quantities of excavated material along the whole line was solid rock, a favorable factor in the saving of time and costs.[15]

FIGURE 148
Army engineers on a tellurometer traverse, 1958, accommodated on a Hudson Bay Railway train.

Surveying operations established a maximum gradient of 1.75 per cent, compensated for curvature, and a maximum rate of curvature of 10 degrees except for a few curves in the line approaching the Churchill River bridge, which were somewhat sharper. Such steep gradients and heavy curvatures are uncommon in railway location work but were adopted in this project to enable construction to be accomplished at a minimum capital expenditure in relation to volume of available traffic and to anticipated cost of operation.

As an integral part of the entire undertaking, buildings in the town of Sherridon as well as heavy mining equipment were moved by tractor trains over winter trails to Lynn

Lake. Rails reached that community on October 23, 1953. The new mine there came into production in that same year. The last spike ceremony, featuring President Donald Gordon of the Canadian National Railways, took place on November 9, 1953, followed by the loading of the first railway car with nickel concentrates for shipment to the Fort Saskatchewan refinery in Alberta.

During the period of 20 years following the end of the Second World War more than 2,000 miles of new railways were built in Canada. This construction effort was spurred by the nation's remarkable industrial growth during that span of time, especially in relation to mining and to the pulp and paper industry.

The development of Canada in general has been influenced to a marked extent by engineers who located the nation's railways. These men and the surveyors who assisted them were not only animated by a vigorous, resourceful, pioneering spirit but possessed as well the vision and optimism indispensable to the opening up of vast new regions. The building of the Hudson Bay Railway, for instance, brought fresh impetus to the surveying of base lines and of meridians, particularly in northern Manitoba; just as the construction of the Canadian Pacific Railway in the late 1870s and early 1880s imparted a dynamic drive and sense of urgency to the subdivision of lands in Canada's western interior. From 1911 to 1917, for example, no less than 1,852 miles of base lines and meridian lines were surveyed in Manitoba's north.

The time-tested uses of barometer, transit, level and chain were no longer the principal means by which location and subsequent railway surveys could keep pace with the rate of progress demanded by fast-moving developments. These tools, by the 1950s, had become less significant for these purposes than precision cameras, air photographs, electronic distance measurers, first-order plotting instruments and the thin chattering vanguard of an army of computers. Fortunately, progress in aerial mapping and in map production techniques generally had advanced to the point at which accurate planning of railway construction could be expedited greatly.

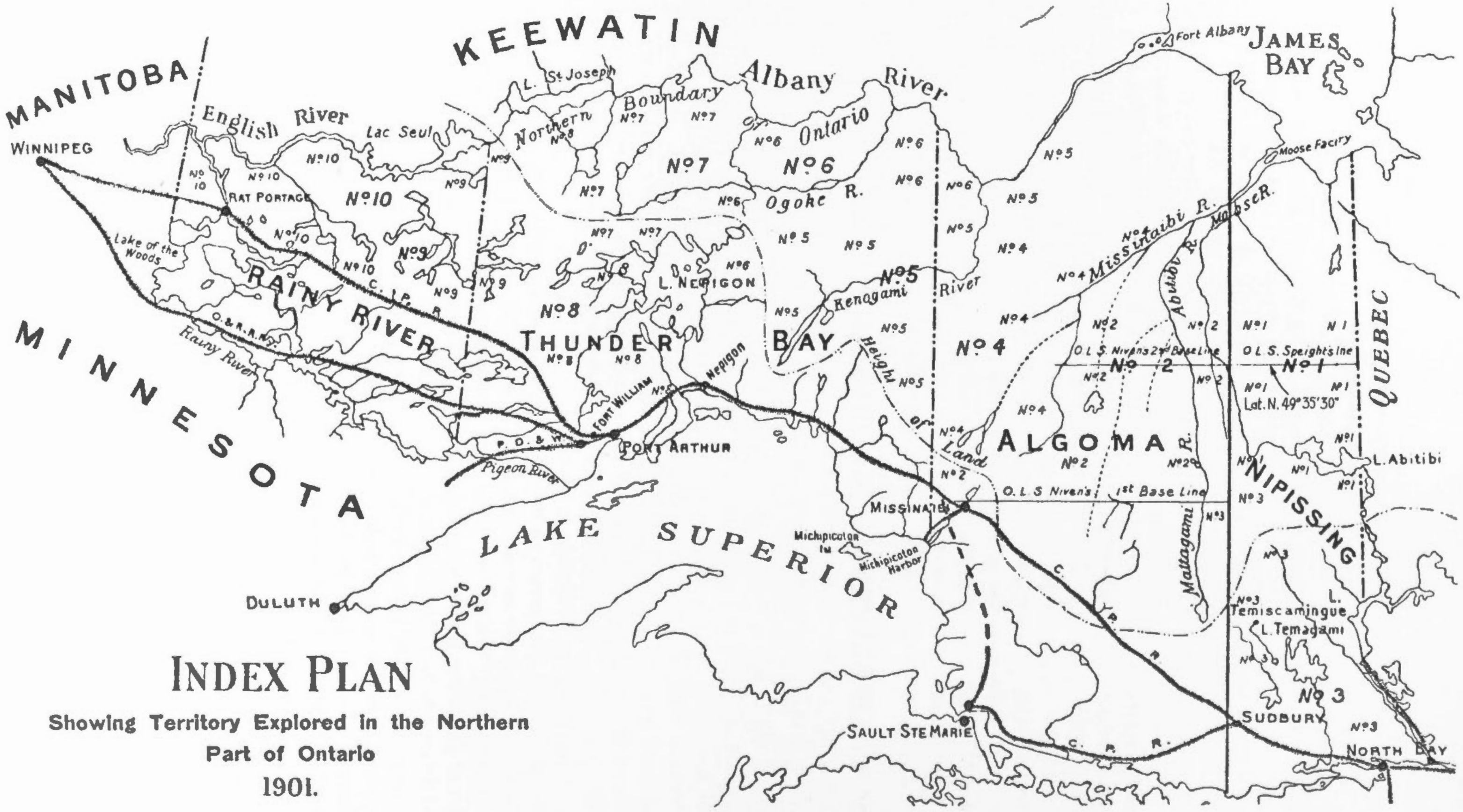
18

THE ROLE OF MAPPING IN FOREST SURVEYS

The term "forest surveys" has the advantage of brevity but the disadvantage of ambiguity. As the term has been employed in Canada such surveys resemble population or special audience types of census-taking rather than any professional surveying in the traditional sense. But forest survey work in Canada in the earliest days of this activity was performed basically for the production of planimetric mapping, information assembled more often for private lumbering or pulpwood firms than for governments or for the use of the general public. Because of its mapping aspects, however, a review of this service to a major industry of this country is relevant, if not quite indispensable, to the story of surveying and mapping in Canada.

Forest surveys or tree counts of the 19th century and the early 20th century in this country were performed by timber cruisers. These durable men, possessed of a special talent for the purpose, "cruised" or walked the woods searching for trees suitable for the production of masts for Royal Navy vessels. Later their reconnaissance work broadened to include timber useful in ship construction and for the production of squared logs. The ability to roam forests and make reliable, accurate estimates of the number of masts and useful logs obtainable from specified areas, as well as their probable dimensions, called for the exercise of special training, skills and good judgment.

One of the pioneer timber cruisers in Canada was Titus Smith, Jr., a land surveyor who, in 1801, at the request of the government of Nova Scotia, toured what was then the interior wilderness of that province to discover and report upon, among other matters, "the quality of the land and the character of the timber, especially that suitable for masts . . ." Smith performed his ambitious survey entirely by foot, equipped only with a compass, rough map of the general area and a small supply of food. The map that he produced as a result of his strenuous tour represented an important milestone in resources mapping and in resources inventory work in the northern half of North America.[1]



MAP 12. Territory covered by resources survey under Ontario government auspices at the turn of the century.

In 1900 one of the most remarkable explorations and reports to be made on this continent for the purpose of presenting data on natural resources over a wide area was undertaken at the request of the government of Ontario. The investigation was prompted by an urgent need for authoritative information on the natural assets of northern Ontario, to enable members of the Legislature of the province to vote intelligently on the nature, size and number of government expenditures that ought to be made for the development of that part of Canada. Accordingly ten field parties were organized and, with one exception, each party was placed in charge of an Ontario land surveyor. The lone non-surveyor party chief was George R. Gray, who was in charge of Party No. 3. Even so, his party included Ontario land surveyors Richard W. DeMorest and George E. Silvester. The land surveyor chiefs, in order of their numbered parties, were Thomas B. Speight, Alexander Niven, Alexander Baird, Walter S. Davidson, Joseph M. Tiernan, Hume B. Proudfoot, David Beatty, James Robertson, and John McAree.

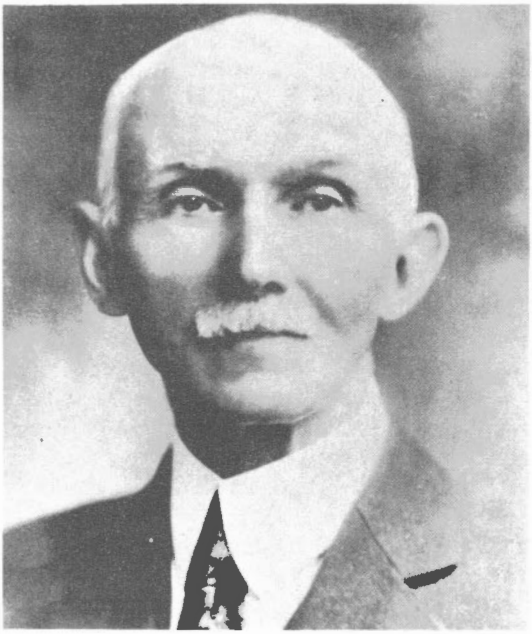


FIGURE 149. Thomas B. Speight.

The official who recommended the over-all scheme of organization for the expedition was the then Director of Surveys for Ontario, the Dominion and Ontario land surveyor George B. Kirkpatrick, who had been asked by the premier of the province, Hon. George W. Ross, to take on that task and to submit an estimate of the cost of such exploration. With the help of information supplied to him by the Department of the Interior and by the Geological Survey in Ottawa, Kirkpatrick arranged for the preparation of a map on a scale of four miles to the inch, showing what was then known of the territory to be examined. Kirkpatrick's estimate of cost was $40,000 and this was the sum actually voted by the Legislature for the purpose. It stands as a tribute to Kirkpatrick's accurate forecasting that the eventual total expenditure on the enterprise amounted to $40,518.28.[2]

Among the duties to be discharged by field parties on this expedition was the compilation of reports on pulpwood resources in the areas explored, on the basis that spruce and poplar formed the principal sources of that product. "It was necessary that the explorations should be performed", the completed report stated, "so that the country could be mapped out and the situation of the good land and timber accurately laid down on the plans of the Crown Lands Department."[3] In addition to a land surveyor each of the ten field parties included a geologist and a timber expert so that, in addition to any required mapping, reports could be prepared on the nature of mineral wealth, water-power potentialities, varieties of soils and extent of pulpwood and timber resources in the entire region.

Apart from the categories of information already mentioned, data was asked on the flora, fauna and fish of northern Ontario. In addition the government sought a description of the general features of the region, procured by a track survey of water communications. Observations were to be taken, at regular intervals, for latitude readings and for magnetic variations.

The total assignment was a most formidable one. Some conception of the work to be accomplished in the course of this single field season of five months may be derived from a description of the limits of the region to be covered by Party No. 5 under Davidson, namely: "Jackfish Station on Lake Superior to Long Lake, then down the Kenogami River to Albany River, then down the Albany River to Hudson Bay. The English River to be explored for 20 miles on each side and the Albany River by way of any large streams flowing into it from the south." Each chief of party was equipped with a theodolite, a pocket sextant, steel tape and pins, compass with Jacob's staff, a micrometer, customary plotting instruments, aneroid barometer, camera with films, tin box for field books and drawing materials and a tin case for preserving specimens of the flora of the country. This in addition to tents, canoes and pack-straps ". . . all to be returned and accounted for."

The report resulting from this ambitious enterprise, published in the following year, 1901, is a classic of its kind and represents, in resource mapping and in the gathering and presentation of resource information, an achievement seldom equalled anywhere in the world. On a small budget Dr. B. F. Fennow accomplished a somewhat similar but much more restricted survey of Nova Scotia in the field seasons of 1909 and 1910.

In 1912 the consulting firm of Lyford, Clark and Lyford prepared a remarkable survey, including the production of maps on a scale of 20 chains to the inch, of the Petawawa timber limits of Gillies Brothers of Braeside, Ontario. These maps were contoured and, despite poor ground control, proved highly accurate.

As a consequence of the growing scarcity of traditional timber cruisers the *valuation survey* became an established procedure and foresters concentrated on the percentage of the particular forest that needed to be tallied as well as on the most effective width of strip or size of sample plots, in order to provide a satisfactory degree of accuracy in their estimates. Often during such a forest study it was essential to produce a reliable planimetric, if not a topographic, map as well as a reliable estimate of timber volume. The network of base lines, run mostly with a staff compass, formed the skeleton on which the map was assembled. Since staff compass lines were of relative accuracy only, transit lines had to be run at wide intervals where cadastral surveys did not extend into the region. Parallel cruise lines, usually at 20-chain intervals, were run between base lines and along these lines topography was mapped and trees tallied.

Aerial Photography and Forest Surveys

Some of the first non-military aerial photography performed in Canada was in support of forest studies. Maps, of course, are aids indispensable to the success of such investigations. Soon after the end of the First World War, pulp companies in Canada expanded greatly. Timber cruisers, men trained in the long tradition of the craft, were few and difficult to find. In addition, these specialists felt that pulpwood surveys were beneath their proud notice. But the companies, now in possession of large timber limits, desperately needed reliable maps of their properties. Such maps, in fact, were required to form the basis of any systematic forest survey.

At about this stage of developments the airborne camera came to the aid of the forestry and pulpwood industries. In 1919 a forester, Elwood Wilson, persuaded the federal Department of Marine to lend to the St. Maurice River Protection Association, of which he was president at the time, two Curtiss naval flying boats of the HS 2L type. In return for the use of these planes Wilson was to submit to the government at Ottawa reports on work accomplished in air photography.[4] Capt. Stewart Graham, with his wife acting as navigator, flew one of the loaned planes to Lac à la Tortue near Grand'Mère, Quebec. Wilson went along in order to observe and assess progress on the venture. He had purchased a small hand camera for taking photographs from the air. In addition Wilson had ordered a large automatic camera for use in air mapping. The 1919 season was so successful for this enterprise that in the following year the federal and Quebec governments established a seaplane base at Roberval.

In 1919 also a little-publicized but highly significant pioneer expedition was organized by a Canadian with the aid of United States capital and some American personnel to undertake an aerial survey in what is now part of Canada. Capt. Daniel Owen (1890-1939) of Annapolis, later Annapolis Royal, Nova Scotia, served as leader of the expedition. Owen had served in the First World War as a pilot in the Royal Flying Corps. In an encounter with enemy aircraft in France Owen's plane was shot down. He lost an eye in the crash landing and was taken prisoner by the Germans. In the postwar project Owen was backed financially by the Southern Labrador Pulp and Paper Company, Inc. of Boston, Massachusetts. A group of about 20 men was organized for the purpose of accomplishing an air survey of the Labrador timber limits leased by this American firm. The limits, about 2,500 square miles in extent, formed a tract in the vicinity of Battle Harbour, St. Louis Inlet and Alexis Bay. H. V. Greene Aerial Survey Company Limited of Canada came into existence primarily to assist in the Labrador project. But by mid-summer of 1919 the firm actively sought contracts "to photograph and survey timber, pulpwood and water areas, cities and towns" in all parts of the United States and Canada "or any part of the world".[5]

For use by this Labrador expedition, which included five pilots, a forester and two surveyors (Charles Whitman of Annapolis County and Peter Hatfield of Yarmouth), special techniques were practised in Annapolis County. It was the summer of the popular visit to Canada of the youthful Prince of Wales. Newspaper front pages in the Maritimes reflected in column after column public absorption with the royal personage and his activities. But this general preoccupation with parades and pageantry failed to erase entirely from the public press some lively descriptions of the Owen expedition.

On July 7, 1919, *The Morning Chronicle*, Halifax, carried an item under an Annapolis, Nova Scotia, dateline of two days earlier, "First Aerial Expedition in World.

Everything in Readiness for Departure for Labrador." The text of the despatch read, "The expedition to explore by airplane the timber resources of Labrador, planned by Dr. Murdoch M. Graham of Boston, has materialized and is expected to sail tonight or tomorrow in the steamer *Granville*. The deck of the vessel, under command of Captain I. C. Rhude, has been fitted to carry an airplane and a seaplane with wireless equipment installed. This expedition will have the distinction of being the first of its nature for commercial purposes. It is expected to accomplish in six weeks by aerial reconnaissance of wooded areas in Labrador what would otherwise take six years to accomplish. The expedition, estimated to cost $200,000, is expected to lead to the development of new sources of supply of wood and pulpwood."

The front page of *The Morning Chronicle* of July 8 bore the heading "Expedition Off for Labrador. Steamer *Granville* Sailed From Annapolis Last Night." Then the text, "A large crowd was on the wharf to see them off and they were heartily cheered as the steamer left the dock. This afternoon a picture was taken of the party which will be shown on movie picture shows." The entire survey operation, in which two Curtiss JN4 planes were employed, was completed in 10 days of flying that summer. Airborne crews were divided into two shifts so that full advantage could be taken of the long hours of daylight available in such latitudes at that season of the year. Photography was carried out at altitudes ranging from 2,000 to 9,000 feet. About 5,000 gallons of gasoline, in addition to supplies of oil, were required.

On August 23, 1919, *The Morning Chronicle* displayed a bold but somewhat misleading heading, "Expedition Returns and Reports Having Explored Millions of Acres" over a despatch from Curling, Newfoundland, dated the previous day. In part the text read, "Cruising in airplanes over Labrador millions of cords of pulpwood could be cut and rolled to streams for direct shipment, members of the expedition which spent the past month there, said today . . . Pictures were taken from the air, numbering 13,000, were said to show dense growth of pulp material in readily available locations. The use of the airplane was looked upon as opening a new field for commercial aviation. The planes cruised inland for more than 100 miles. Captain Daniel Owen, Royal Flying Corps, head of the expedition, and other members of the party left tonight for Boston."

Photographs produced by the survey expedition apparently were taken direct from Newfoundland to the headquarters of the firm in Boston by Capt. Owen. During the years following the expedition and until the year of his death Owen practised law in Annapolis Royal, becoming a King's Counsel. For several years he served as mayor of that town. As far as can be ascertained the air photographs taken by the 1919 expedition to Labrador have not been used in the production of maps available to Canadians.[6]

FIGURE 150. Vickers planes were used in the 1920s in Canada for oblique photography of large areas. This Vickers-Vancouver type is at Waskesiu Lake, Sask.

Probably the first attempt, on a fairly large scale, to utilize aircraft and aerial photography in central Canada for forestry purposes was in 1921. In May of that year the Ontario Department of Lands and Forests assembled three HS 2L flying boats on the shore of Pelican Lake at Sioux Lookout. Familiarization flights commenced at the end of that month. During regular operations, which continued until October, vertical and oblique photographs were taken. Landings were made to enable the flying foresters to inspect each of the forest types, to take sample plots as well as ground photographs. Flights were then made in the region over blocks of timberland about which the provincial government required not only information prior to offering same for sale but complete forest-type maps as well. The greatest problem facing the foresters during the operation was the lack at that time of satisfactory base maps of the area being flown. Large expanses, dotted with lakes, appeared only as blanks. Such lakes had to be sketched in, before forest types could be portrayed and, as a result, mapping of waterways consumed about two-thirds of the total time devoted to the enterprise. Despite all difficulties, forest-type maps and descriptive reports covering about 15,000 square miles were completed. Most of the region covered was north of the Canadian National main line and to English River, Lake St. Joseph and upper Albany River and from the boundary with Manitoba east to a point just beyond the town of Armstrong.[7]

In the years between 1925 and 1930 several thousands of square miles were vertically photographed for the Quebec government and for pulp and paper companies, practically all of it in the province of Quebec.

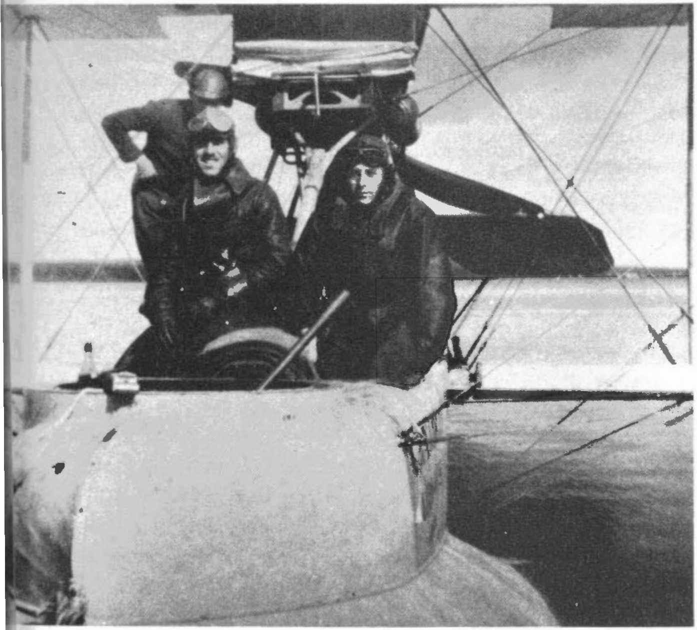


FIGURE 151
Paul Savard, Q.L.S. (left) with pilot and forest engineer Jean G. Rivard, Q.L.S. This Curtiss HS2L plane was used to expedite surveys of part of Hamilton River watershed, 1926.

In 1923 the government of Ontario entered into a three-year contract with Laurentide Air Services for air surveying and mapping of forestry resources in that province. An airbase for the company's HS 2L planes was established at Sudbury and sketching-observer teams for the operations were provided by the Department of Lands and Forests. The sketchwork was done by foresters trained in the art. In each instance the forester directed the course of the plane by a set of pre-arranged signals from the forward cockpit, which he occupied, to the pilot. The task of the forester in flight was to sketch required detail on the best available topographical map of the district being flown. A reliable and detailed forest-type map could thus be produced. At the time, these maps were utilized mainly in forest protection work.

In 1927 Frank T. Jenkins of James D. Lacey and Company (Canada) spoke to the Canadian Society of Forest Engineers and reported that during the six or seven years since aerial mapping had come into existence in this country, and apart from aerial photography, approximately 120,000 square miles of Canada had been mapped by the sketching method.

Jenkins had joined the Lacey Company on graduation and later became its managing director. In 1924 the firm added to their forest engineering service the sketching method of aerial forest mapping. In three seasons beginning that year the firm sketched about 30,000 square miles in Ontario, Quebec, Manitoba, and Nova Scotia. A ground cruising party operating in the sketched area would find such maps invaluable although, where ground control was scanty, tiny lakes would not be represented in the sketching owing to the time factor involved.

In his 1927 address to the forest engineers Jenkins went on to say: "Assuming there is sufficient control, sketch the area as intensively as possible. With this map and the descriptive report, plans can be projected in the office . . . All that remains then is to apply the average per acre figure, as shown by the strip tallies, to respective types."[8]

In this statement the method outlined by Jenkins, in basic form, continued to be that most used in forest-cover mapping during the era following the end of the Second World War. In earlier days of aerial mapping of forests, sketching was accomplished from the cockpit of the plane. Map sections were mounted on beaverboard and one of the first duties that the sketcher had to perform was to check his maps against the country to be represented in order to determine what detail was reliable. The sketch map was oriented to the country and the sketching was carried on by a rough triangulation system. When the forester had sketched the main waterways, intervening details and forest types were added.[9]

In 1927 to 1929 a pulpwood survey took place in Manitoba involving a notable application of aerial mapping to forest survey work. The Manitoba Paper Company, before building a projected pulp mill at Pine Falls on the Winnipeg River, decided to make certain of the existence of a continuous supply of wood for that operation. Air photographs, taken by the Dominion Forest Service, mostly obliques, covered much of Manitoba lying directly east of Lake Winnipeg. There had not been sufficient time to prepare forest-cover maps of the area and so field parties subsequently made use of these photographs frequently in order to locate areas of forest and to cruise same.[10]

Under such pioneering conditions field investigations consisted of surveying a few strip cruise lines through major blocks of timber, utilizing air photographs for control. This procedure speedily provided a reconnaissance survey of a vast area. In 1933 Gerald S. Andrews, then of the Forest Surveys Division, British Columbia Forest Service, and Lyle G. Trorey published an article on the use of aerial photographs in forest surveying. This presentation proved to be a significant contribution to Canadian progress in forest surveying and mapping methods.[11]

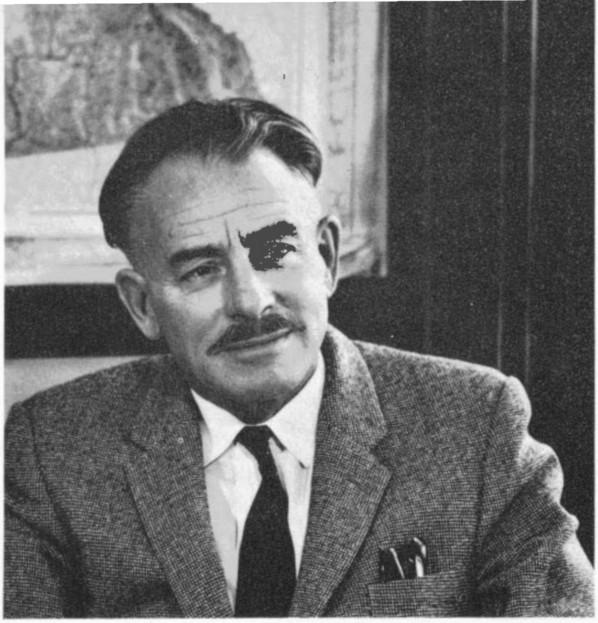


FIGURE 152. Gerald S. Andrews.

For a year, including parts of 1933 and 1934, Andrews was occupied in Europe on a partly foundation-financed study of air survey developments from a forestry standpoint. His studies were carried on in the United Kingdom and, particularly, at the Tharandt Forest School in Germany. Following his return to Canada, Andrews wrote an article, published in this country, descriptive of German photogrammetry and air-photo interpretation procedures as applied to forest surveys.[12] In his article Andrews pointed out that in the intelligent use of aerial photography a revolutionizing aid had been found in advancing systematic descriptive mapping and appraisal of forested areas, including the Canadian method of mapping from obliques. In Germany world-famous industries had grown up, engaged in the manufacture of optical and scientific instruments of high precision. These industries had devoted special attention to the development of photogrammetrical instruments and techniques and to the application of these to air survey work generally. Andrews felt that although unmodified German methods in this field could not be applied to Canadian conditions the Europeans had provided valuable object lessons as well as clues to better procedures in Canadian forest inventory work. Canadians, however, had advanced far beyond any European experience in the qualitative interpretation of air photographs. Andrews warned that the resulting map should not become an end in itself. "The map", he declared, "is only an important contribution to the main end, namely, the efficient use and administration of the country concerned. In the case of a forest survey the map is an indispensable document but, after all, accessory to the real purpose of the survey."

Although another Canadian forester, H. E. Seely, had perfected a system of measuring the height of trees from the length of their shadows as depicted on air photographs, Andrews devised a system of measuring tree heights by parallax, a method suited to mountainous terrain such as that found in British Columbia. The determination of the total height of any tree or stand of trees represents a most important step in the appraisal of uncut timber because the cubic contents of the tree bole is related to its height. The Andrews system was based on micrometer measurements of the difference in parallax between the top and bottom of any tree revealed on stereo-pairs of vertical air photographs, correlated with factors of the plane's altitude, length of air base, and focal length of the airborne camera lens.[13]

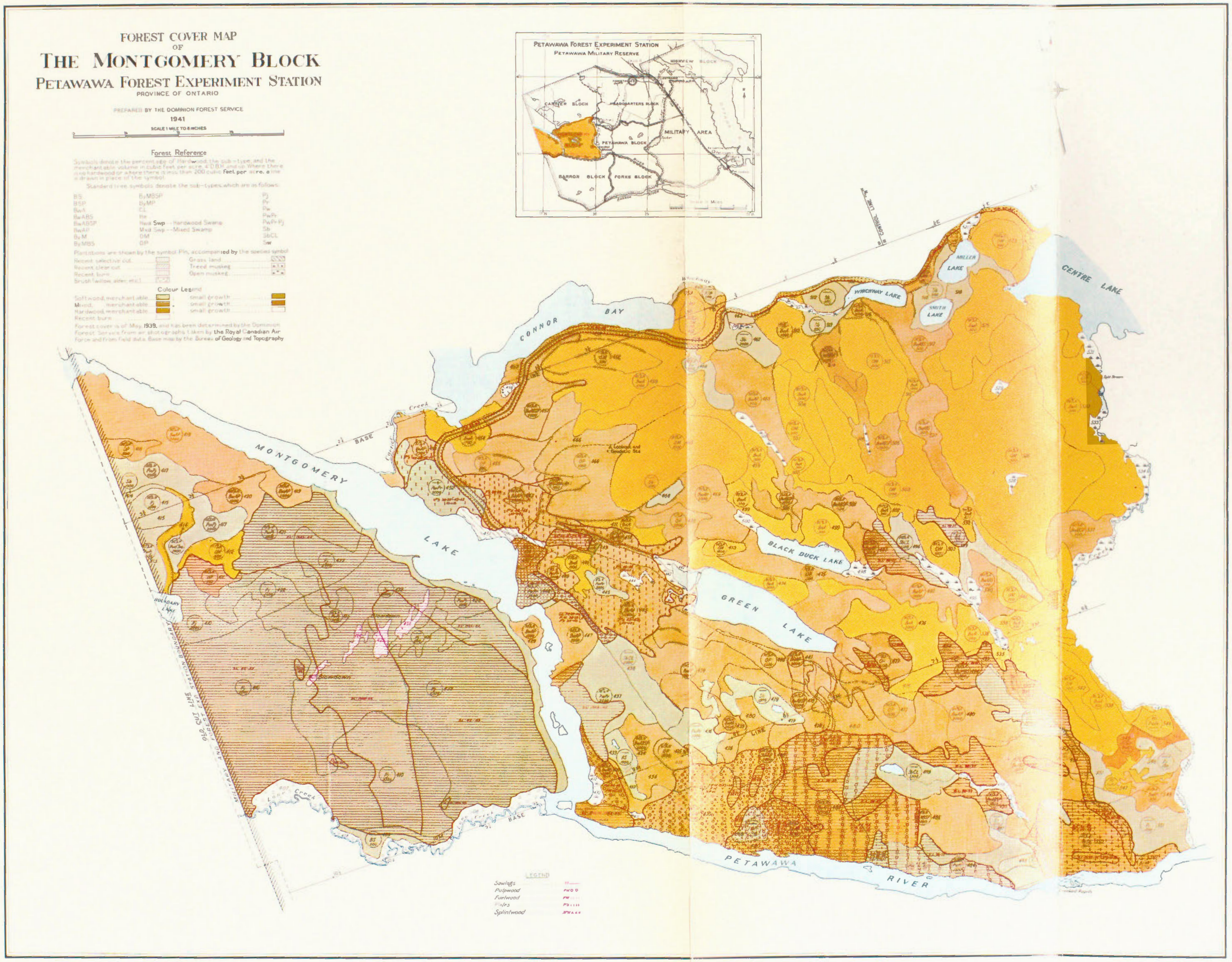
FIGURE 153
Interpretation of forest detail in airphotos.

The Dominion land surveyor, C. B. C. Donnelly, in his writings for *The Canadian Surveyor,* shed an informative light on procedures followed during the depressed 1930s in the conduct of winter surveying with relief labor in this country.

"Last winter [1934-35]", Donnelly stated, "the Dominion Forestry Branch, Department of the Interior, received an area of about 36 square miles for experimental purposes, out of Duck Mountain Forest Reserve. As these lands had been acquired by Manitoba under the transfer of natural resources to the provinces, and as the survey was a function of both federal and provincial governments, instructions were drawn up by the Surveyor General [federal] to accord with the provincial regulations of survey, as enforced by the Director of Surveys for Manitoba.

"Actual work [by a field party of 18 men] commenced on February 9th and ceased on May 31st. The total mileage surveyed came to sixty, which for the period averages one-half mile per day. The maximum daily output was two miles, the minimum was ten chains. It was arduous work travelling on snowshoes through the dense growth which characterizes this area . . . In many places thickets were so dense that axemen had to clear a path before a transit could be carried through . . . Posts were cemented in temperatures of 50 below zero . . .

"Embodied in the Surveyor General's instructions for the survey was an aerial map prepared from vertical photographs of the area. Before leaving for the field I supplied myself with the vertical photographs in question. In addition I carried a collapsible field stereoscope. A comparison of the map and measured line crossings of distinct topographical features revealed an accuracy in the map that is amazing. I do not believe the maximum error exceeded a few chains. The timber typing was particularly well plotted. I was thereby able to guide the [railway] tie makers to areas suitable to their needs . . . The photographs were particularly useful in cross-country walking to and from work, locating trail and daily routine uses. It is possible to trace a path from tree to tree by use of such photographs, that is, where the cover is fairly open. Identification on the



MAP 13. Early example of forest-cover mapping in Canada, produced in 1941 from air photographs.

photographs of individual trees, small rills and openings is possible when one's position is pin-pointed. Many section and quarter-section corners were positively identified on the photographs. Mr. G. Tunstell of the Dominion Forestry Branch located proposed roads on the photographs by the use of the stereoscope, and subsequent delineation on the ground, in conjunction with the aerial map, showed remarkable correspondence."[14]

Early in 1937 a major manufacturer of paper in England employed Canadian Airways Limited to undertake an aerial photographic survey of timberland in the lower Hamilton River region, Labrador, property in which the paper company was interested as a possible source of raw material supply. The survey, in which mapping played a minor role, was to be completed between spring break-up and winter freeze-up.

Jenkins, who by this time was assistant manager of Canadian Airways, was responsible for the planning of the operation. His past experience in the region to be surveyed proved to be most valuable. In 1935 Jenkins had carried out an aerial forest reconnaissance covering all of Labrador where pulpwood might be expected to occur in commercial quantities. During that reconnaissance he had prepared a sketch map of the main

FIGURE 154. Spruce growing under nurse crop of poplar near Upper Manitou Falls, English River.

waterways and forest types across 42,000 square miles. Using two Bellanca Pacemaker planes equipped with floats, each carrying a Fairchild K3 camera unit, the 1937 air survey was completed successfully in the course of 76 hours of photography, spread out over the period from June 24 to September 15. The project covered, in all, 2,150 square miles and 261 miles of control lines. Timber cruisers for the English firm, using joined photographs taken on a scale of 1,000 feet to the inch, produced a rough map judged useful for their particular purposes. The entire enterprise was the first wholly self-sustained aerial photographic operation carried out by Canadian Airways Limited.[15]

In 1937 also the Dominion Forest Service utilized winter oblique and summer vertical photographs in the preparation of a forest-cover map of Riding Mountain National Park in Manitoba. In the following year forester John M. Robinson, using only air photographs, prepared a detailed forest-cover map of a New Brunswick area. Estimates per acre were inserted by Robinson on each delineated stand of timber. In addition, land elevations were denoted and gradients indicated by slope arrows.

In the earlier years of its progress in Canada the art of aerial photography was employed mainly in forest studies rather than for mapping purposes only. With the advent of fast panchromatic film and improved lens filters research was directed more and more towards the production of superior mapping by the use of aerial photography. The experience gained overseas by Andrews in the mid-1930s and the resulting new concepts which he and others introduced in the New World exercised a profound, progressive influence upon forest surveying and mapping in British Columbia in particular and in Canada generally.

During the inter-war period the struggle to introduce and develop aerial surveys in Canada, on a private enterprise basis, was not an easy one. In 1930 the federal government ceased to let contracts for its air survey work to commercial companies because of the economic depression and the more limited budgets of governments. The private firms, after purchasing equipment to handle anticipated government contracts, found themselves with a surplus of equipment. The Quebec government, which had carried on a program of aerial surveying of forest resources for some years, also suspended its program in 1932. The ensuing years were difficult for air survey companies in this country but in 1935 and 1936 the Geological Survey of Canada contracted for some of its aerial survey work. This assistance enabled commercial firms to bridge a critical period and helped to maintain, in the private sector, the nucleus of a Canadian aerial surveys organization.

Despite the relatively small volume of aerial survey work carried on in Canada during the lean years this testing period was one of advancement in the techniques of such mapping methods, particularly in the realm of forest inventory and forest geography. Sound foundations were laid at the time for a more extensive use of aerial surveys in this country in years to come.

19

THE CANADIAN EIGHT-MILE MAP IN PEACE AND WAR

In January, 1946, the American Geographical Society, New York City, announced with considerable satisfaction that a new series of maps portraying Hispanic America had been completed under its auspices. The 107 sheets of the series covered all of South and Central America. Much prominence was given in the broadcast programs and in the press of this hemisphere to this highly commendable achievement, a project that had engaged the energies and resources of the Society for 25 years. Yet two years previously, without fanfare, a mapping project of much greater magnitude had been completed in less than five years by Canadian government agencies. Early in July, 1944, the large press of the Hydrographic and Map Service, Ottawa, was printing hundreds of copies of the final map of the 221-sheet series of Canada's eight-mile (to the inch) Air Navigation series, covering several million square miles. Publicity on this project, through the needs of wartime secrecy, had been drastically curtailed. Nevertheless this prodigious task, accomplished despite numerous technical problems, shortages of materials, depleted staffs and the exacting deadlines of urgent wartime requirements, stands as one of the superlatively great Canadian achievements in the realm of mapping and charting.[1]

In one sense, however, the development of this impressive mapping project had its real genesis almost 20 years earlier. During the decade immediately following the end of the First World War the need to provide greater uniformity in the maps being produced in Canada became fully apparent. What was required was a new, more comprehensive system of mapping the entire country at standard scales. Finally, in 1927, the National Topographic System (N.T.S.) was established after an earlier but abortive attempt to bring it into existence. Under its provisions sheet sizes were allotted for maps at scales of 2, 4, 8 and 16 miles to the inch, as well as at 1 mile to the inch. Here at last was a means by which a suitable series of systematized and standard topographic base maps, covering all Canada, could be constructed on a continuous, orderly basis, with each sheet fitting its neighbors on all sides and with all sheets drawn to the same scale and same specifications. The adoption of this new system constituted a great stride forward in the process of solving Canada's most challenging mapping problems. Prior to this scheme Canada's topographic maps had been issued by several federal government departments and each map-producing agency had its own mapping standards. In the result the sheets had appeared in a variety of styles, sizes, shapes and scales. The N.T.S., as it came to be known, not only provided uniformity of technical factors but also a ready method of map indexing and map reference. Such a system, in fact, was indispensable to any extended, efficient mapping program in this country and, as matters turned out, to the development of Canadian air navigation charts for peacetime and wartime uses.[2]

Not long after the end of the First World War Canadian aviation authorities began thinking in terms of air navigation charts to guide pilots using the air lanes of this country. As early as 1920 the Dominion Geographer was requested to commence preparation of aeronautical maps on the system laid down in the International Air Navigation Convention. The formidable nature of the undertaking was recognized in the official comment accompanying the request, namely, "The process of completing the mapping of Canada on this system will necessarily be a very long one."[3] This Canadian move was a bold one for those times but neither official records nor official correspondence disclose any significant follow-up on this decision until after a number of years had elapsed.

By 1926 the Post Office Department, Ottawa, indicated that it was ready to support the inauguration of regular domestic airmail services and in the same year the Topographical Survey (Interior) issued a chart, generally considered to be the first of its kind in this country, the Winnipeg Aeronautical Map, so styled, produced on a scale of eight miles to the inch and covering the area served by the Winnipeg Air Base of those days. The appearance of this map preceded, of course, the establishment of the National Topographic System. It was in 1926, also, that the use of eight-mile N.T.S. maps, as bases for air navigation charts, was first considered at the official level.[4]

It was obvious by this time that in the near future the Topographical Survey would be called upon to compile and to print air navigation maps for the use of the Royal Canadian Air Force. On April 3, 1929, a letter was received by Deputy Minister Cory of the Department of the Interior from Deputy Minister Desbarats of the Department of National Defence. In this letter the military requirement of the menacing years ahead was foreshadowed in the following terms, "The need for such [air navigation] charts is growing and I shall be glad if you would authorize officers of your department to discuss their production with officers of the Air Service so that the most desirable types of maps may be decided upon and the scale of the maps, the symbols and other details may be settled."

Unlike the United States of America, Canada did not possess the financial resources to make possible the construction and printing of two distinct sets of maps, one topographic and the other aeronautical. This nation had to attempt to satisfy a wide range of interests, including that of air navigation, by means of one basic type of map, using at the outset the technique of overprinting air information on a variation of the topographic base map.

Soon after 1931, when the first civilian-produced N.T.S. eight-mile map, the Winnipeg Lake sheet (63 S.E.) was issued in Ottawa, serious consideration was being given by mapping authorities in the Canadian capital to the formation of a long-range policy covering production of air navigation charts. The Winnipeg Lake sheet, and the

English River sheet (52 N.W.) prepared soon afterward, were made by direct reduction of drawings for four-mile maps. The advent, in 1927, of an airmail delivery service in Canada along various routes led to a demand for strip (air navigation) charts, each sheet a representation of the topography from airport to airport. Such charts were, in fact, issued in 1930 and 1931 and constituted pioneer attempts to meet a pressing, rapidly-growing need at the time. Only the western Canadian strip charts, however, were produced on the eight-mile-to-the-inch scale.

The standard series of eight-mile maps for all Canada was conceived and planned in the course of conferences with officials of the Geographical Section, General Staff (G.S.G.S.) but later a number of maps were prepared covering a portion of the Trans-Canada airmail route. As these sheets were required urgently they were designed and produced quickly. The production of the eight-mile series was under the general direction of the Topographical Survey, the G.S.G.S. working to the Survey's requirements. The usual map legends and headings of the N.T.S. were adopted and whenever compilation and printing was done by the G.S.G.S. this fact was indicated by a footnote.[5]

In the summer of 1932 Surveyor General Peters had reached the conclusion that the eight-mile topographic map must perform a dual function and "whatever information is required for air purposes will be added as an overprint . . ." This decision was followed a year later by a request from Controller of Civil Aviation J. A. Wilson to Topographical Survey for air navigation charts, eight miles to the inch, to cover a flight strip across Canada.[6] This close cooperation between military and civilian mapping agencies in Ottawa featured the early years in the production of the eight-mile series. By early autumn of 1932 Lieut. Col. E. L. M. Burns of G.S.G.S. and his chief draughtsman Cranston were working with J. R. Akins, Chief of the Topographical Division of the Topographical Survey, Bruce W. Waugh and chief draughtsman Birchall in the production of eight-mile N.T.S. maps and charts. They had agreed generally on what land features ought to be depicted on such sheets, what conventional signs ought to be employed as well as on the selection of standard forms, type sizes and colors for the various printings.

In a communication from Burns to Peters the former made some interesting observations in regard to the eight-mile series, "I am not satisfied that we have produced an entirely satisfactory style for this. It seems to me to be a little overloaded with detail, especially where rural post offices and townships are shown, as you consider necessary. It will, of course, be a great advance when these maps are available for all Eastern Canada, a project which is now well on the way. The eight-mile scale was chosen, to some extent, because of its usefulness for aviation purposes . . ."[7]

Gradually the dual-purpose policy developed as eight-mile-to-the-inch topographic base maps were transformed into air navigation charts (initially described as 'maps') of the same scale. The transformation process, at the time, was a complicated one but in the main consisted of three stages: the topographic base map; the skeletonized version of that map and, thirdly, the edition to that version of overprinted air information to constitute the air navigation chart. The point made by Burns for the removal of unnecessary clutter from the topographic sheet in the adaptation process, was a valid one. A first consideration in the production of an aeronautical chart is that it should not be overcrowded with irrelevant details. All information should be presented clearly and often, boldly. The use of small type-face in nomenclature and in other map descriptions should be scrupulously followed. Much detail considered essential to a topographic edition was obviously superfluous to the air navigation edition, information such as the names of many small towns, township boundary lines and rural post offices. Water features, however, were to be outlined with clarity. Cities, railway lines, airfields, meteorlogical and broadcasting stations, radio range stations, beacons, highways as well as important relief were included, the latter emphasized in hypsometric tints, portraying elevations by means of colors.

By the end of 1933 Peters announced that his organization had on hand "the following eight-mile sheets on which we intend to make an overprint of aids to air navigation, namely, Upper Ottawa River, Toronto-Ottawa, Ottawa-Montreal, Megantic, Fredericton-Moncton and Charlottetown-Sydney." Of these the Ottawa-Montreal and Megantic sheets were the work of the G.S.G.S. In 1935 the Fredericton-Moncton sheet became the first eight-mile-to-the-inch (overprint) air navigation chart to be issued in Canada with its sheet lines conforming, at least partially, to the National Topographic System.

Early in 1937 the newly-created federal Department of Transport actively entered the domain of air charting as a consumer and part-time policy maker. This development resulted from the establishment in April of that year of Trans-Canada Air Lines. The new department made known to the Department of Mines and Resources and, through it, to the Surveyor General of Canada, the chart requirements of pilots of the fledgling air lines system. In negotiations that followed A. M. Narraway for the Surveyor General and Major Robert Dodds for the Department of Transport, acted as intermediaries. Special emphasis was laid on chart coverage of the main flight route of the system, east to west in this country. It was the eight-mile-to-the-inch scale of charting that was required here also — "the project is of major importance to the success of the operations of the new Trans-Canada air system."[8] The Department of Transport and the Royal Canadian Air Force collaborated closely with the Legal Surveys and Map Service of the Department of Mines and Resources to establish initial mapping standards.

The second dominant development in this period that profoundly influenced the course of Canadian mapping and charting activity, especially on the eight-mile-to-the-inch scale, was the creation of the British Commonwealth Air Training Plan. The operations of this scheme, established in Canada at the outset of the Second World War, made a contribution toward the final victory of the forces of freedom, the dimensions of which cannot easily be overdrawn or overestimated. It was at this turning point in world history that the wisdom of the selection by Canadians of the eight-mile-to-the-inch scale for the air navigation charts of this country, became clearly evident. A larger scale of mapping would have required an increased number of chart sheets to cover any designated area and, correspondingly, more charts for any specified air route, adding inconvenience to a pilot operating within the limited accommodation of a cockpit. When the wartime plan for training allied pilots in Canada was established the urgent, rapidly-mounting demand under that scheme was for eight-mile-to-the-inch aeronautical charts. This need dovetailed perfectly, not to say miraculously, into the production advances already made in this country on that particular scale of mapping and charting.

The wartime challenge to the Legal Surveys and Map Service, Ottawa, was one of the most staggering proportions. Printing presses in the possession of that organization had seen their best days. Their output was limited by hand-operated feeds and by frequent mechanical breakdowns. Camera equipment was inadequate. In the years of economic depression severe reductions of staff had occurred, with resulting losses of experienced, talented men. To help meet the sudden need for trained personnel a number of superannuated civil servants were induced to return to the federal service.

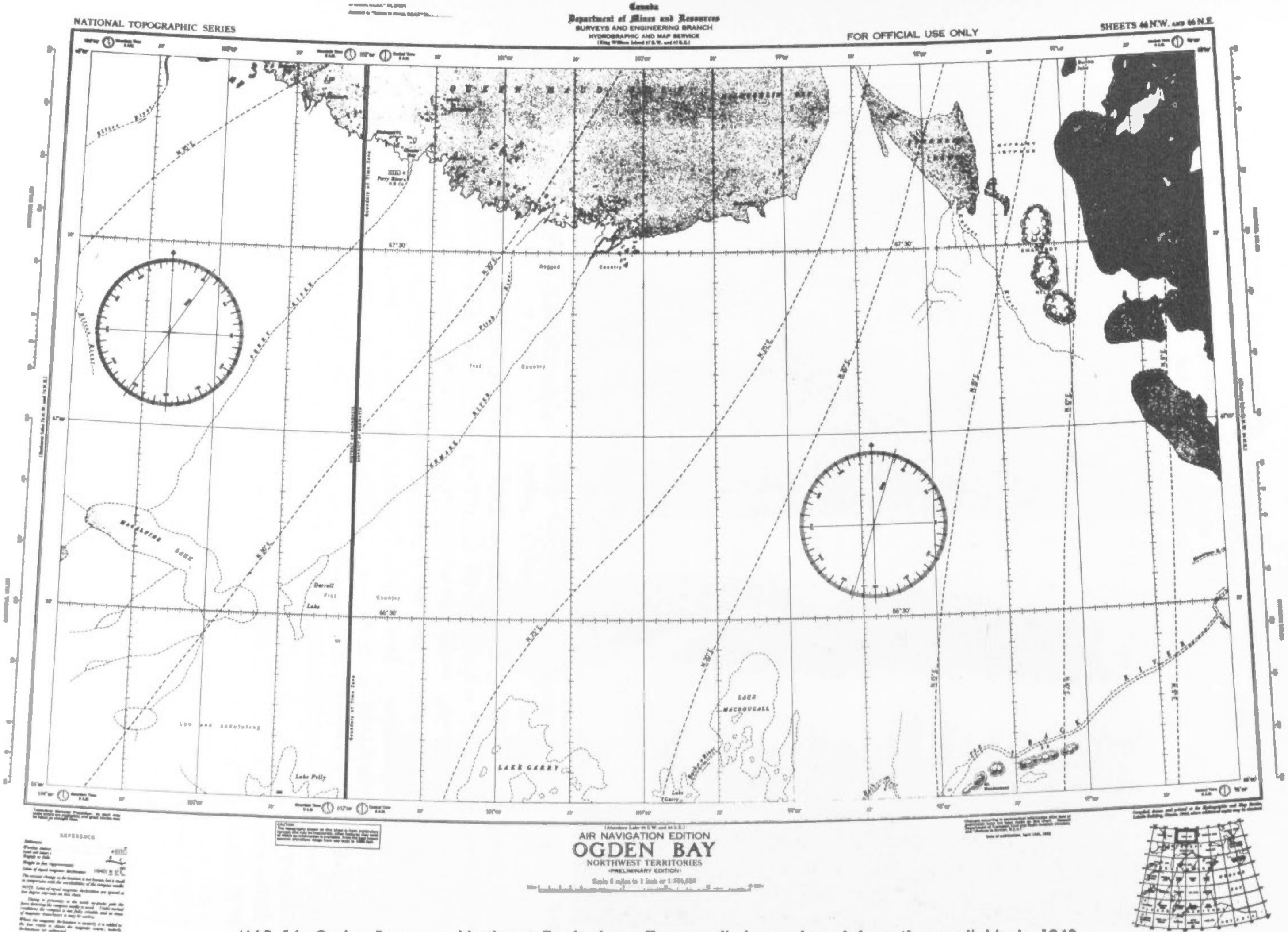
With their important assistance all newcomers to the staff were given extensive instruction.

FIGURE 155. Bruce W. Waugh.

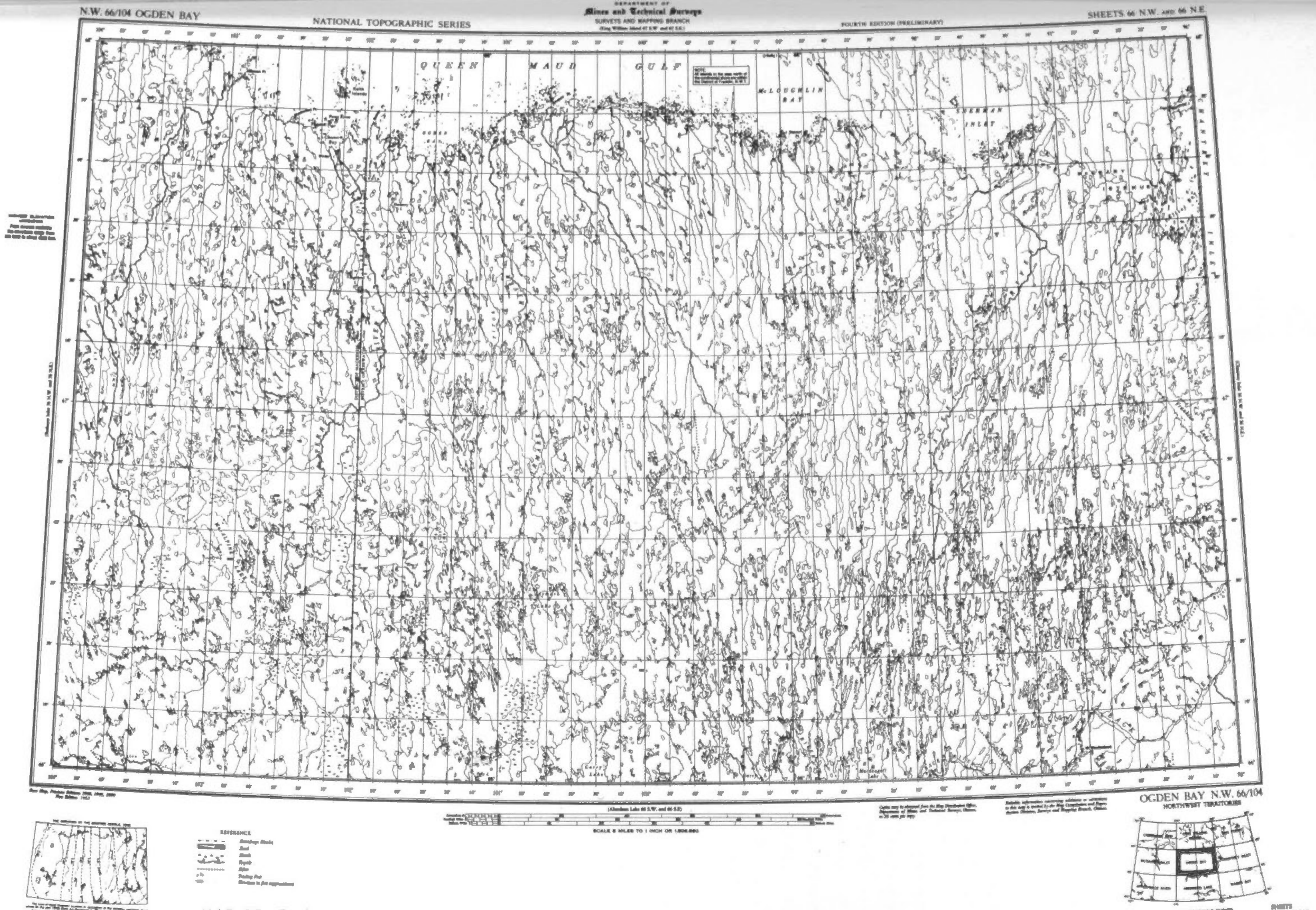
FIGURE 156. Maxwell Cameron.

Three civil servants at Ottawa, in particular, gave inspiring leadership in the course of discharging heavy responsibilities related to production of eight-mile maps and charts. F. H. Peters and Bruce W. Waugh contributed to the success of these efforts in almost equal measure with Max G. Cameron making a vitally important contribution involving the assembling of topographic information essential to the compilation of maps of the then unsurveyed territories of Canada's North. In this task he was assisted by Dominion land surveyor Cecil Barnwell Coslette Donnelly (1889-1966) on loan at the time to the Geodetic Survey of Canada from the Legal Surveys organization, Ottawa. Donnelly made astronomical observations in the northland to enable map compilers to position their data properly. Pilots of flying boats carrying Cameron and Donnelly risked destruction of their craft time and again as landings were made on open water in icy inlets and bays along the Arctic coast. In this way the topographer and geodesist were able to reach shore where the latter kept bone-chilling nightly vigils, peering into his instruments at the frosty stars.

In addition to holding a Dominion land surveyor's commission Donnelly was qualified to practice in Manitoba and Alberta. He was familiar with the northland and had assisted, about the mid-century mark, in surveying boundaries of Wood Buffalo National Park. As early as 1928 Donnelly wrote for publication on the use by the Topographical Survey (Interior) of a navigating sight for aerial photography.[9] Donnelly,



MAP 14. Ogden Bay area, Northwest Territories; office-compiled map from information available in 1943.



MAP 15. Ogden Bay area, Northwest Territories; map resulting from trimetrogon photography, published 1953.

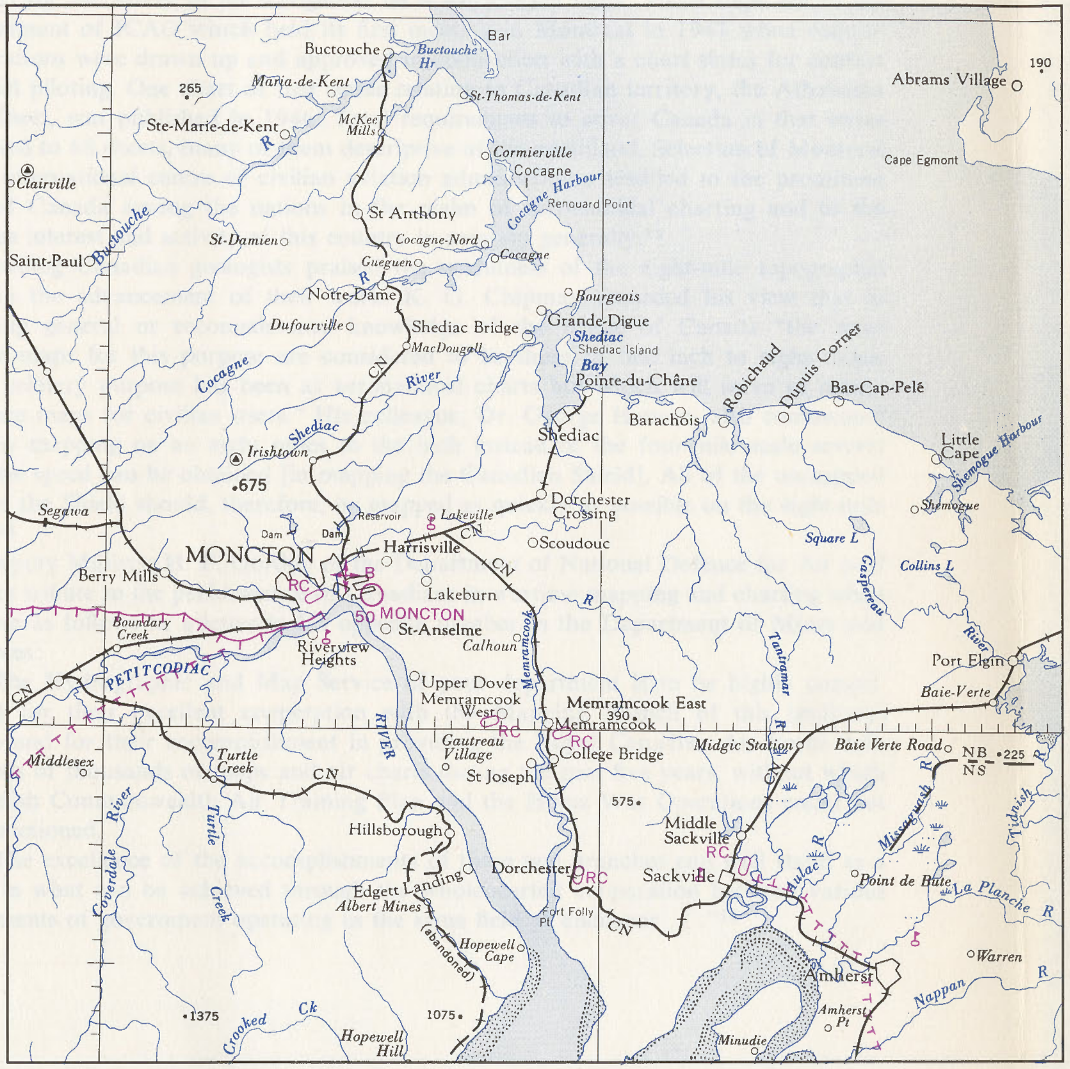
in addition to possessing ability as a surveyor, was a gifted writer of poetic prose. On one occasion, reminiscing in the columns of *The Canadian Surveyor,* he recalled a memorable photographic survey flight north of the Arctic Circle. "Fascinated by the sensation of flying over terrain that remained as nature had fashioned it," he wrote, "we winged into the mellow twilight of the Midnight Sun. Far ahead the icefields of the polar seas gleamed in a ghostly after-glow. We were mapping a vast unexplored country. Hidden in the fold of a timbered valley on the banks of a stream, its impetus hushed by Great Bear Lake, was our camp lying under the shadow of the great mineralized vein, 80 miles long, on which was located the famous silver radium deposits of Eldorado. From the air the broad white seam is like an ancient Roman road, a gleaming ribbon undulating with the inequalities of hill and dale, to dip eventually into the lake, visibly reflected from its clear blue depths when its surface is unruffled."[10]

Cameron was exceedingly diligent in his research in the field of derived mapping on the eight-mile-to-the-inch scale. He assembled all information available on the topography of the area to be charted. In some instances this meant that maps had to be draughted on the basis of data more than 100 years old! Geographical knowledge, gained by the numerous searchers for the lost Franklin Expedition, was consulted with meticulous care as were Admiralty charts of Arctic waters and primitive sketches made by explorers and prospectors. The location of a lonely trapper's cabin at the junction of rivers in an untracked wilderness was more important to the construction of these pioneer aeronautical charts and their users than the location of a large city on an air map portraying heavily populated areas of the nation.

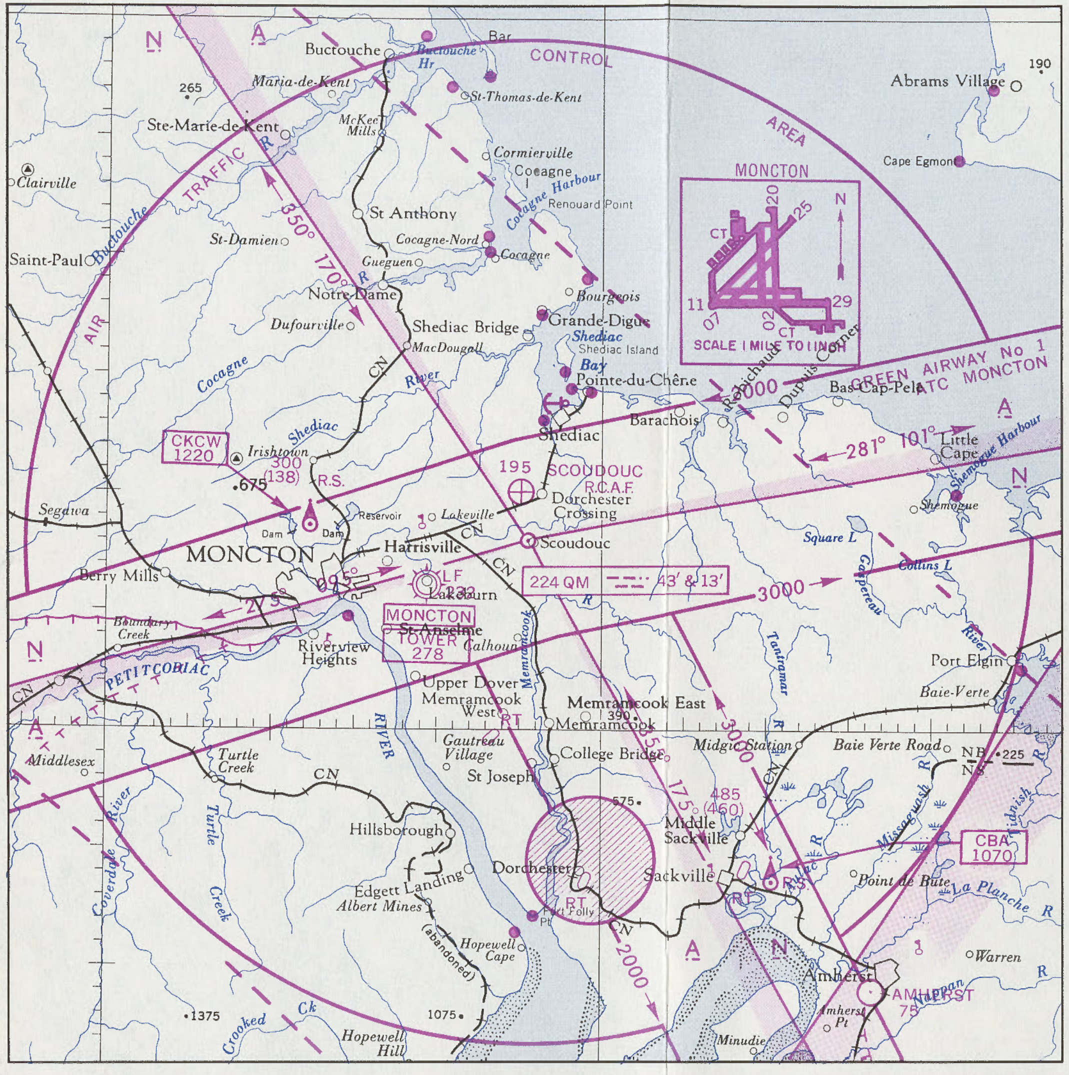
Provincial departments cooperated to the full in this enterprise. Department of Transport officials contributed invaluable air navigation data. The Royal Canadian Air Force provided a steady flow of suggestions based on analyses of various flight reports. The U.S.A.F. and R.C.A.F. maintained a constant supply of air photographs for map and chart compilers in Ottawa. As rapidly as new information reached the draughtsmen these documents would be revised, after the new data had been sorted, screened and then reduced or enlarged, as required, to the proper scale.

The presses owned by the Department of Mines and Resources were inadequate to carry the immense new loads placed upon them. In the emergency, G.S.G.S. equipment was put to this use as was that of a private commercial printing firm. For a normal peacetime year at this stage of Canada's growth the Royal Canadian Air Force might make use of about 200 copies a year of any required piloting chart. Under the British Commonwealth Air Training Plan the demand for each sheet of such charts rose initially to 1,000 copies annually, then to 20,000 copies. In the case of plotting charts the amount reached 190,000 copies in each year of the war. In the peak final year a total of 1,830,000 map sheets, or an average of 6,000 copies each working day, were printed and distributed for all purposes by Legal Surveys and Map Service.[11]

This wartime experience demonstrated that a strictly civilian organization could be geared rapidly and effectively to meet the special stress and demanding needs of military map production. The Air Navigation Chart series stands as a notable cartographic achievement, both in compilation and production, of which Canadians may well be proud. The eight-mile air charts were not only indispensable aids to the war effort of the allies, they proved invaluable in post-war commercial flying, including the tapping and developing of Canada's natural resources. To a great extent the expanded wartime demand for maps and charts continued into the years of peace. While distribution dropped to below the abnormally high wartime levels, the demand from all sources



MAP 16. Part of map (Fredericton-Moncton sheet) showing air information, 1935.



MAP 17. Same area, showing air information, 1947.

remained at a level six to eight times greater than the total for all types of maps distributed prior to the Second World War.

The transition from war years to times of peace was featured by the creation of the Provisional International Civil Aviation Organization (PICAO) in Chicago by a conference beginning late in 1944. Under this world organization a map division was set up, a function of which was to lay down specifications for all aeronautical charts required for the safety of air navigation on a world-wide basis. These steps led to the establishment of ICAO which held its first meeting in Montreal in 1947 when definite specifications were drawn up and approved in connection with a chart series for contact or visual piloting. One chart of that series relating to Canadian territory, the Athabasca River sheet, was published in 1946. Total requirements to cover Canada in that series amounted to 68 sheets, many of them descriptive of the northland. Selection of Montreal as the international centre of civilian aviation administration testified to the prominent place of Canada among the nations in the realm of aeronautical charting and to the vigorous interest and activity of this country in aviation generally.[12]

Leading Canadian geologists praised the usefulness of the eight-mile topographic maps in the advancement of their work. K. G. Chipman recorded his view that in providing general or reconnaissance knowledge of the whole of Canada "the most suitable maps for this purpose are considered to be those of one inch to eight miles, whose primary purpose has been as aeronautical charts but which will serve as reconnaissance maps for civilian users." His colleague, Dr. George Hanson, also commented that "by mapping on an eight miles to the inch instead of the four-mile scale several times the speed can be obtained [in mapping the Canadian Shield]. All of the unmapped parts of the Shield should, therefore, be mapped as quickly as possible on the eight-mile scale."[13]

Deputy Minister H. F. Gordon of the Department of National Defence for Air paid eloquent tribute to the performance of Canadians in wartime mapping and charting when he wrote as follows in a letter to his opposite number in the Department of Mines and Resources:

"The Hydrographic and Map Service of your department is to be highly complimented for their excellent cooperation with the Mapping Branch of this [military] Service and for their accomplishment in providing the Royal Canadian Air Force with hundreds of thousands of maps and air charts during the past five years, without which the British Commonwealth Air Training Plan and the Home War Operations could not have functioned.

"The excellence of the accomplishments of these two branches can well stand as a lesson in what can be achieved through the wholehearted cooperation between various departments of government operating in the same field of endeavor . . ."[14]

20

FINDER OF ALBERTA'S BLACK GOLD

" . . . *so rich a bottom here.*"

—*King Henry IV* (1), Act 3, Sc. 1.

In February, 1947, Leduc No. 1 oil well blew onto the front pages of many newspapers of the western world. That discovery ushered in a new era in the industrial history of Canada, a period in which the resources of mineral fuels disclosed beneath the earth's surface in our western interior made this nation second in energy sources among countries of the western hemisphere.

On the face of things it might appear highly unlikely that the discoverer of the first site in Alberta of a well productive of crude oil or, as it is sometimes described "black gold", would turn out to be the son of a distinguished Clerk of the Canadian House of Commons. It is surprising also that the place of discovery should happen to be located in what is now Waterton Lakes National Park, a placid, impressively scenic region tucked in among the foothills of the Rocky Mountains close to the boundary between Canada and the United States. The element of plausibility grows, however, when it is recalled that the pioneer mainly responsible for the first successful drilling for oil in Alberta was a land surveyor of distinction, namely, Allan Poyntz Patrick (1849-1948).

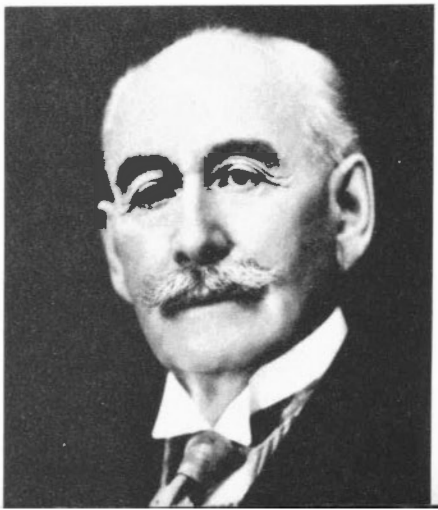


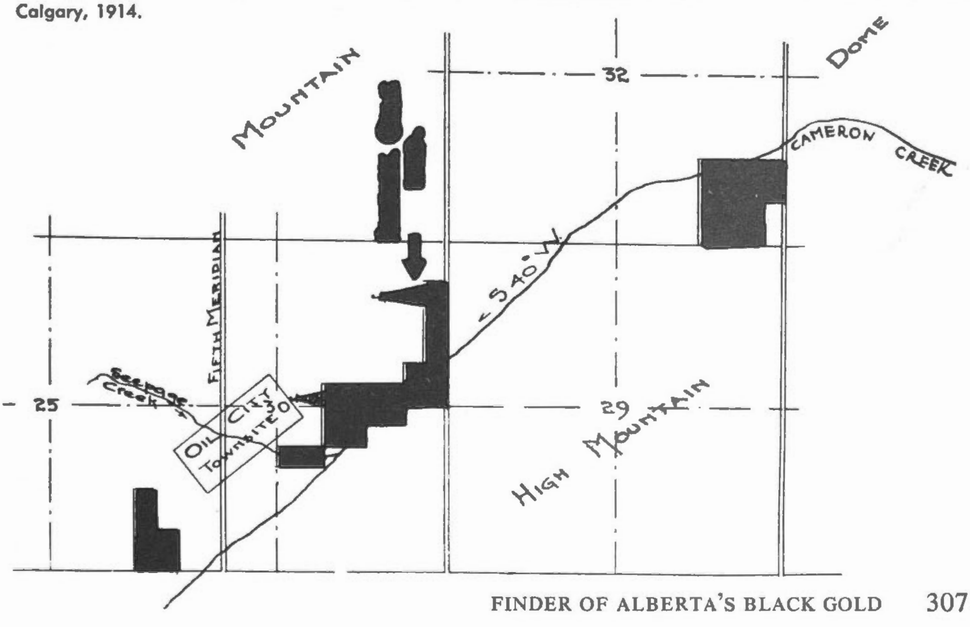
FIGURE 157. Allan P. Patrick.

It is a coincidence worth notice that the historic find was made on what came to be called Cameron Creek named, as were nearby Cameron Lake and Cameron Falls, after the commissioner in charge of the British-Canadian survey party engaged in the 1870s in delineating and marking the international boundary line from the Lake of the Woods to the Rockies.

Son of Alfred P. Patrick, C.M.G., Clerk of the House of Commons, Ottawa, up to 1877, Allan Poyntz Patrick was born in Montreal on July 18, 1849. Educated at Upper Canada College young Patrick qualified for his preliminary certificate that enabled him to practice surveying in Ontario following a training period during which he was articled to Robert Sparks, P.L.S., of Ottawa. In 1874, at the age of 25, Patrick took part in survey work in Manitoba under Lindsay Russell, soon to become Surveyor General of Canada. Patrick also participated in exploratory survey work for the Canadian Pacific Railway, north of Lake Superior. On November 19, 1877, Patrick was commissioned a Dominion land surveyor as well as certified as a Dominion topographical surveyor.[1]

During this period of his life Patrick's health was frail. On doctor's orders, in the year following his dual achievement, Patrick travelled to a part of the North-West Territories now known as southern Alberta. Soon he was thriving on rough fare and a vigorous life outdoors. On instructions from Ottawa he began a topographical survey of a large tract of land extending from Highwood River to Waterton. In the course of this lonely task he struck up a friendship with Lafayette French, a trapper and trader. One day in an Indian encampment the two men came upon an injured boy whose leg was improperly bandaged. On closer examination they found that the wrapping cloth was soaked in oil. Apparently the substance had been used by a squaw convinced of its healing qualities. Patrick and his companion realized at once the significance of this revelation. But there remained the task of tracing the oil to its source. Only after considerable argument and the trading to the Indians of food and a rifle was the squaw induced to guide the two white men to the place where the crude oil had been obtained.

FIGURE 158. Sketch map, site of Discovery well, Patrick properties. From Sinclair and Allan Prospectus, Calgary, 1914.



At the end of a prolonged search, oil seepages were found along the banks of the mountain stream known then as Oil Creek, later as Cameron Creek. That was in the summer of 1878.[2]

In those early days in the West Patrick and his friend found it difficult to arouse any active interest in their discovery. Neither could John George "Kootenai" Brown, well known as a pioneer rancher in the Waterton area. Brown was content to skim oil globules from the creek's surface and to use the substance for lubricating farm machinery and as lamp fuel. For a period of time one of his enterprising ranch hands collected sufficient oil from seepages along the creek to sell the product to nearby ranchers at a dollar a gallon.[3]

For ten years Patrick persisted in efforts to interest drillers, or men with capital, in his find near Waterton as well as to attract the attention of authorities in Ottawa in its possibilities. At this time Dr. A. R. C. Selwyn was Director of the Geological Survey of Canada. Patrick persuaded him to visit the southwest corner of what is now Alberta in order to assess its oil production potentialities. In the 1890-91 annual report of the Geological Survey, Ottawa, Dr. Selwyn reported on his findings in regard to a section of land some eighteen miles south of Pincher Creek. He mentioned in that report that he had visited the site "of a proposed boring, on July 20, 1891, on a small flat on the left bank of the tributaries of the Waterton River." On the following day Selwyn found "nothing whatever to indicate the existence of petroleum in this vicinity. It seems highly improbable that it should be found here, though, of course, not impossible. Heard later that a copious flow of water had been struck and the boring abandoned."

Finally Patrick, in 1889, filed formal claim to 640 acres in the vicinity of the discovery site. At the time there were not any official application forms pertaining to petroleum rights available at the federal office in Fort Macleod and so a form relating to quartz mining claims was adapted to the purpose.[4] In the meantime, in 1884, an English firm of bankers had filed a claim on a section of land near Twin Butte, close to Patrick's property, but drilling was not commenced there until seven years later by a corporation known as the Southern Alberta Land Development Company. After drilling to a depth of 190 feet an artesian well was punctured and the resulting flow of water forced abandonment of the hole. Oddly enough the Canadian Pacific Railway, which had so often searched for subterranean water supplies in this part of Canada, found only natural gas whereas the promoters of Twin Butte, seeking crude oil, found only water! Another hole was drilled in the vicinity of Waterton Lakes in 1893 by the same company but difficult drilling conditions prevented any significant progress being made.

Some years after these abortive attempts John Lineham, a prominent stockman of Okotoks, near Calgary, became interested in Patrick's story of his discovery. At this stage Arthur Sifton, later to become premier of Alberta, was closely associated with Lineham as was John Leeson. At the turn of the century the Rocky Mountain Development Company Limited was formed, including these men and Patrick, to develop for oil production the acreage held in the name of the land surveyor. A drilling rig, costing $680 was shipped from Petrolia, Ontario, to the site of the proposed well and operations began in November, 1901. On September 21, 1902, at a depth of 1,020 feet, the drillers struck oil. It was reported that the well began to flow at the rate of 300 barrels a day. The strike occurred in Section 30, Township 1, Range 30, West of the 4th Meridian. In honor of the event this place, 25 miles southwest of Pincher Creek, was christened, somewhat ambitiously, Oil City. But soon after the strike drillers of the discovery well began to encounter formidable difficulties. Drilling tools became lodged in the hole.

Efforts to recover the tools began immediately but were unsuccessful. Apparently drilling with cable tools had cut the well casing and, as a result, gravel poured into the hole. Steam pressure in the boiler at the well site was insufficient to dislodge the tools. Accordingly the operator tied down the safety valve to produce more pressure whereupon the ancient equipment, unable to withstand the additional strain, blew up. In addition, because of the high paraffin content of the oil the hole became cemented and this reduced the daily flow from 300 to only 40 barrels. Several storage tanks, built with a capacity of 2,000 gallons, had been filled from the well's output before operations were suspended. Operations were resumed spasmodically thereafter and by May, 1906, Lineham certified that the Patrick well had produced a total of 8,000 gallons of oil.[5]

In the spring of 1905 the Canadian Pacific Railway, curious about the spate of rumors concerning the production of this pioneer well, asked the Dominion land surveyor William Pearce to visit the site and to report on what he found there. Pearce advised the company that he had found three full storage tanks, each "holding upwards of 2,000 gallons" along with a small and rather primitive refinery.

During several years following the initial strike numerous holes were drilled in the vicinity of the discovery without any trace of oil being found. In 1907, on the advice of an eminent geologist, Dr. I. C. White, drilling in the Waterton area was discontinued and the search for black gold shifted toward Pincher Creek. Thus the "Oil City", that Patrick and his associates had so cheerfully visualized, never emerged from the dream stage. As late as 1936 a hole was drilled to a depth of 2,500 feet within a very short distance of the site of Patrick's well but no sign of oil was encountered as a result.

In the years following his initial find of oil seepages Patrick, now known to close friends as "A.P.", pursued the practice of his profession, surveying townsites of settlements located along the Canadian Pacific Railway line from Fort Macleod northward to Edmonton. In addition he became one of the first cattle ranchers in the high country south of Calgary, starting Mount Royal Ranch on the Ghost River. After participating in the field in the campaign against Louis Riel, Patrick homesteaded on a ranch he named "Holmpatrick". In these early years of western development Patrick was also kept busy surveying in Calgary and in the nearby Indian Reserves of the Stony and Sarcee tribes. In 1890 he qualified to practise surveying in British Columbia and became an Alberta land surveyor in 1911, having been entitled to carry on his profession in the

FIGURE 159. A. P. Patrick in Highwood River country, Alberta, 1925.

FIGURE 160
A. P. Patrick with a close friend, Viscount Bennett.

territories previously by virtue of being a Dominion land surveyor. From a condition of indifferent health in his youth Patrick developed great stamina and lived to an advanced age. In 1943, at the age of 94, he fell and broke a hip. But on March 4th of that year, prior to his accident, he had written to J. E. R. Ross, a fellow-member in that rare fraternity of Dominion topographical surveyors, "Am still working and have just finished a subdivision survey which has been registered without question by the Director of Surveys." At that time he was the oldest practising land surveyor in English-speaking Canada.

In the course of time Allan P. Patrick has come to be regarded generally as the father of commercial oil production in the western interior of Canada. Following the discovery at Leduc, Alberta, in 1947, Canada became a leading nation in the producing, as well as the consuming, of oil. The Imperial Oil Company's successful Leduc No. 1 well was the 134th hole to be drilled in a 20-year-long campaign, costing upwards of $25,000,000 in the search for black gold beneath the surface of the prairies. The strike imparted new impetus and direction to oil prospecting in Canada and in Alberta particularly. Whereas 62 geophysical survey teams functioned in this country in 1948, by 1957 a total of 156 such field parties were active. The annual total of such survey groups never fell below 150 in the interval between those years. During that same period the number of producing oil wells in Canada rose from 703 to 10,885. Most of this increase occurred in the western interior. More than 100 new oilfields were developed in the region in that decade.[6]

Patrick died early in April, 1948, in his home in Calgary, a city he served not only as a pioneer surveyor but as an alderman for two terms of office. His life came to an end just a few months before his 100th birthday anniversary would have occurred. Today an abandoned oil well, a rough wooden sign reading "Oil City, 1878-1954" and several discarded, rusting pieces from a primitive oil rig are all that remain to mark the site of Alberta's first oil strike, an event engineered by a Dominion land surveyor.

21

MEN AND MERIDIANS IN CANADA'S NORTH

> *"There's nothing situate under Heaven's eye*
> *But hath his bound, in earth, in sea, in sky."*
>
> —*The Comedy of Errors*, Act 2, Sc. 1.

Whenever Canadians contemplate the extent and greatness of their country their eyes, generally, are fixed upon east-west lines of sight, all the way from the Atlantic to the Pacific. But north of the 60th parallel of latitude and between the 60th and 141st meridians of longitude the Northwest Territories and the Yukon Territory together comprise more than 1,500,000 square miles, or about one-third of Canada's total land mass. Yet because four out of five Canadians reside within a relatively narrow strip, averaging about 80 miles in depth, adjacent to the United States of America, there is the national tendency to overlook the fact that it is possible to fly in a straight line, south to north in this country, for about 3,000 miles without leaving the air space belonging to Canada.

The importance of the territories at the top of the map of this country can be minimized no longer. In terms of discovery and exploration by the white man Canada's northern regions possess a history as extensive in time as that claimed by any other part of the nation. The Northwest Territories, in fact, rival Newfoundland in length of contact with Europeans. Along with the Yukon these northern regions form a part of Canada that is becoming more and more strategically significant, increasingly attractive as a new and growing field of investment and productive of increasing opportunities for future generations of Canadians.

The long-nurtured popular conception of a single, unvaried, rigorous North has been slowly yielding to the progressive march of greater public awareness and knowledge of this part of Canada. There is no single North but, rather, several distinctive north-lands differing markedly in climate, topography and prospects for development. The high Arctic, for example, bears little resemblance to the lush valleys of the Yukon Territory. The treeless tundra northwest of Churchill shows little in common with farmlands bordering the Mackenzie River. Nor does the hardrock country around Great Bear Lake and Great Slave Lake suggest any similarity to the spongy delta lands in which Aklavik is located.

About half of the mainland area of the Northwest Territories and all of its islands in the Arctic Ocean lie within the Arctic Circle. The eastern two-thirds of the mainland portion and many of the islands form part of the Canadian Shield. This vast land, when viewed from the air, appears as an almost endless expanse of flatlands and countless lakes. Actually the terrain is rough and hilly, consisting mostly of solid rock. But the Territories include Canada's longest river, the Mackenzie, and largest lake entirely within Canada, Great Bear Lake.

The Yukon Territory is a land of majestic beauty, of imposing mountains and lofty hills; of broad, sweeping, silent valleys threaded by swift-running streams. In previous chapters of *Men and Meridians* the Yukon and its dynamic inhabitants have received attention. Surveying and mapping activity in relation to the Klondike gold rush and to the Alaska Highway project have been described. Airborne surveyors photographing its thousands of square miles, land surveyors bounding innumerable mineral claims, discovering and mapping its varied natural features and resources as well as helping to locate its highways and measure its forests; all have contributed to the growth and importance of the Yukon.

True to tradition, surveyors by land, air and water have spearheaded activities devoted to opening up the northern territories of this country to development. Stories of what has been accomplished by some of the durable and dedicated Canadian land surveyors who have been in the forefront of progress in the North, are recounted in the remainder of this chapter.

A well-known Canadian land surveyor whose name is linked with northerly surveys in Canada's western interior also served a term of office, in 1920, as president of the Association of Dominion Land Surveyors. Born in Bruce County, Frederick Victor Seibert (1885-1966) was educated in public and secondary schools in that part of Ontario as well as at the School of Practical Science, University of Toronto. After specializing in astronomy and geodesy Seibert graduated in 1909 and joined a federal topographical survey party operating in the Yellowhead Pass area. The chief of party was Dominion land surveyor John Baird McFarlane.

Seibert was always proud of an ingenious device that he constructed in an emergency during his initiation in the field as a student. It was a roughly made Abney level or, as he described it, a "crude clinometer" made from materials at hand at the time. Seibert used the side of a packing box and a bit of tin punctured by a nail to provide a peephole. The tin was then fastened to one corner of the wooden panel. The latter he shaped into a semi-circle and carved on it degrees and half-degrees. From a nail in the centre of the half-circle the plumb bob was hung. An Abney level is used, of course, to ascertain the slope angle of all tape measurements. Seibert's device was held so that one end of it pressed against the surveyor's shoulder. Seibert claimed that his home-made instrument worked satisfactorily on fairly steep slopes encountered in the course of chaining section lines during that season.

In that same season Seibert nearly lost his life by drowning. His canoe upset suddenly in rough waters of the Snake Indian River, Jasper National Park. He narrowly

FIGURE 161
Seibert clinometer.

survived the mishap but lost the tripod of a transit, some chaining tape and, most serious of all, the field notes belonging to party chief McFarlane covering 50 miles of surveying.

In the seasons of 1910 and 1911 Seibert served on survey parties operating under Dominion land surveyor A. H. Hawkins in the Peace River country, and in 1912 headed a survey party of his own. He was most active in the practice of his profession from 1909 to 1922, a service interrupted briefly by his enlistment in 1917 in the Royal Air Force.

It was in February, 1913, that Seibert received instructions from Ottawa to take a survey party into the field and to run the 21st base line from the Fourth Initial Meridian (Alberta-Saskatchewan boundary) west to the Fifth Initial Meridian. Seibert assembled a group of 23 men for the expedition and it is interesting to note the nature and variety of the contents of his list of provisions for the party:

"Flour, rolled oats, fine and coarse salt, white and brown sugar, rice, tapioca, sago, dried green peas, split peas, apples, tomatoes, lard, raisins, canned peaches, prunes, currants, onions, dehydrated potatoes, macaroni, butter, corned beef, pickles, codfish, jam, jelly, plums, spices, canned pumpkin, buckwheat, tomato catsup, tea, coffee.

powdered milk, cocoa and mapleline from which syrup could be made to go with flapjacks. In addition 400 pounds of bacon and 50 pounds of ham were included, all dried and double-smoked. Another staple, apricots, accounted for an additional 50 pounds."

FIGURE 162. Survey cache, 23rd base line, Alberta, 1913.

A half-century later Seibert, in commenting upon this venture, stated, "I left Edmonton early in 1913 with my survey party. The journey to the field took from March 15 to the first day of May! Today a railway to McMurray from Edmonton saves at least three weeks of travel by scow and by pack-horse. In those days we built our own scows. By helicopter, of course, a man can now be lifted over that entire distance in a few hours."[1]

In 1921 The Department of Mines, Ottawa, asked the Topographical Survey Branch, Department of the Interior, to survey the Mackenzie River shoreline, including both banks and all islands, from Great Slave Lake to Fort Norman. The purpose of this exercise was to provide plots of the traverses to geologists in the field and to deliver final plans to the Mines Department by the end of that year. All was carried out efficiently and on schedule. More than 4,000 miles of shoreline were surveyed by three field parties headed, respectively, by G. H. Blanchet, E. P. Brown and W. H. Norrish. Each party, in addition to its chief, had two assistant Dominion land surveyors, one range-finding

FIGURE 163. Surveyors on 27th base line, Alberta. F. V. Seibert on extreme right.

expert, two rodmen, one draughtsman, four canoemen and a cook. Seibert was given a sort of roving commission in relation to all three parties, with particular emphasis on provisioning them.

Survey monuments were placed by the parties at intervals from 2 to 5 miles on both sides of the Mackenzie River. These markers were intervisible and provided control for all surveys of oil and mineral claims in the region. An essential feature of these survey tasks was the extension into the Mackenzie River basin of the Dominion Lands Survey System, linking it to the already established intersection point of the Sixth Initial Meridian with the 60th parallel of latitude (the northwest corner point of Alberta). Flow measurements were made in important streams, magnetic observations were taken and useful meteorological data obtained.[2]

Late in 1922 Seibert resigned from the Topographical Survey Branch, Department of the Interior, to join the National Development Intelligence Bureau of that department. From that organization he was recruited in 1930 for the staff of the Natural Resources Division, Canadian National Railways. Seibert will be remembered as a surveyor of special ability who helped to open up Canada's northland. An important lake just east of Lac la Biche, Alberta, has been named for him in commemoration of his accomplishments. Seibert was a Canadian who served his country well in wartime and in peacetime as a Dominion land surveyor as well as a qualified surveyor in the provinces of Ontario, Saskatchewan and Alberta.

Frederick Carlyle Lamb (1887-1966) was a Dominion land surveyor and a Saskatchewan land surveyor who participated in northern surveys in his adopted province.

FIGURE 164. F. C. Lamb.

Born in Walkerton, Ontario, Lamb matriculated from high school there and entered the University of Toronto, graduating in 1909. Although he worked as a student on federal summer survey parties in Saskatchewan under Dominion land surveyor James Warren, during several seasons prior to 1910, Lamb did not move permanently to Saskatchewan until that year, making his home in Saskatoon. In his graduation year he worked with J. W. Tyrrell in northern Manitoba. Two years later he was awarded his D.L.S. and S.L.S. commissions.

In 1938 Lamb began work in the North. In that year he assisted the Dominion topographical surveyor C. H. Ney in locating the precise northwest corner point of Saskatchewan. He has described this project as one of the most interesting surveying tasks he ever performed. Night observations were made for latitude readings and fixes. Again, in 1941, Lamb worked with the Dominion, and Manitoba, land surveyor Ed. Gauer on the Manitoba-Saskatchewan boundary.

This prairie surveyor of high repute, whose son J. A. Lamb also became a practising surveyor in Saskatchewan and Alberta, has been accorded permanent recognition in the naming after him of a lake in the Kamsack area of the province he loved and which became his home.

Some aspects of Guy Blanchet's survey work in the Canadian North have already been described in this volume, particularly his part in the building of the Canol pipe line. This Dominion, and British Columbia, land surveyor received his formal education in the capital of Canada and at McGill University, from which he graduated in 1905. From 1910 to 1920 Blanchet surveyed base lines and township outlines, as a member of the Topographical Survey (Interior), in northern districts of the three prairie provinces.

FIGURE 165. Guy H. Blanchet.

Subsequently he explored, surveyed and mapped in the vicinity of Great Slave Lake, along the Mackenzie River and in the Coppermine River area. It was on these assignments in the Northwest Territories that a romance began between Blanchet and Canada's North, a love affair destined to flourish for the remainder of his active days. For years Blanchet surveyed headwaters of rivers of the Far North draining into Hudson Bay and the Arctic Ocean. Many surveyors of note received training in this region from him, men such as Ney, Narraway, Bostock, Wright and Joslyn. Blanchet, among other accomplishments, acquired a working knowledge of the Cree language and could surpass any Indian of that tribe in recounting their traditional legends and anecdotes.

In the 1926 season, while conducting a survey near Fort Reliance, Blanchet met John Hornby and his two companions as they prepared to journey into the barren lands. Blanchet tried in vain to induce the Englishmen to give up their risky venture and to take employment with his field party. The three ill-fated travellers perished, however, in the sub-Arctic wilderness during the following winter. Three years later Blanchet participated in the first search and rescue operation in the Canadian Arctic to make use of aircraft. This expedition was organized in an effort to locate a party of mining promoters led by Col. C. D. H. MacAlpine, a group regarded for a time as "lost" somewhere along the Arctic coast in the course of a flight from Baker Lake to Bathurst Inlet. They turned up, finally, at Cambridge Bay after many adventures and much privation. The imaginative use of aircraft in this search and the wide publicity the rescue operation received, as well as the liaison role played by Narraway, contributed substantially to the increased employment of planes for a variety of purposes in the Canadian North.[3]

More than 29,000 miles were flown during the nearly two months of this first major air search in the history of Canada. But the prolonged operation, extending from September 8 to November 15, 1929, added immeasurably to Canadian knowledge concerning flying in the Far North. In the course of the extensive search a number of pilots became familiar with the barren lands, much of those lands being wholly unmapped at the time. Pilots learned the special techniques of Arctic flying through the risky process of trial and error. The MacAlpine expedition itself had five planes wrecked and one vessel sunk during its sojourn in the North but no lives were lost.

Aeroplanes had been used successfully in the 1920s for observation and transportation purposes in northern areas of Canada. But their range, in those days, was so limited that vast regions of the North lay beyond their winged reach, unless airbases could be established in the North itself for their use, including repair work and refuelling. Chief among those responsible for lifting this logistical idea out of the realm of hope into that of reality was Col. MacAlpine.[4]

Blanchet was a prolific writer, mostly on northern themes, for such magazines as the *Canadian Geographical Journal, The Beaver,* and *The Canadian Surveyor.* An example of the writing of which he was capable at his best is to be found in the following passage from his book concerning the MacAlpine rescue project, *Search in the North:*

"As the rim of open water evidenced, the blue sea appeared again, rippled by the light wind; once again, after months of silence, when the sea had been scarcely distinguishable from the land, we could hear waves breaking on the beach, singing their old song. The white line of the retreating ice vanished beyond our islands, leaving a rearguard of grim fragments — like ships gleaming in the light of the setting sun. The change had been so sudden it seemed unreal. We had lost our familiar river, the tide gauge, the anchorage markers and the coal sacks that had been our air strip."[5]

In 1921 Blanchet had served as president of the Association of Dominion Land Surveyors, succeeding his friend, F. V. Seibert. A fellow of the Royal Geographical Society, Blanchet's reputation as an authority on the Canadian North was not confined to this country. In 1923 an island in Great Slave Lake was named after him as a tribute to the important role he had played in the development of Canada's North. Blanchet spent the later years of his life in Victoria, dying in the British Columbia capital in August, 1966, at the age of 82.

FIGURE 166
Blanchet taking time signals at Upper Taltson River, Northwest Territories, 1925.

FIGURE 167. Survey, 23rd base line, west of 4th meridian, 1911.

Hugh Edward Pearson (1887-), a well-known Edmontonian, associated as a land surveyor with Guy Blanchet at one period of his career in the Far North, was born in Minnedosa, Manitoba, and was educated there. Young Pearson served as a chainman on a section survey near Fort Macleod in the Alberta foothills in 1906. After that experience he was left with vivid recollections of the disaster suffered by southern Alberta ranchers during the extremely severe winter of 1905-06. He saw everywhere in that area the sun-bleached bones of cattle that had starved and then frozen to death in the blizzards of that calamitous season.

The spring of 1907 found Pearson again chaining and digging boundary-marker pits on surveys north and east of Edmonton. That autumn he joined a survey party, headed by Dominion land surveyor, J. L. Côté, then engaged on a survey of timber limits near Fort Assiniboine. This was the beginning of five consecutive seasons on parties under Côté, mostly on subdivision surveys. At Athabasca Landing, for example, 43 sections were subdivided ambitiously into town lots, some of them located on steep hillsides. Such lots were sold to real estate speculators all over the western world. In 1912, when he was commissioned a Dominion land surveyor, Pearson entered into partnership with Côté and Tremblay.

In 1915 Pearson enlisted in a Canadian infantry battalion and served overseas, winning the Military Cross. He was wounded and returned to Canada in 1919. After a season of resurveying sections south of Brandon in his native province of Manitoba, Pearson became active in Canada's North for several seasons in the early 1920s, operating under Guy Blanchet. During the first of these seasons a private survey was made of claims staked at Pine Point, on the south shore of Great Slave Lake, for the Paragon mining group. At intervals since the days of the Klondike gold rush the area had been staked and restaked. As a result considerable confusion existed over the location of boundary lines. Although hundreds of these wooden markers were to be found in the locality, most of the inscriptions on them were beyond deciphering. Pearson, however, discovered a sufficient number of guideposts on which to base a satisfactory survey. On leaving the vicinity he encountered the Erickson brothers of Seattle who revealed that they had staked on what Pearson had assumed was Paragon property. There was no alternative, therefore, but to return to Pine Point and to resurvey there, preserving the Erickson claim intact in the heart of the Paragon holdings.

In those years surveyors generally did not have radio receiving sets in the field although in 1924 the Blanchet party was equipped with wireless in order to receive from the Annapolis Naval Station in Maryland accurate time signals for ascertaining longitude positions. Following that season Pearson travelled to Ottawa where he completed his field notes and brought his career as a surveyor to an end. His interest had been aroused in the commercial possibilities of the newly-developing radio industry in western Canada. In 1927 the Taylor and Pearson radio supply firm was formed and soon began their long-term operation of the *Edmonton Journal* broadcasting station, CJCA.

Another Dominion land surveyor who helped to open up Canada's North, and who also served during 1935 as president of the Canadian Institute of Surveying, was Colin Stone Macdonald (1886-1954). A native of Ottawa and educated in that city, Macdonald gained his first field experience at the age of 16 on a party surveying the route of the National Transcontinental Railway, north of Lake Superior. On his first portage Macdonald, carrying a 100-pound pack of bacon on his back, lost his footing and tumbled down a steep bank and was prevented from falling into the rapids only by the quick action of an alert companion. The young Ottawan was quick to learn the fundamentals of his profession and, with the passing of a preliminary D.L.S. examination, became a member of the Topographical Survey Branch, Department of the Interior, in 1910. Four years later he was commissioned a Dominion land surveyor. During the First World War his career with the federal department was interrupted briefly while he served overseas with the Royal Canadian Engineers.

In 1924 Macdonald was instructed by the Topographical Survey to undertake mapping operations in northern Manitoba and Saskatchewan, mostly by canoe. He selected The Pas as his base and hired his Cree canoemen there. The itinerary of his party included Cumberland House on the Saskatchewan River, Amisk Lake south of Flin Flon, Pelican Narrows, Reindeer Lake, Brochet, and Wollaston Lake. Macdonald observed that from the latter lake — waters of one of its river outlets, namely Fond du Lac, flowed into the Arctic Ocean by way of Lake Athabasca, whereas waters of another outlet, Cochrane River, flowed into Hudson Bay and the Atlantic Ocean by way of Reindeer Lake and Churchill River.

FIGURE 168. Survey work in barren lands, 1931.

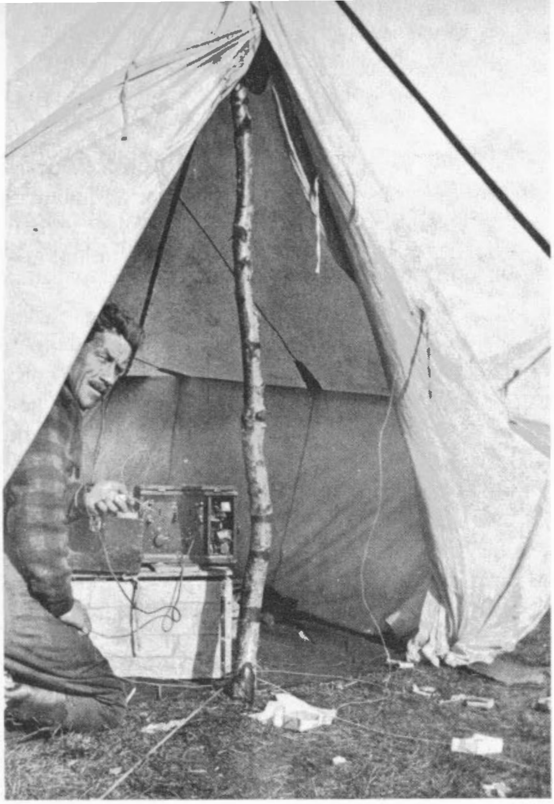


FIGURE 169. Colin S. Macdonald.

Macdonald conducted numerous stadia control surveys for mapping purposes along the Churchill River or in the areas immediately north of that waterway. At intervals he would take observations for latitude and longitude and for magnetic variations. It was on one of these assignments that he experienced in northern Saskatchewan, north of Lac la Ronge, a mishap the consequence of which, in time, brought about his premature retirement. In the 1929 field season Macdonald, in crossing a portage, was at the stern of a canoe being carried by an Indian and himself. The Indian, in a moment of careless high spirits suddenly, at the end of the portage, dropped his end of the craft causing Macdonald to wrench his back painfully. Subsequently this spinal injury brought him increasing discomfort and immobility, especially during the final 15 years of his life.

During 1930 Macdonald was seconded to the Royal Canadian Air Force in order to carry out a comprehensive inspection of gasoline fuel caches for the use of that organization in the Northwest Territories for surveying and transportation purposes. Over the years he had acquired a vast knowledge of Canada's North, especially when he was engaged on ground control surveys that formed such an important part of the framework on which subsequent aerial photographic survey work could be undertaken in that immense region. His contributions to national magazines on the subject of the northland revealed the imposing extent of Macdonald's first-hand acquaintance with that part of Canada, its dimensions, conditions and possibilities for development. Much of this information was gleaned by him in the course of 8,000 or more miles travelled by plane and canoe in the Territories.[6]

In 1931 Macdonald took part in an aerial photographic survey tour of the Northwest Territories, starting at Great Slave Lake and flying over Point Lake to the upper Coppermine River, thence to Bathurst Inlet, Western River, upper Back River to the lower Thelon and Dubawnt rivers. On this flight a total of some 2,800 miles of waterways were photographed. During his most active years in the northland Macdonald and Guy Blanchet were keen rivals in competition for the best record of accomplishment in the field. No history of the development of Canada's North could be complete without an indication of the unique achievements of these two outstanding Dominion land surveyors and explorers.

Dominion land surveyor Robert Archibald Logan (1892-) was closely associated also with pioneer efforts to apply aerial photography in the tasks of mapping in Canada's North particularly. Born and raised in Middle Musquodoboit, Nova Scotia, young Logan decided to follow the example of his grandfather, who had been a land surveyor. In 1909 he had his first taste of surveying in the field in Nova Scotia. In the spring of the following year he received a telegram from Ottawa, telephoned from the local station to his home, stating that he had been appointed as articled student to the Dominion land surveyor, Phidyme R. A. Belanger, and directing him to report to him at Winnipeg as soon as possible. The message was signed ***Deville, Surveyor General.*** The telegraph operator, unfamiliar with the French language, pronounced the word as ***Devil.*** Accordingly the intelligence received by Logan over the telephone was that a message had arrived for him from the devil in Ottawa.[7]

During the next several seasons Logan worked as a student in the field under Belanger, Guy Blanchet, Hugh Matheson and George Henry Herriot, all Dominion land surveyors. During the summer of 1913 Logan assisted Herriot in running parts of the 18th and 19th base lines west of the Principal Meridian in the vicinity of the Nelson River in northern Manitoba. It was while Logan was engaged in these tasks that he first became interested in the possibilities of making reconnaissance surveys through the use of aerial photographs.[8] At that time he realized that if only his party had known in advance the relative sizes and positions of lakes and rivers in the district being surveyed, much time and labor could have been saved, the work could have been planned more efficiently and greater accuracy in the topographical mapping work attained. The idea of being able to study the nature of the country from the air and to select the best routes or best bases for triangulation appealed to Logan. He became convinced that before many years had passed surveyors would be provided with aerial photographs and sketch maps produced from them to aid in running survey lines more easily and more efficiently.

At the age of 22, following his field work in the western interior of Canada, Logan won his D.L.S. commission, just a few months prior to the outbreak of the First World War. Soon afterward he joined the Royal Flying Corps and was sent to France. The claim has been made that Squadron Leader Logan, in March, 1916, over German-occupied France, took the first vertical aerial photographs ever credited to a Dominion land surveyor. On that occasion his aircraft was an open-cockpit, 2-seater biplane minus any parachute but equipped with an air-cooled 90-horsepower engine. The airborne camera was attached to the outside of the fuselage at the pilot's right hand. It contained 18 plate glass negatives and the exposure was made by pulling a string. The observer-gunner manned a Lewis machine gun mounted between the two seats.

Over one hour's flying was required in those days for a plane to attain 8,000 feet, the altitude at which the photographs were to be taken. As Logan flew over the front lines of the opposing forces he saw nearby a German plane on patrol over the area. Logan realized that the only way in which his observer could fire at the German aircraft would be while his own aircraft was flying away from it. Accordingly he had to allow the German plane to shoot at him while endeavoring to get into proper position over the area to be photographed. Time and again, while Logan's plane was riddled with bullets he had to take several plate exposures before turning his aircraft so that the enemy fire could be returned. Logan was wounded in the right hand, baring the bone of the middle finger. Although the injury did not prevent use of that hand, blood dripped from it all over the camera. Five times the two aircraft came close enough for a hail of bullets to be exchanged and until a total of 18 plate exposures had been completed by Logan's crew.[9]

As soon as the last plate had been exposed Logan headed for his home base and was astonished to observe that the German plane also was flying away from the scene of their hostile encounter. Fourteen years later, in a most unlikely place, Logan discovered the reason for the abrupt departure of the German. In July, 1930, during a diplomatic reception at the Mexican Embassy in Rio de Janeiro, he met the English-speaking representative of a German aviation firm operating in Brazil. Logan learned from the German in casual conversation that the latter had been a First World War pilot and when the two ex-pilots exchanged reminiscences it was found that they themselves were the combatants who had exchanged gun fire on that March day in 1916. The German war veteran explained that he had been compelled to withdraw from the action because he had run out of ammunition.

On Easter Sunday, 1917, Logan was shot down after a battle in the air, and captured. While a prisoner of war in Germany he prepared a scheme for the resurvey of Nova Scotia. On his return to Canada after the end of the war Logan resumed surveying activity. In the spring of 1922 the federal government decided to send an expedition to the Arctic for the establishment of police posts and further exploration of the region. The Department of the Interior placed the Dominion land surveyor, J. D. Craig, in charge. The authorities at Ottawa, in recognizing the importance of aerial observation in preliminary exploration work and mapping, requested the cooperation of the Air Board. Their most urgent requirement in this matter was an experienced pilot, well qualified in meteorology and navigation, to investigate and report upon flying conditions in the Far North. Logan was chosen for the assignment. The expedition sailed from Quebec on July 18, returning to that port on October 2, 1922, after visiting Baffin, Bylot, Ellesmere and North Devon islands. Logan made a comprehensive report dealing with aviation in the Arctic and the uses of aircraft in the Far North as well as about the nature of ground equipment considered essential for their efficient operation.[10]

Logan, by this time, was convinced that aircraft could facilitate exploration, surveying and mapping of the Canadian Arctic. A passage in the Air Board report for 1922 heralds the advent of the airborne camera as an aid to mapping of the Far North. "The developments during the past year", it is noted, "in the use of aerial photography for exploration and for preliminary survey work also show great promise. The survey services are alive to the importance of the problems. The development of methods of mapping from aerial pictures rests with them. *There is little doubt that the lines on which they are now working will be further developed with far-reaching results.* Even today it is not too much to say, in unsurveyed country, where there are no great differences of elevation, given geodetic control, the topographic detail of the whole district may be filled in from aerial pictures with a speed and certainty unobtainable by any but the most minute ground surveys. *The assistance that aircraft can be to surveyors, geologists and others working in the remoter parts of the country, by providing a rapid, economical, and easy method of transportation is proved beyond all reasonable doubt"* [author's italics].

Five years later Logan was placed in charge of survey work in Central Africa, including air photographic operations in Northern and Southern Rhodesia. These projects involved the taking, along the Zambesi River, of obliques for the production of line maps and of verticals for producing mosaic maps.[11] After Lindbergh's historic transatlantic flight Logan accompanied the United States Air Force colonel on an investigation of northern transatlantic air routes. Ten years later he turned up as head of the Eire Air Force and was the first man in Ireland to greet "Wrong Way" Corrigan on the completion of his famous flight, allegedly made in the direction opposite to that he wished to travel. In 1941 Logan was occupied in surveying base sites for aircraft in Greenland, as part of the allied war effort.

Logan has been, indeed, a man of many parts. A Dominion land surveyor, Provincial land surveyor, Fellow of the Royal Geographical Society, a wartime pilot, a pioneer in aerial photography; he was also a student and authority concerning the Cree (Indian) language and compiled an English-Cree dictionary. He was, as well, a prolific writer on the various subjects that held his interest. A number of his articles are to be found in the pages of *The Canadian Surveyor*.

In 1930 W. G. Jewitt, then a flying geologist on the staff of Consolidated Mining and Smelting Company, made the first geological traverse by air north of Canada's Arctic mainland. He flew from Prince Albert Sound, Victoria Island, to Collinson Inlet, King William Island, mapping an area some 40 to 60 miles in width.

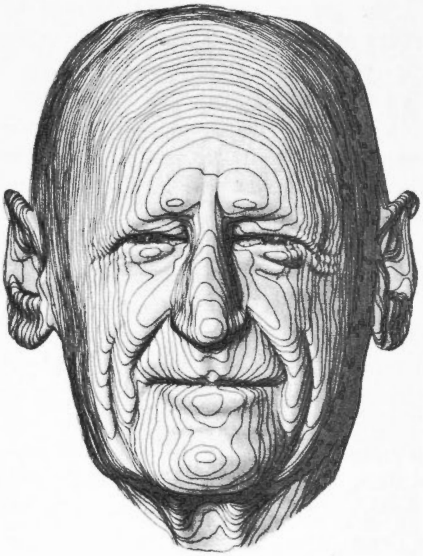


FIGURE 170
H. N. Spence . . . a contoured portrait.

The land surveying career of Howard Nathaniel Spence (1900-), who performed a considerable amount of work in the Yukon Territory for the Topographical Survey, straddled two fairly well defined periods in the recent history of Canadian surveying field work. During the first half of his professional life an important feature or requirement of activity in the field was physical prowess. On chain traversing Spence had the reputation of keeping an assistant moving along the line at a dog trot. On triangulation work it was asserted that Spence had achieved the remarkable feat of accomplishing

80 climbs of mountain peaks within a span of 100 days! In any event the competitive spirit was strong among surveyors of that period in the attainment of a high volume of work by intensive physical exertion. In the case of Spence he believed that total advantage ought to be taken of any existing conditions favorable to the performance of a survey. Even during periods of inclement weather his restlessness sought outlet in planning "tomorrow's work".

The second half of the working life of Howard Spence was marked by the advent and development of the use of aircraft and of electronic instruments, a combination that tended to diminish the significance of the surveyor's physical endowments and endurance. In fact, the contribution made by Spence through promoting the application of the helicopter to control surveys in Canada is a noteworthy one. As early as the season of 1948 Spence was in charge of a helicopter operation destined to take place in Canada's northwest. But the venture proved abortive when the aircraft involved faltered in flight soon after its departure from Vancouver. It was about this time that the helicopter came into experimental and rather limited use in Canadian geodetic survey work along the Alaska Highway.

In the following season, 1949, on the opposite side of the continent a helicopter was placed in charge of Howard Spence who headed a survey party of seven, including a cook. The purpose of this field operation was to obtain horizontal control required to map an area of about 6,000 square miles in the Knob Lake area of Quebec-Labrador. The type of helicopter selected after careful study was capable of carrying a pay load of 450 pounds, including two surveyors. The ability of this craft to hover at heights as high as 6,000 feet proved invaluable, especially in the selection of sites for triangulation stations. Prefabricated, 12-pound survey signals were used. The helicopter pilot was provided with photographic mosaics of the area to be mapped. Spence's conclusion, after the successful operations of that season, was that the use of the helicopter for survey work under such conditions would be practical and economical and he strongly recommended the increased use of helicopters by the Topographical Survey (Canada).[12]

FIGURE 171. Topographical surveyors checking on day's work in Knob Lake area.

As a result of the experience and perception of Howard Spence two helicopter operations were arranged by Topographical Survey in the following season, one of which was placed in his charge. Spence helped bring about the rapid transition from single-season surveying projects that covered a relatively limited area of, say, several hundred square miles, to those embracing a region of several thousand square miles. He earned the genuine respect of aviation firms and resource development industries associated with his survey activities. In the field Spence's subordinates were driven hard by their chief but he always evinced a deep personal interest in his men as individuals and a real concern for their welfare.

In 1967 Howard Spence retired as chief of the field surveys section of the Topographical Survey, an event appropriately observed by his many friends at a large function held in Ottawa. This occasion marked the completion of 44 years of action and achievement in the realm of surveying and mapping, a substantial portion of that lengthy period having been served in the Canadian North.

FIGURE 172. Winter survey work, using prismatic compass and odometer, Baffin Island, 1927.

Airborne Profile Recorder

Special mention should be made in this chapter of a distinctively Canadian invention — the Airborne Profile Recorder — by means of which information was compiled in extensive areas of Canada's North (as well as in other regions) enabling the profile, or critical heights of land features, to be mapped on aeronautical charts speedily and economically. In the years following the Second World War the instrument, known in the initial stages of its development by the rather cumbersome name — Narrow Beam Recording Radar Altimeter — was highly useful in establishing elevations of shoran geodetic stations in the Canadian Arctic. On the islands, vertical control was established by the Airborne Profile Recorder lines run from sea level to sea level. But the use of this instrument was not confined to the North nor to Canada only.

The Dominion land surveyor Bruce Wallace Waugh who was, at the time, assistant to Surveyor General Peters in Ottawa, succeeding him in that position in 1948, faced a pressing wartime problem in aeronautical charting. During the early years of the Second World War demands had mounted swiftly for accurate, detailed aeronautical charts of Canadian territory. In about 70 per cent of the whole area of the country the federal government found it imperative to map the ground profile speedily for the purpose of indicating critical heights on such charts.[13] Waugh had heard an address by R. C. Newhouse in 1939 descriptive of a new instrument named the Terrain Clearance Indicator. Newhouse was then a scientist employed in the Bell Telephone Company laboratories in New York City and his paper on this subject had been delivered to the American Society of Photogrammetry meeting in Washington, D.C. That address stimulated Waugh's thinking on what seemed to him to be a promising practical application of the Indicator, namely, an electronic device, mounted in aircraft, capable of measuring altitudes continuously along a flight track.

On June 1, 1943, Waugh wrote to Newhouse stating in part:

"What we need is a Terrain Clearance Indicator that will read distances up to 4,000 feet with a maximum error of 100 feet or so. We would like to have it fitted with a continuous recording device so that if a plane is flown at a constant elevation, the resulting graph will be a profile of the terrain traversed. This, together with an altigraph record of the up and down flight path of the plane and a record of the barometry gradient in the area, should give a fair indication of the elevation of the ground above sea level."[14]

Because of the vital interest of the Royal Canadian Air Force in the production of adequate aeronautical charts, the federal survey organization was provided with Hudson aircraft and equipment so that Waugh's idea could be tested. The Terrain Clearance Indicator operated on frequency-modulated radio principles and was designed to determine the critical altitude of an aeroplane above the sea for the launching of torpedoes at enemy ships or submarines. The first of several secret flight trials was carried out in September, 1943, and these tests proved encouraging over water surfaces although the instrument's performance over rugged land surface left much to be desired. This shortcoming was discussed with the National Research Council of Canada and the survey organization was advised that an Indicator based on radar-pulse principles would be more effective. However, it was also pointed out that the production of such a device would need to await the end of hostilities.

The National Research Council was approached again on this subject after the end of the war. With Sid Jowitt of the Topographical Survey staff assisting, work on the project was resumed in close cooperation with the Royal Canadian Air Force and the National Research Council. In 1947 a member of the Council staff, Brian Cooper, designed and constructed for topographic surveys the terrain clearance indicator named Narrow Beam Recording Radar Altimeter. Another requirement in Waugh's proposed new survey technique was an altigraph record of the up and down flight path of an aircraft. Ray Westby, also of the Council staff, designed and built a special auxiliary instrument for this purpose, named a Pressure Height Corrector. This instrument automatically corrected terrain clearance measurements. As a result the altimeter accurately recorded the profile of the terrain even when a pilot failed to maintain a constant flight level. A third improvement in the recording instrument was made by T. J. G. Henry of the federal Department of Transport, who suggested a meteorological formula for evaluating barometry gradients at altitudes above the frictional effects of the earth's surface. Because the Narrow Beam Recording Radar Altimeter was designed to record the profile of the ground, similar equipment was later known as the Airborne Profile Recorder.

Waugh's new surveying technique was thoroughly tested in 1948. Flight trials, arranged by the Royal Canadian Air Force in that year with Jowitt aboard, demonstrated the success of the apparatus beyond the most optimistic expectations. Some of the traverses extended 350 miles between ground control points and the accuracy of results was astonishing. The average error was plus or minus ten feet only. This represented a far higher order of accuracy than was required for aeronautical charting. The new technique also showed considerable promise of usefulness in larger scale topographical mapping.

In 1949 the Royal Canadian Air Force ordered six sets of the Airborne Profile Recorder for its use. In that same year the first of several private Canadian air survey firms to make use of the Airborne Profile Recorder device equipped itself with a set and was awarded a contract to survey an extensive area in Quebec and Labrador. In fact, private aviation firms in Canada have been responsible for significant refinements in this equipment during the years following its official adoption for surveying purposes. The Airborne Profile Recorder not only produced excellent results when used in Canada; sets made in Canada were purchased by agencies in the United States, England, Australia, Holland and Pakistan, among other countries. The instrument has been used by private Canadian companies to map extensive areas in countries of Central and South America as well as countries in Africa. In areas totalling between 50 and 60 per cent of all Canada, including its Arctic regions, the Airborne Profile Recorder was used as a means of providing information for contouring aeronautical charts and later, as additional improvements were made in the device, for 1:250,000 topographical maps.

SURVEYORS GENERAL
(Federal)

	Years in office
John Stoughton Dennis, P.L.S. (Ontario).	1871-1878
Lindsay Russell, D.L.S.	1878-1884
Edouard Gaston Daniel Deville, LL.D., D.T.S., D.L.S.	1885-1924
Frederic Hatheway Peters, O.B.E., D.L.S.	1924-1948
Bruce Wallace Waugh, D.L.S.	1948-1953
Robert Thistlethwaite, D.L.S., B.C.L.S., A.L.S.	1953-

APPENDIX

INCORPORATION OF SURVEYORS' ORGANIZATIONS (MARITIME PROVINCES)

New Brunswick

The year 1954 proved to be an historic one in the formation of an organization of land surveyors in New Brunswick. In the years between the two world wars several attempts were made in New Brunswick to arouse interest in the creation of a province-wide association of this nature but these efforts foundered on the shoals of apathy. By 1950, however, the need for such an organization had become more apparent than ever. In September, 1953, several New Brunswick land surveyors gave leadership in this project by circulating a questionnaire among fellow professionals resident in the province. Each surveyor was asked to express his opinion for or against the idea of a provincial association. Of the 93 forms mailed out, 53 replies favorable to the proposal were received, none against. Elated by this response the core group sent out a second circular containing information that an organizational meeting would be held on November 16, 1953, in Fredericton.

At the November meeting, attended by 39, the provisional Association of New Brunswick Land Surveyors was organized. A president, W. F. Roberts, was named along with a vice-president, eight councillors and a secretary-treasurer. The meeting passed a motion authorizing the Council to call a first annual meeting to take place on January 12 and 13, 1954, and passed as well a motion authorizing the preparation of a draft act of incorporation to be submitted, on proper approval, to the Provincial Legislature. At the conclusion of this historic meeting the new president distributed to each councillor, for his guidance, a set of the various provincial acts passed in Canada establishing surveyors' organizations. Each councillor was requested to form and to preside over a committee in his own area in order to study these acts and to select sections of such legislation or to suggest new sections suitable to be included in a New Brunswick act. All were asked to have reports ready for consideration at a meeting to take place on December 28, 1953.

At this deliberation of councillors the rough draft of an act was compiled from the various area reports received. During the first few days of January copies of the compilation were produced for consideration at the first annual meeting of the association in Fredericton. The weather on January 12 threatened to abort the birth of the new body. One of the worst blizzards of the winter did leave some members firmly snowbound in their homes. But enthusiasm had been running high for the incorporation project and, despite the hostile elements, 41 surveyors arrived for the occasion. A draft bill was given careful study, section by suggested section. In the course of a day and a half the complete text was approved unanimously. A leading lawyer in Fredericton spoke to the meeting on various legal aspects of the draughting of such a measure. At the formal dinner on January 12 the gathering was addressed by Hon. N. B. Buchanan, Minister of Lands and Mines, New Brunswick. At luncheon, on the following day, the special speaker was W. H. Miller, Director, Surveys and Mapping Branch, Ottawa.

Throughout February, 1954, officers of the embryo organization met on a number of occasions with the solicitor to the association in clarifying and adding finishing touches to the bill. Finally the measure was judged ready for consideration by the Provincial Legislature then in session. Suspense among the surveyors began to build up as the time for parliamentary discussion approached. On March 10 the measure, Bill No. 38 of that session, passed its formal first reading stage, with second reading taking place on the following day. The bill was then referred, according to custom, to the corporation committee of the Legislature. On March 18, 1954, the entire membership of the Council of the association, together with its solicitor, appeared before the legislative committee which then proceeded to examine the bill, section by section. By noon of that day the representatives of the association were asked to re-word two sections and to appear again before the committee later that day. One of the revised sections, that of authorizing entry to properties for measuring purposes, continued to arouse objections and was discarded. The re-wording of the other disputed section, relating to the custody of field notes of deceased surveyors, was accepted and the bill was given final approval for submission to the committee of the whole house.

To the dismay of the surveyors the latter body returned the bill to the corporation committee for clarification of the right to survey a highway or street. Accordingly, on legal advice, the councillors of the association dropped this provision and inserted a new section, giving all persons working under the Highway Act of the province the right to survey their highway location. On March 24 the newly added section having met with approval, the bill was safely navigated through the remaining stages of legislative discussion and received royal assent on April 12, 1954.

At the time of incorporation of New Brunswick surveyors their first president, Willis F. Roberts, was a forester on the staff of the photogrammetric and survey branches of the Department of Lands and Forests, New Brunswick. Roberts had graduated from the University of New Brunswick in forest engineering. In 1955 he was appointed assistant director by H. P. Longley. Other officers elected that year were C. F. Cook, vice-president, and J. R. Bedard, secretary-treasurer. Councillors chosen were C. B. McKiel, R. S. Jones, H. G. Rogers, W. I. Spence, G. D. Hughes, E. R. Jamieson, R. G. Brown and C. M. Roy.

Nova Scotia

The Association of Nova Scotia Land Surveyors, as it is now known, came into existence following a series of attempts to organize members of the profession on a provincial basis. On October 10, 1924, for example, a group of land surveyors practising in the province met at Middleton and decided that it would be in the best interests of the general public and of the profession to form an Association of Provincial Land Surveyors of Nova Scotia. With this object in view all surveyors qualified to practise in the province were circularized. They were asked to meet for organizational purposes in Halifax on November 21, 1924. About 50 persons turned up for that meeting and a number of communications were received from the absent but eligible remainder indicating agreement with the purpose of the event. At the meeting the proposal to form such an association was endorsed unanimously. Officers elected to prepare a draft constitution for submission to a general meeting to take place in January, 1925, included the chairman of the preliminary gathering, J. R. MacKenzie of Halifax (subsequently named association president); J. R. MacKenzie of Springhill (named vice-president) and Professor W. G. Hardy (Nova Scotia Technical College) secretary-treasurer. Elected to the Council were J. R. Morrison, J. Lorne Allen, Otto Schierbeck, H. J. Congdon and F. H. Hanson, deputy minister of Crown Lands for the province.

As chairman of the October, 1924 gathering J. R. MacKenzie set forth six main points representing aims of the proposed new organization, namely:

1. All new surveys be performed by transit to the true meridian and the compass be allowed only in retracing old lines.

2. To avoid confusion between the two meridians all descriptions of lands in deeds and leases should be written and certified by a member of the association.

3. In order to make surveys of permanent value all surveys executed by members should be filed with the association secretary until a provincial government department could be formed to deal with such work.

4. To induce the government of the province to have all Crown Lands surveyed by association members.

5. To induce the government to have cadastral surveys started by surveying and placing permanent monuments at all suitable points along all county, township lines and public highways.

6. An agreed standard scale of fees be charged by association members.[1]

In 1928 Bill No. 58 was introduced in the Provincial Legislature, "an act to incorporate

. . . and to facilitate the acquirement and interchange of professional knowledge among its members." First reading of this measure was accomplished on February 24, following which the bill was rejected. After this set-back organizing activity among surveyors dwindled rapidly and, in fact, disappeared entirely for upwards of a quarter-century. Enthusiasm for the creation of a province-wide association revived about the mid-century mark.

In December, 1950, several provincial land surveyors who were especially eager to promote an association of their fellow professionals in Nova Scotia met, with Professor Piers serving as chairman, in the Technical College building in Halifax. Edward Otis Temple Piers, a graduate in civil engineering from McGill University, had been Dean of Engineering at Mackenzie College in Sao Paulo, Brazil, from 1910 to 1931. Returning to Canada he had specialized in highway engineering and had made his home in Halifax after 1936. Professor Piers, from time to time, has been described as the "father of the (N.S.) Association". It is certain that without his vision and persistence the development of the provincial organization would have been long delayed. He and Professor (Colonel) Spencer Ball, also of the Technical College staff, were largely instrumental at this time in reviving and bringing to fruition the earlier concept of a province-wide organization of land surveyors.

Col. Spencer Ball was trained in civil engineering at the University of Saskatchewan. When the First World War broke out he enlisted in the western universities battalion. C. J. Mackenzie, also of the University of Saskatchewan, and in later years president of the National Research Council, was Spencer Ball's platoon officer at the time. After the war Col. Ball was associated for some years with the Ontario Hydro Commission. He served with the Directorate of Military Training, Ottawa, during the Second World War, after which he practised his civilian profession as consulting engineer, including land surveying and bridge approach work.

In February, 1951, at a meeting also held in the Technical College and marking the first successful attempt to form a land surveyors' organization in Nova Scotia, Professor Piers was elected president, J. G. Mackenzie, vice-president and W. A. G. Snook, secretary-treasurer. Council members included J. E. R. March and F. Tupper from Halifax County; R. E. Dickie and Major J. A. H. Church from outside the Halifax area, and A. H. Martell from Cape Breton.[2] The purpose of the revived organization, as expressed at the time, was to promote the common welfare of surveyors of the province, to maintain standards of ethical conduct in the practice of the profession in Nova Scotia, and to provide opportunities for common action in all matters concerning the association in its relations, and those of its members, with the general public.

The next step, following the formative meeting in 1951, was to arrange for incorporation. For this purpose the first directors of the Association of Provincial Land Surveyors of Nova Scotia were J. E. R. March of Halifax, R. Eric Millard of Liverpool, Roy M. Schofield, Freeman Tupper and J. L. Reid, all of Dartmouth. The objects of the organization, as set forth in the official memorandum over these names, were described as (a) to foster and promote the practice of land surveying and to provide for the betterment of the members and for uniformity and efficiency in land surveying; (b) to formulate and administer policy and discipline among its members; (c) to provide for professional, educational, social and recreational activities and (d) not to engage in the carrying on of any trade, industry or business.

Rather impulsively, and without first obtaining legal advice, the enthused surveyors submitted a draft measure to revise the existing Provincial Land Surveyors' Act and submitted the draft to the legislative committee of the Provincial Legislature. This committee returned the measure without approval, recommending that legal assistance be obtained in the wording of the bill. Compliance with this suggestion involved a delay of 18 months. In the meantime the surveyors grew restive over their unincorporated condition and decided to press ahead with their efforts to become a legal entity. The statutory instrument selected for this purpose was the Societies Act (1953) of the province. Under a certificate issued by the Registrar at Halifax, under provisions of that act, the Association of Provincial Land Surveyors of Nova Scotia was declared to be duly incorporated on January 26, 1955.

After a succession of drafts had been prepared for the purpose of merging the act of incorporation and the provincial surveyors' statute, an Act to revise chapter 230, Revised Statutes of Nova Scotia (1954), being the Provincial Land Surveyors' Act, originally known as Bill No. 16, received royal assent at last on March 26, 1959.[3] Under authority of that measure the Association proceeded to organize a board of examiners, to compile a code of professional ethics and to establish standards of work. By this time membership in the organization had risen to 130.

Col. Spencer Ball, after serving as president, was made an honorary member of the organization as, in time, were Reginald E. Dickie, R. E. Millard (editor of The Nova Scotian Surveyor), Col. C. C. Lindsay, Q.L.S. of Montreal, Robert A. Logan, D.L.S., and J. E. R. March.

One of the sponsors in 1928 of Bill No. 58 was Stephen Edgar March (1870-1966). Son of a Baptist minister S. E. March began his career as a lawyer following graduation from Dalhousie University in 1893. In March, 1915, he qualified to practise in Nova Scotia as a provincial land surveyor. His final active year in the profession was 1951. At the age of 81 he had the largest private surveying practice in the province, though not the most lucrative. In 1937 S. E. March was appointed a magistrate at Bridgewater, Nova Scotia, and served in that capacity until near the year of his death at the age of 96. His son, John Edgar Ruskin March entered, in 1933, into what proved to be a long period of continuous service with the Department of Lands and Forests of Nova Scotia. In 1948, after a number of years in the position of Assistant Director, "Rusty" March, as he was known in the profession across Canada, was appointed Director of Surveys for the province.

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3. *Nova Scotian Surveyor*, v. 9, no. 19, p. 1 (May 1959).

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DON W. THOMSON

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MAP AND FIGURE GUIDE

MAPS

1. Ontario-Manitoba boundary (in part) 34
2. Alaska Highway route .... *facing page* 79
3. Triangulation, Geodetic Survey of Canada, to 1935 127
4. Quebec-Newfoundland boundary (in part) *facing page* 202
5. Thematic (volumetric symbols) map .... *facing page* 234
6. Thematic (isarithms) map .... *facing page* 235
7. Thematic (dots) map .... *facing page* 236
8. Thematic (forest types) map .... *facing page* 237
9. Lake Huron sheet, 1933 .... *facing page* 246
10. Nottaway (Que.) sheet, 1927 .... *facing page* 247
11. Arctic Islands inset, 1945 .... *facing page* 248
12. Ontario resources survey, 1901 286
13. Forest cover (air) map, Canada .... *facing page* 294
14. Office-compiled map of Ogden Bay area, N.W.T., 1943 302
15. Map from trimetrogon photography, Ogden Bay area, N.W.T., 1953 303
16. Fredericton-Moncton air chart, 1935 .... *facing page* 304
17. Fredericton-Moncton air chart, 1947 .... *facing page* 304

FIGURES

1. Cliff street, Ottawa, laboratory 3
2. Comparator, Ottawa, about 1915 4
3. Perspective grid, Canadian Rockies 5
4. Site marking, mountain country 6
5. Ottawa-Hull area mosaic, 1925 7
6. A. M. Narraway 9
7. Air view, Burritts Rapids, Ont. .. 13
8. Dioptra, Hero of Alexandria 17
9. Champlain's astrolabe, 1603 18
10. Hadley's quadrant 19
11. "S.G." type theodolite 21
12. Dolland sextant 21
13. Ramsden dividing engine 22
14. Logan odometer 24
15. Gunter's chain 25
16. Photo-alidade 26
17. Mountain transit and camera 28
18. Brunton's pocket transit 29
19. Boyd alidade, plane table 30
20. Tellurometer in use 32
21. Initial monument, Ont.-Man. boundary 35
22. J. W. Pierce 36
23. Pierce party, Berens River, 1922 39
24. Surveyors on Palsen River, 1929 40
25. C. H. "Marsh" Ney 40
26. Boundary marker, Hudson Bay 41
27. Ney party, Hudson Bay, 1930 .. 43
28. Monument 82, Ont.-Man. boundary 43
29. H. E. Beresford 44
30. E. Gauer, Ont.-Man. boundary .. 45
31. John G. Pierce, Hudson Bay, 1948 45
32. Types of transport, Ont.-Man. boundary 46
33. Mortimer Co. pressroom, 1918 51
34. Graining lithographic plate 52
35. W. A. Cunningham 53
36. Inking printing plate for hydrographic chart 54
37. Transfer press in use 55
38. Offset press and rotary press 55
39. Map manuscript compilation 56
40. Use of stereoscope 57
41. E. D. Baldock 58
42. Paul Metivier 59
43. W. H. Miller 59
44. Mann offset press, 1957 61
45. Mann offset press, 1961 62
46. Map-making processes 63
47. Priest's Farm, Montreal 66
48. Jeffry's plan, Montreal, 1758 67
49. Charland plan, Montreal, 1803 .. 69
50. Eastern Townships map, 1842 .. 70
51. J. Rielle 72
52. F. W. Blaiklock 72
53. Hon. J. P. B. Casgrain 72
54. Map of Montreal, 1907 74

55. Quebec Land Surveyors' convention, 1932 75
56. Downtown Montreal, 1962 76
57. Alaska Highway (Yukon) 80
58. A. D. McLean 81
59. F. C. Swannell 84
60. Pioneer winter trail, Alaska Highway 85
61. Typical temporary bridge, Alaska Highway 87
62. Survey truck fording stream 88
63. Peace River Bridge, 1942 89
64. Surveyor on Alaska Highway 92
65. Alaska Highway plaque 95
66. Levelling, Alaska Highway 97
67. Capt. F. Anderson 100
68. Lighthouse, St. Lawrence River 102-103
69. R. J. Fraser 104
70. Dr. W. Bell Dawson 106
71. H. W. Jones 106
72. F. C. G. Smith 107
73. Echo sounder, 1937 108
74. F. H. Peters 109
75. N. G. Gray, 1931 110
76. CHS *Wm. J. Stewart* 111
77. Capt. D. M. Snelgrove 112
78. CHS launch *Anderson* 112
79. H. D. Parizeau and group 113
80. Houseboats and CHS *Lillooet* 114
81. CHS *Baffin* and first *Bayfield* 116
82. CSS *Parizeau* 117
83. Noel Ogilvie and J. M. Riddell 120
84. J. L. Rannie 124
85. Portion of Ottawa map, 1921 126
86. J. E. R. Ross 129
87. A. C. Hamilton 130
88. Trans-Canada Highway route 134
89. Ontario highway system, 1922 138
90. Don Valley development 139
91. Toronto waterfront, 1949 and 1962 140-141
92. Triangulation, Ontario highways 143
93. Clarkson, Ont., 1930 and 1968 144-145
94. Pembina overpass, Man. 147
95. Trans-Canada Highway, Banff 150
96. Snowshed, Glacier National Park 152
97. Snow guards and avalanche 153
98. General A. G. L. McNaughton 156
99. Air survey crew, 1924 159
100. Lieut. General E. L. M. Burns 161
101. Army mappers, England, 1944 166-167
102. Army map press truck 168
103. Army survey map press, Ottawa 169
104. Hon. Wm. Benidickson with K. G. Chipman and E. S. Fry 171
105. Multiplex plotter (Army) 177
106. Central Toronto (sketch) 1830 180
107. Toronto: old and new 181
108. H. L. Seymour 183
109. Stewart Young 183
110. Charles Unwin 189
111. Don Mills, Ont., 1952 and 1967 190-191
112. Don River mouth, Toronto 192
113. T. D. leMay 193
114. University Avenue, Toronto 194
115. Toronto Island 195
116. Typical title, Quebec maps 198
117. Newfoundland boundaries 200
118. Levelling, Labrador, pre-1927 201
119. Mineral regions, Labrador 206
120. Interprovincial boundary, Schefferville, Que. 208
121. Georges Côté 209
122. W. S. McClenahan 217
123. M. M. Thomson 217
124. Magnetometer in use 225
125. Dr. C. A. Chant 228
126. David Dunlap Observatory 229
127. Chant Silver Medal 231
128. D. B. Dowling 243
129. Victoria Memorial Museum, Ottawa 244
130. W. McInnes 245
131. W. H. Collins 246
132. A. Dickison 249
133. G. A. Young 250
134. G. Hanson 253
135. R. B. McKay 256
136. G. S. Hume 256
137. Major Church at his desk 258
138. Surveyors (Army) class, Halifax, 1943 259
139. Nova Scotia Land Survey Inst. bldg. 261
140. Class instruction, Nova Scotia L.S.I. 262
141. Nova Scotia L.S.I. students in field 265
142. Hudson Bay Railway construction, 1915 269

143. Airphoto, Pelican Narrows, Sask., 1922 273
144. Nelson River crossing 274
145. Port Churchill from the air 275
146. C.N.R. Prince Rupert line (B.C.) from the air 277
147. Knob Lake railway 279
148. Army traverse, 1958 282-283
149. T. B. Speight 287
150. Vickers survey plane, Sask. 290
151. Curtiss survey plane, 1926 291
152. G. S. Andrews 293
153. Forest detail in airphotos 294
154. Forest air survey, Ont. 295
155. B. W. Waugh 301
156. M. Cameron 301
157. A. P. Patrick 306
158. Map of Discovery oil well site, Alta. 307
159. Patrick in Alberta, 1925 309
160. Patrick with Lord Bennett 310
161. Seibert clinometer 313
162. Survey cache, 1913 314
163. Baseline surveyors, Alberta 315
164. F. C. Lamb 316
165. G. H. Blanchet 317
166. Blanchet in N.W.T., 1925 318
167. Baseline survey, 1911 319
168. Survey work in barren lands, 1931 320
169. C. S. Macdonald 321
170. H. N. Spence 324
171. Topographical surveyors, Knob Lake area, Que. 325
172. Winter survey work, Baffin Island, 1927 326

INDEX

Abitibi (region), 209.
Abitibi River, 281.
Abney level, 312.
Abrams Sketchmaster, 145.
Acadia, CHS (ship), 100, 104, 112; echo-sounding, 108.
Acadia-Challenger model (echo sounder), 108.
Acadia University, N.S., 220.
Adams, John, 71, 180-2.
Admiralty, British, 53, 99, 104, 115; surveys, 100; Hydrographer to, 105; vessel, 108; charts by, 119, 304.
aerodist, 132.
Agas, Ralph, 20.
Agincourt, Ont., magnetic observatory at, 225.
Air Board (Canada), 5, 7, 11, 12, 323; report, 272.
airborne gravimeter, 132.
Airborne Profile Recorder, 31, 128, 327-8.
airborne survey camera, 31, 58, 178, 293; in Far North, 322.
Air Navigation series, 297, 304.
air surveys, 160, 170, 176-7, 321-2; photo, 164; Section, 255, 289; forest surveys, 293.
Aitkin, Alexander, 184-5; York survey, 186-7.
Akins, J. R., 299.
Aklavik, 312.
Alaska, 80, 82, 86, 91, 96, 98, 276; terminal, 90; Panhandle, 198.
Alaska Highway (Alcan), 79, 80, 85-8, 90-8, 142, 312, 325; Dr. Lord and, 254.
Alaska Railway (Project), 276.
Albany River, Ont., 288, 291.
Alberta, 7, 8, 12, 79, 81, 147, 204, 225, 269, 281, 306, 310, 314-5; L. B. Stewart at, 121; Ney in, 128; highways in, 148; Fry in, 170-1; town planning, 181; maps by, 238, 252, 258; survey courses in, 266; refinery in, 284; Sask. boundary with, 313; Pearson and, 319.
Alberta Dept. of Agriculture, 238.
Alberta Great Waterways (Railway), 270.
Alberta Land Surveyors' Assoc. Act, 266.
Alberta, University of, observatory, 230; soil maps by, 238.
Alcock, F. J., 245.
Alexander, S. G., 254.
Alexis Bay, 289.
alidade, 27; photo-, 26.
altimeters, 31.
Aluminum Co. of Canada, 184.
American Geographical Society, 203, 297.
American Society of Photogrammetry, 327.
Amisk Lake, 320.
Amsterdam, 48.
Anderson, Capt. F., 100, 107, 109.
Anderson, CHS (launch), 112, 115.
Anderson, L. L., 97.
André, Mathieu, 207.
Andrews, G. S., B.C.L.S., Maj., 165, 237, 292-6.
Anjou, Que., 69.
Annapolis, N.S., 95, 133, 290; Royal, 289.
Annapolis Basin, 115.
Annapolis County, 258.
Annapolis Naval Station, Md., 320.
Annapolis Valley, N.S., 257-8.
Anse Sablon, 199, 201-2.
Anticosti Island, 109, 199.
Anyox, B.C., 117.
Archer, F. S., 49.
Architectural Association of Canada, 181.
Arctic, CGS (ship), 11.
Arctic Circle, 82, 226, 312; air surveys north of, 234.
Arctic (Islands), 128, 253, 327; region, 221, 225, 273, 328; map inset of, 249; coast, 301; high Arctic, 312; mainland, 324.
Arctic Ocean, 107, 273, 304, 312, 320; voyages, 224; Blanchet and, 317; flying, 318; Logan at, 323.
Argentia harbor, 115.
Armstrong, Ont., 291.
Army Survey Establishment, R.C.E., 169, 170, 175; map production of, 178.
Arnold, Dick, 50, 247.
Arpenteurs Jurés, 74.
Arrowsmith (London), 202.
Arsenault, Pierre, 68.
Artillery Survey Reinforcement Unit, 164.
Arvida, Que., 184.
Assiniboine (River), 146.
Associate Committee on Survey Research, 129, 161.
Association of Alberta Land Surveyors, 148, 182.

Association of Dominion Land Surveyors, 14, 36, 312, 318; town planning and, 181.
Association of New Brunswick Land Surveyors, 331.
Association of Nova Scotia Land Surveyors, 332.
Association of Ontario Land Surveyors, 35, 36.
astrolabe, 17, 18, 20.
Astronomical Branch, Ottawa, 214-7.
Athabasca (region), 171.
Athabasca River (region), 225; Landing, 319.
Atlantic (Ocean), 14, 82, 105, 123, 201-2, 210, 224, 311, 320; Coast, 101, 104; region, 106; route, 110; lifelines, 111; Battle of, 113; Charter, 115; fisheries, 199; rivers into, 203; tidewater, 267.
Atlas of Canada (1915), 236; (1957), 236.
Attfield, A. E., 163.
Aurora, Ont., 128, 218.
Australia, 230.
Avalon Peninsula, 114.

Babel, Rev. Louis, O.M.I., 206.
Bachand, G. A., 100, 107, 109.
Back River, N.W.T., upper, 321.
Baddeck, N.S., 4.
Baedeker, Karl, 160.
Baffin, CHS (ship), 116.
Baffin Island, 11, 323, 326.
Bagguley, D. Howard, 59.
Baie d'Urfé, Que., 69.
Baird, Alexander, O.L.S., 287.
Baird, Maj. W. J., 164.
Baker Lake, N.W.T., 317.
Baldock, E. D., 58, 59.
Bancroft, Ont., 142.
Banff, Alta., 121, 150.
Barbier, Gilbert, 66.
Bartholomew, John, and Son, 248, 254.
barometer(s), 23, 31, 288; aneroid, 3; on rail surveys, 284.
Barr and Stroud, Glasgow, 163
Basset, Benigne, 66.
Basset, Charles, 68.
Batchawana, Ont., 142.
Bathurst Inlet, 317, 321.
Batiscan River, 11.
Battle Harbour, 172, 289.
Battle of the Atlantic, 113.
Bayfield, CHS (ship), 100, 107; and Superior Shoal, 109, 112, 116.
Bayfield, Lieut. H. W. (R.N.), 186.
Bay of Chaleur, 23.
Bay of Fundy, 119, 121.
Beaconsfield, Que., 69.
Beals, Dr. C. S., 220-1.
Beatton River, 85.
Beatty, D., O.L.S., D.L.S., 287.
Beatty, F. W., O.L.S., D.L.S., 44, 171.
Beaudry, Toussaint, 68.
The Beaver, 318.
Beaver Creek, 12.
Beaver Indians, 87.
Bedaux, C. E., (Expedition), 83-4.
Bedford Basin, 113.
Beech, C. E., 268, 271.
Beech, William, 268, 271.
Bélanger, Ernest, 73.
Belanger, P.R.A., D.L.S., 322.
Belisle, Jean-Baptiste, 68.
Bell, J. A., 148.
Bell, R. B., 73.
Bell, Sapper G., 168.
Bell Telephone Co., 327.
Bell, Dr. W. A., 256.
Bellanca Pacemaker planes, 296.
Belle Isle (Strait of), 105, 107, 109, 199; Labrador and, 197.
bench mark, 31.
Benidickson, Hon. W., 171.
Bennett, Premier W. A. C., 237.
Benson, (Hon.) E. J., 98.
Bent, R. W., (Bent Rock), 109.
Berens River, 39, 53.
Beresford, H. E., M.L.S., D.L.S., 44.
Beresford, H. G., M.L.S., D.L.S., 44.
Beresford Lake, 38.
Bereskin, Capt. A. I., 168.
Besserer, C. W., 60.
Big Bend Highway, 151.
Bigger, C. A., 131.
Bird, Lieut.-Col. F. G., 164.
Black, Hon. George, 80.
Black Duck Lake, 42.
Blaeu, W. J., 48.
Blaiklock, F. W., D.L.S., 72-3.
Blanchet, G. H., B.C.L.S., D.L.S., 40, 93-4, 221, 316-9, 322; Ney with, 128, Mackenzie River survey, 314.
Blaskowitz, C., 134.
Blind River sheet (1925), 254.

Bloodvein River, 38.
Board of Examiners, 1, 2, 15.
Board of Topographic Surveys and Maps, 158.
Borden, Sir Robert, 50, 51.
bornage, 75-6, procès-verbal, 77.
bornage à l'amiable, 76.
bornage judiciare, 76.
Bosch photographic seismographs, 222-3
Bostock, Dr. H. S., 163, 317.
Boston, Mass., 203, 289, 290.
Botwood, Nfld., 172.
Boucher *dit* Boisbuisson, Louis-Marie, 66.
Bouchette, Joseph, 185.
Boudreau *dit* Graveline, Gabriel, 68.
Boulton (launch), 108.
Boutin, Jean, 68.
Bowman, Isaiah, 233.
Bow River, 8, 150.
Boyd, W. H., 255-6.
Boyer, Marc (Dr.), 59.
Brabazon, Claude H., 121-2.
Bradford, Ont., 40, 128.
Braeside, Ont., 288.
Brampton, Ont., 217.
Bridgewater, N.S., 334.
Bristol Fighter (aircraft), 7, 122.
British Admiralty, *see* Admiralty (British).
British Columbia, 79, 80-86, 104-6, 117, 121-2, 164, 171, 184, 217, 225, 270, 276, 296, 316, 318; Yukon boundary survey, 96, 98; waters, 99; coastal charts of, 120; roads in, 135, 149, 151; Andrews and, 165; Vicars and, 175; Blanchet in, 221; maps by, 237; centennial year, 238; Chipman in, 242-3; Dr. Lord in, 254; Maj. Church in, 257; Forest Service, 292; Patrick in, 309.
British Columbia, University of, 238.
British Commonwealth Air Training Plan, 60, 300, 304-5.
Brock, R. W., 243.
Brockville, Ont., 142.
Brown, E. P., 314.
Brown, J. G. "Kootenai", 308.
Brown, L. O., D.L.S., 121, 131.
Brown, T. W., D.L.S., 171.
Bruce County, 211, 312.
Brunton transit, 29.
bubble tube, 31.
Buchanan, Hon. N. B., 331.
Buck Creek, 85.
Bulkley Canyon, B.C., 277.
Bureau of the Cadastre, Que., 237.
Bureau of Economic Geology, 250.
Bureau of Geology and Topography, 251, 255-6.
Bureau of Mines, 251.
Bureau of Surveys, Que., 237.
Burgess, A. M., 202.
Burland, Miss M. S., 217.
Burns, Lieut.-Gen. E. L. M., 160-2, 299, plotter by, 163; advisor to, 177.
Burnt Creek, 207.
Bylot (Island), 11, 323.

Cabbage Town Store, 188.
Cabot Island, 203.
Cabot Strait, 107.
Cadillac, 67.
Cairns, J. R., 159.
Calgary, 8, 175, 308; Patrick dies at, 310.
Cambridge Bay, 317.
cameras, 95, 123; trimetregon, 96; LB (Mark 1), 122; airborne survey, lens, 162; by helicopter, 278, 289, 300, 322, 323.
Cameron (or Oil) Creek, 307-8.
Cameron Falls, 307.
Cameron Lake, 307.
Cameron, Max G., 60, 176-7, 301.
Campbell, A. W., 148, 149.
Campobello Island, 119.
Camsell, Dr. Charles, 81, 160, 243, 246.
Canada Highways Improvement Act, 149; Canada Highways Act (1919), 149, 150.
Canada West, 135, 137.
Canadian Air Force, 39, 122.
Canadian Airways Ltd., 295-6.
Canadian Broadcasting Corp., 216.
Canadian Corps Survey Section, 157-8.
Canadian Geodetic Society, 121.
Canadian Geographical Journal, 318.
Canadian Good Roads Association(s), 149.
Canadian Government Railways, 269.
Canadian Hydrographic (Survey) Service, 54, 100, 104-9, 113, 117; Mortier Bay survey, 115.
Canadian Institute of Surveying, 177-8, 264, 320.
Canadian Kodak Co. (award), 177.
Canadian National (Railway) Co., 269, 270, 277, 281, 291; Maj. Charles and, 276; Donald Gordon of, 284; Resources Div., 315.

Canadian Northern (Railway), 267-9.
Canadian Pacific Railway, 73, 267-9, 276, 284, 309; mountain surveys, 270; Alberta oil and, 308.
Canadian Society of Forest Engineers, 292.
The Canadian Surveyor, 4, 184, 294, 318, 324; Donnelly in, 304.
Canadian Vickers Ltd., 12.
Cannon, J. B., 218.
Canol Project, 91, 93, 316; Highway, 94.
Canso, N.S., 220.
Cap Rouge, 134.
Cape Breton Island, 110, 121, 231; geodetic surveys on, 122.
Cape Chidley ("Chudleigh"), 201-3.
Cape Race, 225.
Carcajou River, 93.
Cariboo area, 252.
carpenter's square, 16, 20.
Carroll, John, D.L.S., 6, 10, 35, 37; air surveys, 176.
Carroll Lake, 38.
Cartier CHS (ship), 100, 107, 109-10, 112; echo-sounding, 108; gyro compass, 113.
Cartier, Jacques, 65.
Cartwright, Hon. Richard, 186.
Cascades, Que., 69.
Casgrain, Hon. J. P. B., 72-3.
Catalina (flying boat), 173.
Cauchon, Noulan, 180.
Cautley, R. W., A.L.S., D.L.S., 205.
Cave, Viscount, 198.
Cedars, Que., 69.
Central Canada Railway, 270.
chain(ing), 20, 24, 37-8, 319, 324; Gunter's, 23; on highways, 137; chainman, 140, 144, 280; Man., 146; on rail surveys, 284.
Chalifour, J. E., 236.
Challenger, HMS (ship), 108.
Chant, Dr. C. A., 212, 215; Dunlap Observatory, 227-31; Dunlap and, 227-8.
Chant Silver Medal, 219, 231.
Chapotot, 31.
Charland, Louis, 68.
Charles, J. L., 276.
Charlottetown, 110, 134; Sydney map sheet, 300.
Chatham, N.B., 133.
Chewett, W. C., 135, 187; Windmill Line and, 188.
Chicago, 82, 305.
Chidley, John, 202.
Chief Geographer's Branch, 120; Series, 161.
Chief Topographical Engineer, 255.
China, 81.
Chipman, K. G., 171, 242-3, 255; 8-mile mapping, 305.
chorobates, 17.
chorochromatic, 234.
choropleths, 255.
Christie Pass, 93.
chronometer, 131.
Church, Maj. J. A. H., 257-9, 260, 262; principal, 261; honored, 263-4.
Churchill, Man., 115, 268, 271-2; tests at, 269; tundra north of, 312.
Churchill Harbour, 269, 271; sea floor at, 268.
Churchill, Prime Minister Sir Winston, 113; at Placentia, 115.
Churchill River, 10, 281, 320; bridge, 283.
circumferentor, 20, 23.
Civil Code, Que., 74-5.
Clark, R. W., D.L.S., 170.
Clark, W. J., 59.
Clark City, Que., 8.
Clarkson, Ont., 144.
Clayton Lake, 39.
Cleveland, Ohio, 208, 213.
Cliff Street, Ottawa (laboratory), 2; site, 3, 215.
Clifford, Brig. F. L. T., 174.
clinometer(s), 31; Seibert, 312.
Clinton, General Sir Henry, 187.
Coast and Geodetic Survey, U.S., 57, 96-7, 120; New Brunswick and, 119.
Cobalt, Ont., 128.
Cochrane, Ont., 280-1.
Cochrane River, 320.
Cole, Humphrey, 20.
Collingwood, Ont., 109.
Collins, John, 23, 185, 187.
Collins, Dr. W. H., 243-8, 251; retirement, 250; at Blind River, 254.
Columbia River, 151.
Columbus, Christopher, 17, 65, 223.
Commissioners of Longitude, 22.
Commons, House of (Can.), 51.
comparator, 2, 4.
compass, 123, 131, 137, 143, 149, 332; course, 172; gyro, 108; magnetic, 17, 23, 29; origins, 223; in N.S., 261-2; in Ontario, 288; prismatic, 326; solar, 23.
computers, 284.

Comtois, Hon. Paul, 236.
Conception Bay, 133.
Consolidated Mining and Smelting Co., 324.
Cook, Capt. James, 99; at Nootka, 224.
Cooke, H. L., Prof., 11.
Cooke, T., and Sons Limited, 27.
Cooke transit, 27, 28.
Cooke, Troughton and Simms, 27.
Cooper, Brian, 328.
Coppermine River, area, 317; upper, 321.
copperplate engraving, 48-9, 50-9.
Coral Harbour, 115.
Corning, N.Y., 228.
Cornwall, Ont., 101; Massena earthquake, 223.
Cornwall-Massena earthquake (1944), 223.
Cory, W. W., 222, 298.
Côté, Dr. Georges E., Q.L.S., D.L.S., 198, 209-10.
Côté, J. L., A.L.S., D.L.S., 319.
Côté St. Antoine, 66.
Côté Saint-Luc, 69.
Coteau du Lac, 69.
Crabtree press, 165, 169.
Craig, J. D., D.L.S., 183, 323.
Cree Indians, 87; language, 317; canoemen, 320.
Crossley, R., 82.
cross-staff, 20, 131.
Crown Lands Dept. (Ont.), 288.
Crown Lands Dept. (Que.), 206.
Cumberland House, 320.
Cunningham, Thomas, 54.
Cunningham, W. A., 53-4, 59, 60.
Cunningham, W. C., 50, 57.
Curling, Nfld., 290.
Curtiss (H.S. 2L flying boats), 272, 291.
Curtiss (JN4 plane), 290.
Curtiss *Seagull*, 11.

Daigle, R. B., 205, 207.
Dalhousie University, 334.
Dalton, G. F., 121.
Danforth, Asa, 135.
Danforth Road, 142.
Dart, J., 279.
Dartmouth, N.S., 170, 333.
Daughtry, G. S., 254.
David Dunlap Observatory, 219, 228-30; Chant and, 227.
Davidson, R. D., D.L.S., 6, 10, 37-8, 177; pioneering, 159; biography, 176.
Davidson, W. S., O.L.S., 287.
Davis, John, 18.
Davis quadrant, 18.
Davis, Theodore, 71.
Dawson City (Dawson), 80.
Dawson Creek, 79, 81-7, 90, 96.
Dawson, Dr. W. Bell, 105-6.
Dayton, Ohio, 176.
de Casson, Dollier, 66-7.
de Champlain, Samuel, 18, 133, 207; magnetic survey by, 224.
de Cosa, Juan (chart), 47.
de Couagne, René, 68.
de Fancamp, M., 67.
Delft, Holland, 263.
Delury, R. E., 218.
de Maisonneuve, P. de C., 66, 67.
DeMorest, R. W., O.L.S., 287.
Denning, R. S., 205.
Dennis, J. S., P.L.S., 329.
Dennis, W. M., D.L.S., 30, 121; Rannie and, 124.
Department of
  Justice, 203.
  Labour, 260.
  Marine and Fisheries, 101, 272; loan of planes, 289.
  Militia and Defence, 120, 158; maps by, 160.
  Mines, 8, 244, 246; Lynch with, 250, 314.
  Mines and Resources, 54, 101, 175, 218, 255, 304, 305; creation of, 251; air charts and, 300.
  Mines and Tech. Surveys, 60, 200, 236, 256; Lynn Lake and, 281.
  National Defence, 94, 115, 158, 174, 259, 298; Burns in, 160; cartography in, 236; maps by, 242; for Air, 305.
  National Revenue, 98; Preventive Service, 107.
  Naval Service, 54, 101, 120, 269.
  Public Printing and Stationery, 51, 247.
  Railways and Canals, 268, 270.
  Transport, 83, 85, 101, 304, 328; air charting and, 300.
  Veteran Affairs, 163, 260.
Deptford, (London), Eng., 224.
Detroit (River), 51.
de Verneuil, J.-J. O., 67.
Deville, E. G. D., D.L.S., D.T.S., 1-5, 11-5, 27, 35, 322, 329; and National Defence, 158; town planning and, 182-4.

de Villeneuve, Robert, 66.
Dezery, Amable, 68.
Dickens, C. H. "Punch", 81.
Dickison, Alexander, 248-9, 256.
Digges, Leonard, 20.
dioptra, 16, 17.
dip circle, 225.
Director of Surveys, Hdqts., Can. Army, 165.
dividing (graduating) engine, 22, 23.
Dodds, Maj. R., 300.
Dodge, G. Blanchard, 3.
Dolland, John, 20.
Dolland, Peter, 20.
Dominion Astronomer, 218, 220-1; assistant, 223.
Dominion Astrophysical Observatory, 211, 214; construction of, 219-20; Blanchet at, 221.
Dominion Atlantic Railway, 257.
Dominion Forest Service, 292, 296; Branch, 294-5.
Dominion Geodesist, 129; Assistant, 128; Ross, 131.
Dominion Hydrographer, 110.
Dominion Lands Survey System, 33, 315.
Dominion Observatory (Ottawa), 2, 211, 213, 217-8, 222; time service, 215-6; Beals at, 221; seismology and, 223; magnetic surveys, 225; gravity, 226-7; Arctic surveys, 253.
Dominion Standard Yard, 3.
Don Mills, Ont., 196; views of, 190-1.
Don River, 188; valley, 139; mouth, 192; Parkway, 196.
Donnelly, C. B. C., D.L.S., 176, 294, 301.
Doolittle, Dr. P. E., 149.
Dorchester, Lord, 184-5.
Dore, Richard, 37.
Dorion, Henri, 204, 208.
Dorval, Que., 69.
dots, 235.
dotter, 54.
Dowling, D. B., 243.
Draughting and Reproducing Div., 252.
Dubawnt River, 322.
Dublin Tp., Ont., 185.
Duck Mountain Forest Reserve, 294.
Dufresne, Marius, 73.
Duluth, 67.
dumpy level, 31.
Dundas Street, 142.
Dunlap, David A., 227; Chant and, 228; Observatory, 229; Park, 230.
Durrell, Wm., 174.

Eastern Townships, Que., 68.
Eaton Corner, Que., 36.
Eaton, D. I. V., 206-7.
Echoing River, 43-4.
echo sounder (s), Acadia-Challenger model, 108.
Edinburgh, 180, 248, 254.
Edmonton, 79, 81-5, 91, 94, 170, 257, 281, 314; survey net, 97; observatory at, 230; rail survey to, 309; Pearson and, 319.
Edmonton, Dunvegan, and B.C. Railway, 270.
Edmonton Journal, 320.
Edmonton sheet (map), 12.
Edwards, W. S., 203.
Egypt, 17, 47.
89th meridian, 33, 42.
Elbow River, 12.
Eldorado, 304.
Eldorado Crown Company, 254.
Eldorado Gold Mining Co., 254.
Ellesmere (Island), 11, 225, 323.
Elliot Lake, 41.
Elmira, Ont., 131.
Engineering Institute of Canada, 181, 223, 256.
Engler, Bruno, 152.
Engler, Carl, D.L.S., 183.
English foot, 77.
English River, 288, 291, 295; sheet, 299.
engraving, 48, 52, 54; negative, 58.
Eratosthenes, 132.
Esquimalt, 109, 221.
Experimental Farm Service, Ottawa, 237.

Fairbanks, 79, 80-6, 90-6.
Fairchild Aerial Surveys Co. (Canada) Ltd., 11.
Fairchild FC2W plane, 274.
Fairchild K3 camera, 11, 296.
Fairchild (seaplane), 203, 279.
Faribault, E. R., 243.
Farley, A. L., 238.
Fawcett, S. D., D.L.S., 128.
Fegan, Capt. Fogarty, R.N., 113-4.
Fennow, Dr. B. F., 288.
Field, R. H., 4, 162.
Field, Ted, 82.

Fifth Initial Meridian, 313.
Finland, 235.
1st Corps Field Survey Co., 163-5. Renamed 1st Field Survey Co., R.C.E.
1st Map Photo Section, 168.
1st Survey Regiment, R.C.A., 164.
Fitzgerald, J. W., O.L.S., D.L.S., 36.
Fleming, Sandford, 73; time zones, 215.
Flewin, Capt. W. R., 157.
Flin Flon, Man., 320.
Florida, 79.
flow maps, 234.
Flying Fortresses, 174.
Foden diesel truck, 165-6.
Fokker Universal (aircraft), 82.
Fond du Lac, 320.
Forbes, Alexander, 203.
Ford, A. D., 193.
Ford, E. K., 260.
Fort Assiniboine, Alta., 319.
Fort Coulonge, Que., 207.
Fort Garry, Man., 146.
Fort Macleod, Alta., 308-9, 319.
Fort Nelson, B.C., 83-7, 90-1, 143.
Fort Norman, N.W.T., 91, 93, 128; survey to, 314.
Fort Prince of Wales, 271.
Fort Reliance, 317.
Fort Rouille, 188.
Fort St. John, 82-9, 90, 143.
Fort Saskatchewan, Alta., refinery at, 284.
Fort Smith, N.W.T., 82.
Fort Wrigley, 128.
Fortier, Y. O., 253.
Foster, James, (Toronto), 30.
4th Field (Air) Survey Co., 164-5.
Fourth Initial Meridian, 313.
Franklin Expedition, 304.
Franklin, Sir John, 224.
Fraser (boat), 114.
Fraser, D. J., 121.
Fraser, R. J., 104-5.
Fraser River, 135; delta, 7; valley, 8; watershed, 122.
Fredericton, N.B., 133, 331.
Fredericton-Moncton sheet (1935), 300.
French, C. A., 213-14, 225.
French Fort, 188.
French, Lafayette, 307.
French (Paris) foot, 77-8.
French River, 65.
Frey, Philip, 185.
Frisius, Gemma, 19.
Frobisher Bay, 115-6.
Fry, Eric S., D.L.S., 6, 10, 171-6; in Labrador, 111; biography, 170.
Fundy, Bay of, 105, 133.

Galbraith, Prof., 148.
Gale, L. A., D.T.S., 124.
Galileo, G., 226.
Gamble, Maj. S. G., 164-5; and Church, 263.
Gambo sheet (map), 61.
Gander, Nfld., 170; airfield, 170, 173.
Gardiner Expressway, 141, 196.
Gardner, Gérard, 204.
Garner Lake, 38.
Gascoign, 31.
Gaspé, 23, 73.
Gauer, Edward, M.L.S., D.L.S., 43-5; Fred Lamb with, 316.
Gellibrand, Henry, 224.
Geodetic Survey (of Canada), 2, 7, 38, 40, 119-20, 124, 131, 203, 212, 218, 226, 301, 325; Branch, 8; Rannie of, 28; Alaska Highway, 96-7; town planning and, 125-6, 183; triangulation, 127; Ney and, 128; Ross and, 129; earthquakes and, 222.
Geodimeter, 132.
Geographia (Ptolemy), 48.
Geographical Board of Canada, 248-9.
Geographical Branch (federal), 236.
Geographical and Draughting Div., 242, 247-8.
Geographical Section, 164, 169, 170, 236, 304; General Staff, 158-9; mapping by, 160-2; Burns with, 163; Davidson joins, 177; 8-mile maps and, 299, 300.
Geological Map of Canada, 249.
Geology and Mines Act (federal), 241.
Geological Society (Eng.), 252.
Geological Society (U.S.), 252.
Geological Survey (of Canada), 54, 92-3, 218, 243-5, 252-5, 287, 308; geodetic surveys and, 120; Low and, 206; Labrador and, 207; mandate of, 241; Department of, 241; maps by, 242; displays of, 246; engravers with, 247-50; Collins and, 251; of Canada, 256; air surveys and, 296.
geometrical square, 20.
geophysics, 226.
Georgian Bay, 65, 187.
Georgia Strait, 107, 267.

Gibbs, Alexander, 71, 309.
Gibling, G. M., 96.
Gilbert, W., 224.
Gill, J. E., 205-6.
Glacier National Park, 151.
Goad, C. E., 71.
Godfrey, Air Vice-Marshal A. E., 173.
Godsell, Philip H., 83.
Golden, B.C., 151.
Gold Lake, 37.
Goose Bay, Labrador, 111, 170; Fry at, 172-4; first use of, 174; area, 199.
Gordon, Donald, 284.
Gordon, Deputy Minister, H. F., 305.
Government Printing Bureau (Ottawa), 50-4; engravers join, 247.
Governor Simcoe, *see* Simcoe.
Governor's Road, The, 142.
Graham, Dr. M. M., 290.
Graham, Capt. S., 289.
Grand Allée, 134.
Grand'Mère, 11, 289.
Grande Prairie, 85.
Grand Trunk Pacific Railway, 171, 189, 267; merged in C.N.R., 269.
grand voyers, 134.
Grant, Al, N.S.L.S., 264.
Grant, A. M., 121, 125.
Granville (ship), 290.
Gravel River, 92-3.
Graves, Capt. Thomas, 199.
gravimeter, airborne, 132; stations, 227.
Gravity Map (of Canada) (1956), 227.
gravity survey, 226-7.
Gray, G. R., 287.
Gray, N. G., 110, 115.
Great Bear Lake, 254, 312.
Great Highways (Man.), 146.
Great Lakes, 100, 185; survey, 101; iron ore and, 209.
Great Slave Lake, 107, 162, 312, 317-8; survey from, 314; Pearson and, 319, 321.
Greene, H. V., Aerial Survey Co., 289.
Greenland, 115, 170, 197, 324; air ferry over, 174.
Greenwich Observatory, 215.
Greenwich (time), 41, 83, 215.
Grenier, Jean-Baptiste, 68.
Groves, John, 172.
Guelph, Ont., University of, 237.
Guérin, Thomas, 73.
Guillaume, C. E., 2, 25.
Gunter, Edmund, 20, 24.
Gurley, W. and L. E., Company (U.S.), 16, 30.
Guthrie, Hon. Hugh, 158.
Guy, Eugene, 71.
Guy, Pierre, 71.
Gzowski Medal, 223.

Hadley's (quadrant), 18; (sextant), 23.
Hale, A. E., 254.
Haliburton, Hon. E. D., 264.
Haliburton, Ont., 36.
Halifax, 7, 100, 110, 113, 121, 125, 149, 173, 224, 259-60, 332-3; triangulation to, 119; road to Windsor, 133; seismological station at, 223.
Halifax and Cape Breton Railway, 71.
Hall, James Barclay, 258, 264; Hall bequest, 261.
Hamilton, A. C., D.L.S., 130.
Hamilton, Ont., 136.
Hamilton Inlet, 100, 111.
Hamilton (Churchill) River, 172, 208; airport site, 173; watershed, 291; region, 295.
Hampstead, Que., 69.
Hanna, M. A., Co., 207.
Hanson, F. H., 332.
Hanson, Dr. George, 245, 253, 305.
Hanson, Ralph, 111.
Hardy, Prof. W. G., 332.
Hare, F. K., 204.
Harper, Dr. W. E., 211, 213, 219; death of, 218; at Dunlop Observatory, 228.
Harrison, Dr. J. M., 253.
Harvard University, 230.
Hatfield, Peter, 289.
Hawkins, A. H., D.L.S., 183, 313.
Hay, Richard, 71.
Hazelton, B.C., 277.
Hearn and Harrison, (Can.), 30.
Hecate Strait, 101.
Heerbrugg, 28, 124.
helicopter(s), 96-7, 278; lighthouse, 103; Spence and, 325-6.
Henderson, J. P., 218.
Henry Hudson (launch), 109.
Henry, T. J. G., 328.
Herbert, W. H., 3.
Herriot, G. H., D.L.S., 322.
Higbee, Lester C., 16.
High River, Alta., 12.

Highways, Ontario Department of, 137, 142, 144; map by, 138.
Highwood River, 307.
Hillsborough, Lord, 134.
histograms, 234.
Hjort, Dr. Johan, 100.
Hobbs, S/L Basil, D.S.O., 159, 176.
Hochelaga, 65-6.
Hodgson, E. A., 221-3.
Hodgson, Dr. J. H., 223.
Hogg, Dr. H. S., 230.
Holland, Samuel, 187, 231.
Hollinger Consolidated Gold Mines Ltd., 208; Dunlap and, 227.
Hollinger Lake, 279.
holometer, 19.
horizontal bars, 233.
Hornby, John, 317.
Howlett, Dr. L. E., 162.
Hubbard, C. J., 203.
Hudson aircraft, 327.
Hudson Bay, 33-6, 41-6, 197, 268, 270, 317, 320; railway, 106; Madill and, 214, 221; rail line to, 267; tides on, 271.
Hudson Bay Junction, 268.
Hudson Bay Railway, 106, 269, 270-2, 283; air surveys along, 274-5.
Hudson's Bay Company, 271; territory of, 202.
Hudson Strait, 108-9, 199; ice hazard in, 271.
Hueston, George, 96.
Humber River, 185-6, 196.
Hume Cronyn Observatory, 230.
Hume, Dr. G. S., 246, 256.
Humphrys, G., 206.
Hunter, A. F., 218.
Hurtubise, Pierre, 66.
Hydrographic and Map Service, 110, 255, 297, 305; in Labrador, 279.
Hydrographic Survey (of Canada), 100, 104, 113, 115; Branch, 105; *Service*, 110; geodetic surveys and, 120, 247.
hypsometer(s), 31.

ICAO (PICAO), 305.
Iceland, 115, 170.
Ile d'Orleans, 135.
Imperial Oil Co. (Canada), 91, 94, 245, 310; plotter cost, 163.
Innes, Dr. M. J. S., 227.
Inside Passage, 101.
Institute Journal (Town Planning), 182.
Interior, Department of, 8, 11, 13, 36, 54, 59, 120, 175-6, 203, 214, 222, 224, 248, 250, 255, 274, 287, 298; end of, 101, 251; Geodetic Survey and, 125; Fry and, 171; map of Labrador, 199; Dom. Observatory and, 218; Chief Geographers of, 236; maps by, 242; Churchill townsite and, 268; Mackenzie River survey, 314-5, 320.
International Air Navigation Convention, 298.
International Boundary Commission, 120; Commissioner Rannie, 124; Ross, 131.
International Hydrographic Bureau, 118.
International Joint Commission, 7, 8.
Invar tape, 25, 37; base lines and, 131.
Iron Ore Co. of Canada, 207, 278.
Iroquois, 65.
Irwin, Henry, 73.
isarithm, 235.
Island Lake, 33-4, 39, 41-4; surveys, 122.
isopleth maps, 237.
isostasy, 226-7.
Italy, 47, 163; Italian, 48.
Itsi Mountain, 94.

Jackson, J. E., O.L.S., D.L.S., 151.
Jacob's staff, 288.
James Bay, 106, 280.
James, W. F., 205.
Japan, 84.
Jasper, Alta., 8.
Jasper National Park, 312.
Jena, 162.
Jenkins, F. T., 292, 295.
Jenkins, Col. J. H., 163.
Jervis Bay (merchant ship), 113, 114.
Jewett, W. G., 324.
Joanes, A., 254.
Johnsons Crossing, Yukon, 93.
Johnston, John, 202.
Johnston, John, (U.S.) 20.
Johnston, R. N., 90, 142.
Johnston, W. and A. K., (Edinburgh), 202.
Jolliet, Louis, 67.
Jones, Adolphus, 185-6; York streets survey, 188.
Jones, H. W., 105.
Journal of the Royal Astronomical Society of Canada, 221, 223, 230.

Jowitt, S., 328.
Juan de Fuca Strait, 107.
Judicial Committee, Privy Council, 198-99, 201-05, 210.

Kamloops, B.C., 171; Vicars dies at, 176.
Kamsack, Sask., 316.
Keefer, Maj. T. C., 164.
Keele, Joseph, 92-4.
Kenogami River, 288.
Kentville, N.S., 264.
Kern, 30.
Kettle Rapids, 270.
Keuffel and Esser, (U.S.), 30.
Kihl, T. H., 97.
Killinek Island, 202-3.
Kindle, E. M., 245.
King, Dr. W. F., D.L.S., D.T.S., 2, 131, 212-3; director, 211; Mrs. Motherwell and, 219.
King's Highway, 141.
Kingston, 23, 101; Burns in, 160, 186.
Kingston Road, 142, 196.
King William Island, 324.
Kirk, Thomas, 73.
Kirkpatrick, G. B., O.L.S., D.L.S., 287.
Kitchener, Ont., 131, 182, 184.
Klemmer, Lieut. E. F., 168.
Klondike, 312.
Klotz, Dr. O. J., D.L.S., D.T.S., 212, 219, 222; director, 213; death, 214; and seismology, 221.
Kluane Lake, 79, 83, 90; Range, 80.
Knight, Comm. J. H., 101.
Knob Lake, 205-9; railway to, 278, 280; Spence at, 325.
Koidern River, Yukon, 80.
Kupsch, W. O., 239.

Labelle Building, (Ottawa), 54, 55, 56, 255.
LaBine, Gilbert, 254.
Labrador (coast), 95, 117, 121, 197, 198, 201-10, 280, 289, 295, 325, 328; air base, 110; Goose Bay, 170; Fry in, 172; administration of, 199; boundary award, 204; forest surveys in, 290.
Labrador Mining and Exploration Co., 207.
Labrador Trough, 207, 280.
Lac à la Tortue, Que., 289.
La Canadienne, 100.
Lac Brochet, 176.
Lachine, Que., 69.
Lachine Canal, 69.
Lac Ile-à-la-Crosse, 176.
Lac la Biche, Alta., 315.
Lac la Ronge, 321.
Lake Athabasca, 254, 320.
Lake Huron, 65, 187.
Lake Huron sheet, (1933), 248.
Lake Melville, 111, 172.
Lake Nipissing, 36.
Lake of the Woods, 146, 307.
Lake Ontario, 135, 142, 185; harbors of, 186.
Lake St. John, 248.
Lake St. Joseph, Ont., 291.
Lake St. Peter, 107.
Lake Simcoe, 186.
Lake Superior, 65, 73, 150, 248, 288; triangulation and, 125; Patrick north of, 307, 320.
Lake Winnipeg, 8, 33, 37, 41, 53, 268, 292; highway along, 146.
Lady Job Harbour, 203.
Lamarque, E. C. W., 83.
Lamb, F. C., S.L.S., D.L.S., 315-6.
Lamb, J. A., S.L.S., A.L.S., 316.
Lambart, H. F. J., D.L.S., 121.
Lambert Conformal Conical (Projection), 249.
Lancaster bomber, 274.
Land, H. L., D.L.S., 105.
La Salle, Que., 69.
La Salle, Sieur de, 69.
La Tuque, Que., 122.
Laurentide Air Services, 291.
Laurentides National Park, Que., 237.
Laurier, Sir Wilfrid, 51.
Laval University, 209, 265.
La Vérendrye, 67.
Lawrencetown, 257-8, 261-5; move to, 260.
Lawson, Maj. W. E., 244.
Lawson, W. L., 82.
Leadman, H. L., 107, 110, 115.
Leclair, J.-Hermyle, 73.
Le Devoir (Montreal), 204.
Leduc, Clovis, 73.
Leduc, Jean, 66.
Leduc No. 1 (Oil well), 306, 310.
Lefroy, Lieut. J. H., 224.
Legal Surveys and Map Service, 300, 301, 304.
leMay, T. D., O.L.S., 193.
LeMoyne, Charles, 67.

Lenoix, François-Enouville, 68.
Lerouge, Jean, 66.
LeRoy, O. E., 243-4.
level (spirit), 23, 137, 145.
level(ling), 16, 26, 280; dumpy, 31; wye, 31; on Alaska Highway, 97; on rail surveys, 284.
Lévis, Que., 222.
Lewis and Clark, 20.
Leyland Retriever truck, 165, 168.
Liberator plane, 111.
Lillooet, CHS (ship), 100-1, 109, 114.
Lilly, J. E., D.L.S., D.T.S., 124.
Lindbergh, Col. Charles, 82, 234.
Lindsay, Col. C. C., Q.L.S., 71, 334.
Lindsay, R. J., 71.
Lineham, John, 308-9.
lithography, 49, 51; stones, 50; press, 57.
Little Grand Rapids, 38.
Little Saanich Mountain, B.C., 219.
Liverpool, N.S., 333.
Livingston, D. A., 279.
Loates and Assoc., Ottawa, 279.
Lockheed Lightning aircraft, 174.
lodestone, 223-4.
Logan, R. A., D.L.S., 11, 322-4, 334.
Logan, (Sir) William, 241, 247, 252.
London, Eng., 20, 27, 30-1, 203, 213, 270; and Placentia, 115; Arrowsmith of, 202; Labrador, 204; Bridge, 224.
London, Ont., 125, 230.
London University, 220.
Long Lake, Ont., 288.
Longueuil, 67, 70, 73.
Longwoods Road, 142.
Lord, Dr. C. S., 254.
Louisbourg, 110.
Louisiana, 67.
Low, A. P., 206-7.
Lower Canada, 68, 199, 202.
Lower Canada College, 160.
Lower Post, B.C., 83, 97.
lozenge, 54.
Lyford, Clark and Lyford, 288.
Lynch, F. C. C., 250-51, 256.
Lynn Lake, Man., 281-4.
Lyon, Lieut.-Col. J. E., 163.

MacAlpine, Col. C. D. H., 317-8.
MacAlpine expedition, 318.
Macdonald, C. S., D.L.S., 320-1.
MacDonald, Donald, 80.
MacDonald, Maj. W. K., 164-5.
Mack, A. L., 111.
MacKenzie, J. D., 244.
MacKenzie, J. R. (Halifax), 332.
MacKenzie, J. R. (Springhill), 332.
Mackenzie King, Rt. Hon. W. L., 228.
Mackenzie River, 91, 128, 315, 317; Valley, 93; Range, 91; magnetic surveys along, 225; gravity surveys, 226; Basin, 245; farmlands along, 312.
MacMillan, David, 97, 121.
Macmillan, Rt. Hon. H. P., 201.
Macnabb, T. C., 276.
Macoun, Dr. J., 213.
MacQuisten, City Surveyor (Montreal), 73.
Madill, R. G., 213-4, 225.
Magdalen Islands, 110.
Magnesia, Asia Minor, 223.
magnetic declination, 224-5.
Magnetic Observatory (Toronto), 225.
magnetic survey, 224.
magnetometer, 225.
Magpie River, 280.
Manitoba, 8, 9, 33-9, 40-5, 82, 128, 218, 251, 269, 272, 284, 291, 316, 320; Ontario boundary, 122; shoran in, 129; highways in, 146-7; magnetic surveys in, 225-6; Alcock in, 245; railways in, 267; air photography in, 274; forest surveys in, 292, 294; Pearson and, 319.
Manitoba, Dept. of Industry and Commerce, 238.
Manitoba Economic Atlas, 238.
Manitoba Paper Co., 292.
Manitoba, University of, 217.
Manitou Rapids, 268; Falls, 295.
Mann, Capt. Gother, R.E., 185.
Map Compilation and Reproduction Division, 60, 64.
Map Engraving Division (Geological Survey of Canada), 247-8.
map nomenclature, 49.
March, J. E. R., N.S.L.S., 264, 333, 334.
March, S. E., P.L.S. (N.S.), 334.
Marquette, Jacques, 67.
Marquis wheat, 14.
Mason and Dixon (Line), 20.
Matador truck, 165.
Matheson, Hugh, D.L.S., 322.
Mathieu, N.-C., 73.
Matthews, Col. H. H., 161.
Mayo area, Yukon, 252.

McAree, John, D.L.S., D.T.S., 189, 287.
McAree, J. V., 188.
McArthur, J. J., D.L.S., 14.
McClenahan, W. S., 216-7.
McColl, S. E., M.L.S., D.L.S., 43.
McConachie, Grant, 82.
McConnell, B. D., 73.
McCusker, K. F., D.L.S., 83, 86-7, 94, 97.
McDame Creek, 83, 253.
McDiarmid, F. A., 121.
McFarlane, J. B., D.L.S., 312-3.
McGill University, 69, 217, 316.
McGillivray, A., 146.
McGrath, W. N., 122.
McInnes, William, 243-6.
McKay, R. B., D.L.S., 162, 177, 255-6.
McLaughlin, R. S., 136.
McLean, A. D., 81-2; mapping, 161.
N.B. McLean (icebreaker), 108, 111, 115, 272; in Labrador, 173.
McLean, Robert, 23.
McLean, S. C., 249.
McLean, W. A., 148-9.
McLelan Strait, 203.
McLeod, Clement H., 73.
McMillan, Stan, 82.
McMurray, Alta., 171, 314.
McNamara Construction Co., 174.
McNaughton, General A. G. L., 156-60; staff of, 254.
McQuesten area, Yukon, 252.
Meach Lake, Que., 162.
Meanook, Alta., observatory at, 225.
Megantic sheet (1933), 300.
Megiscane River, Que., 209.
Melfort, Sask., 268.
Melville, Sask., 171.
Menzies, J. W., D.L.S., 122.
Meppen, Germany, 168.
meridian(s), 18, 140, 332; line, 23, 44; section, 37; intersection, 42.
meridian circle telescope, 216; and time division, 217-8.
Meridian, Fifth Initial, 313.
Meridian, Sixth Initial, 315.
Meridian, Principal, 322.
Meridian Work and Time Service, 212.
Metivier, J. P. E. A., 59, 60.
Meuser, Maj. H. L., 164; Colonel, 165.
Michaud, J.-Louis, 73.
Michelin, Dan, 172.
Michelin, Robert, 172.
Michipicoten, Ont., 142, 245.
micrometer, 288.
microscope, 28.
Middle Musquodoboit, N.S., 322.
Middleton, N.S., 261.
Militia and Defence, Minister of, Department of, 54.
Millard, R. E., N.S.L.S., 333, 334.
Miller, A. H., 226-7.
Miller, O. M., 203.
Miller, W. H., 59, 226, 331.
Millman, Dr. P. M., 218.
Mills, W. D., 264.
Milner, Sgt. A., 159.
Milne-Shaw seismograph, 222-3.
Minaker, Glen, 83.
Minas Basin, 121.
Mineral Creek, B.C., 242.
Mines and Geology Branch, 251.
Mines, Forests and Scientific Services Branch, 255.
Minnedosa, Man., 319.
Minto Lake, Yukon, 252.
Mississippi River, 67.
Mitchell aircraft, 274.
mitoyen-wall, 78.
Moisie River, 207, 279, 280.
Monaco, 118.
Monkman Pass, 276.
Montreal, 30, 65-9, 70-2, 76, 78, 125, 163, 224, 230; district, 73; gauges below, 101; road from Quebec, 135; earthquakes and, 222.
Montreal-Est, 69.
Montreal-Nord, 69.
Montreal-Sud, 70.
Moodie, John, 136.
Moose Mountain Reserve, 8.
Moosonee, 280-1.
Morning Chronicle, Halifax, 289-90.
Mortier Bay, 115.
Mortimer Company (Ottawa), 51-4.
Motherwell, R. M., 218-9.
Moulton, H. P., 121-2.
Mount Abbott (Observatory), 152.
Mountain River (Valley), 93.
Mount Kobau, B.C., 232.
Mount Royal, 65, 68-9; cemetery, 71.
Mullarkey, J., 73.
multiplex projector, 144.
Munk, Jens, 271.
Murdie, W. C., D.L.S., 121.

Murphy, Hon. C., 50.
Murray, Alexander, 247.
Musgrave, Capt. P. C., 101.
Muskoka, district, 36.
Muskwa River, 83.

Naden (schooner), 100.
Nanaimo, B.C., 244.
Narraway, A. M., D.L.S., 9, 10, 12, 300, 317; air surveys, 160-1.
Narrow Beam Recording Radar Altimeter, 327.
National Air Photo Library, 12-14, 275; title change, 251.
National Development Board, 250, 315.
National Museum of Canada, 251; building, 255.
National Research Council (Canada), 4, 129, 218, 255, 327; air surveys for, 160; plotter, 162; Miller and, 227.
National Topographic System (N.T.S.), 161, 297-8.
National Transcontinental Railway, 8, 320.
Natural Resources Intelligence Service, 13, 236.
negative engraving, 58.
Nelles, D. H., D.L.S., town planning and, 182-4.
Nelson River, 42, 268, 271; estuary, 269; Logan at, 322.
Netagamu River, 100, 109.
Netherlands, 50.
Newark, (U.C.), 186.
New Brunswick, 110, 115, 133, 243; maps by, 238.
New Brunswick Dept. of Lands and Mines, 238.
New Brunswick, University of, 266.
Newcastle, Ont., 176.
Newfoundland, 61, 100, 114, 170-4, 200-10, 255, 290; in Confederation, 117; streets laid out, 133; boundary with Quebec, 197-8; and N.W.T., 311.
Newfoundland Act, 199.
New Glasgow, 12.
Newhouse, R. C., 327.
New Quebec Company Ltd., 204.
Newton, Maj. Gen., 73.
New Westminster, B.C., 125.
New York City, 101, 203, 297; Bell Telephone in, 327.
Ney, C. H., M.B.E., D.L.S., O.L.S., 36, 39, 40-3, 316-7; polar navigation and, 125; biography, 128.
Niagara-on-the-Lake, 186.
Niagara (Peninsula), 23, 142.
Nicholson, Dr. N. L., 236.
Nicholson, Maj. R. A. V., 163.
Nile (River) Valley, 16, 47.
19th Alberta Dragoons, 257.
Nipisso River, 280.
Niven, Alexander, O.L.S., D.L.S., 36, 188, 287.
Nootka, B.C., 224.
Norman, G. W. H., 255.
Norman Wells, 91-4.
Norrish, W. H., D.L.S., 40, 128, 314; town planning and, 183.
North Devon (Island), 11, 323.
Northeast Staging Route, 170.
Northern Alberta Railways, 270.
Northland (seaplane), 142.
North Pacific Planning Project (1947), 236.
Northumberland Strait, 115.
North West, 186-7.
Northwest Passage, by air, 82; by sea, 90.
Northwest River, Labrador, 172-3.
Northwest Staging Route, 82-6, 91, 94.
Northwest Territories, 81-2, 93, 251, 254; highways in, 147; Act, 203; atlas of, 239; Patrick in, 307, 311, 317; R.C.A.F. caches in, 321.
Norway House, Man., 122, 268.
Nottaway sheet (Que.) (1927), 248.
Nova Scotia, 4, 12, 95, 113, 119, 120-2, 170, 220, 242, 257-9, 266, 285, 292, 322; south shore, 104; HMCS *Cornwallis*, 115; highway in, 133; gravity survey in, 227; Education Dept. of, 260-4; resources survey, 288; Logan resurvey and, 323, 333.
Nova Scotia Land Survey Institute, 257, 261-2; course, 260; building, 264.
Nova Scotia Technical College, 257, 259, 333.
No. 1 Field Survey Co., R.C.E., 169.
No. 1 Survey Section, R.C.E., 164, 168.
No. 6 (Army) Vocational Training School, 259.

Oak Bay Observatory, 230.
Observatories Branch, 221; director, 223.
Observatory Inlet, 117.

Ocean Falls, 101, 117.
O'Connell, J. R., 121.
odometer, 24, 326.
offset press, 49, 55.
Ogden Bay, N.W.T., 302, 303.
Ogdensburg Agreement, 84.
Ogilvie, Noel J., D.L.S., 119, 120.
Oil City, Alta., 308, 310.
Okotoks, Alta., 308.
141st meridian, 311; at Yukon River, 120.
Ontario, 8, 9, 12, 33-6, 42-5, 109, 122, 146, 151, 182, 189, 211, 243, 245, 286-8, 291, 312, 315; survey flights, 123; highway surveys in, 131-9; legislation, 141; historic roads, 142; photogrammetry in, 144; map production in, 237; photography in, 274; forest surveys in, 293; Fred Lamb and, 316.
Ontario Forest Atlas, 237.
Ontario Forestry Branch, 237.
Ontario Dept. of Highways, 90, 138, 142, 144, 237; map, 138.
Ontario Highways Act, 138, 237.
Ontario Hydro Commission, 333.
Ontario Lands and Forests Dept., 90, 237, 291-2.
Ontario Dept. of Mines, 237.
Ontario Northland Railway, 270, 280.
open-window negative, 61.
Ordnance Survey (U.K.), 49, 50.
Ortelius, Abraham, 48.
Ostell, John, 73.
Ostell and Perrault, 71.
Ottawa Citizen, 214.
Ottawa Journal, 213.
Ottawa-Montreal sheet (1933), 300.
Ottawa River, 215, 222, 300.
Ottawa sheet (map), 158.
Outremont, 69.
Owen, Capt. D., 95, 289-90.
Owen Sound, Ont., 211.
Owl River, 281.
Oxford University, 226.

Pacific (Ocean), 14, 83, 100-5, 108-9, 113, 151, 267, 311; area, 91; Coast, 99, 100, 119, 128; region, 106; surveys, 117; Ney and, 128; rail line to, 276.
Palliser, Gov. Hugh, 199.
Palmer (Sir) Frederick, 270.
Panama Canal, 109.
Papineau, François, 68.
Papineau, Joseph, 68.
Papove, W. N., B.C.L.S., A.L.S., D.L.S., 98.
Paris, Treaty of (1763), 198.
Parizeau, H. D., 101, 113, 115; CSS (ship), 117.
Passamoquoddy Bay, 119.
Patrick, Alfred P., C.M.G., 307.
Patrick, Allan P., A.L.S., D.L.S., D.T.S., 306-10.
Patten, Richard, 23.
Peace Pass, 276.
Peace River, Alta., 82, 225, 313; bridge over, 89; district, 252; country, 270.
Pearce, Dr. J. A., 220.
Pearce, William, D.L.S., 309.
Pearl Harbor, 86.
Pearson, H. E., D.L.S., 319, 320.
pedometer, 24.
Pelican Lake, Ont., 291.
Pelican Narrows, 176, 273, 320.
Pelly Crossing, 80.
Pelly River, 92-3.
Pembina, Man., 146; overpass, 147.
Pembina Valley Railway, 270.
Pender (houseboat), 117.
Pennoyer, Jesse, 68.
Penticton, B.C., 232.
perambulator, 23-4.
Permanent Force Survey Detachment, R.C.E., 164.
Perrault, Joseph, 68.
Perrault, H.-Maurice, 70.
Perspectives (Montreal), 204.
Perth, Ont., 218.
Petawawa, 288.
Peterborough, Ont., 35, 36, 60; Madill and, 213.
Peters, F. H., D.L.S., 3, 12, 39, 110, 161, 327, 329; Surveyor General appointment, 109; Burns and, 162; Labrador survey, 205; 8-mile mapping, 299, 300-1.
Petrie, R. M., 220.
Petrolia, Ont., 308.
Pettitot, Père, 91.
Phelan, M. F., 163.
Philadelphia, 23, 30.
photogrammetric (ist), 144, 178, 276, 278; control, 146; Davidson as, 177; in forestry, 293.
Photographic photometry, 212.
Photo-Mechanical Section, 60.
PICAO, 305.

Picard, 31.
pie graphs, 233.
Pierce, John G., O.L.S., 36, 44-6.
Pierce, J. W., O.L.S., M.L.S., D.L.S., 35-9, 41-2, 183; in Athabasca, 171.
Piers, O.T.P., 333.
Pincher Creek, Alta., 308.
Pine Falls, 292.
Pine Point, N.W.T., 319.
Placentia Bay, 115.
Place Royale, 66.
plain table (plane table), 19, 20, 23; on air surveys, 123.
Plaskett, H. H., 219, 220.
Plaskett, Dr. J. S., 219, 220; Stewart and, 231.
plumb bob, 16, 17, 31.
Pointe-aux-Trembles, Que., 69.
Pointe du Bois, Man., 37.
Pointe Platon, 73.
Point Grey (Vancouver), 184.
Point Lake, N.W.T., 321.
Port Alberni, B.C., 117.
Port Burwell, 203.
Port Nelson, 42, 268-9, 271, 274-5; rail survey to, 274-5.
Portugal Cove, 133.
Positional Astronomy Division, 217.
Post Office Department, 82, 247, 298.
Pounder, J. A., D.L.S., 121.
Precise Water Levels Division, 107.
Preliminary Dominion Land Surveyors' School, 168.
Pressure Height Corrector, 328.
Prince Albert Sound, 324.
Prince Edward Island, 115, 121; roadbuilding, 134; atlas of, 239, 260.
Prince George, 80, 81, 276.
Prince Rupert, B.C., 101, 117; Ogilvie and, 119; line to, 277.
Prince's River, 103.
Princeton University, 11.
Prince Town, 134.
Principal Meridian, 322.
Privy Council, Judicial Committee of, 198-9, 201-10.
proportional cubes, circles, spheres, 234.
protractor, 123.
Proudfoot, H. B., O.L.S., D.L.S., 287.
Public Printing and Stationery, Dept. of, 51.
Public Roads Administration (U.S.), 142.
Public Works, Department of, 151.
quadrant, 23.
Quatsino Sound, 101.
Quebec Boundaries Extension Act, 203.
Quebec Bureau of Mines, 207.
Quebec City, 11, 68, 73, 113, 134, 185, 231, 265, 289; tidal action at, 107; Geodetic Survey and, 125; road to, 135; magnetic survey at, 224; Logan leaves, 323.
Quebec City Observatory, 230.
Quebec Dept. of Municipal Affairs, 237.
Quebec Inventory, Natural Resources, 237.
Quebec Land Surveyors, Corp. of, 73.
Quebec Meteorological Bureau, 237.
Quebec North Shore and Labrador Railway, 207, 278, 280.
Quebec, Province of, 1, 11, 36, 73, 75, 122, 142, 182, 184, 200-10, 216-7, 223, 272, 291, 325, 328; law, 78; aircraft in, 123; Labrador boundary, 197-8; Quebec Act, 199; iron ore, 205, 207; maps, 210; western, 227; geological map, 252; forest surveys in, 292; government of, 296.
Quebec Streams Commission, 237.
Queen Elizabeth Way, 142, 144, 196.
Queen's Rangers, 186.
Queen's University, 213.
Quinze Dam, Que., 216.
Quong, James, 96.

radar, 31, 178.
Radio Corporation of America, 129.
Railway and Swamp Lands Branch, 250.
Railway Belt, B.C., 175.
Rainboth, A. J., 121.
Raley, G. S., 121.
Ramsden, Jesse, 22, 23.
Rannie, J. L., D.L.S., D.T.S., 28, 30, 121, 123, 129; on Wild theodolites, 124.
Rathborne, Aaron, 20.
Ratz, W. F., D.L.S., 131.
Red River, (cart) 14, 53, 146; rail survey party on, 268.
Regina, 148, 182.
Regnaud, F.-T.-V., 73.
Reid, J. L., 333.
Reindeer Lake, 159, 320.
Retty, J. A., 207.
Revelstoke, B.C., 151.
Rhude, Capt. I. C., 290.
Richardson, James, 247.
Richmond Hill, Ont., 229; site selection, 228; Chant's death, 230.

Riddell, J. M., D.L.S., 120.
Riding Mountain National Park, 296.
Ridout, Surveyor General (U.C.), 23.
Riel, Louis, 309.
Rielle, Joseph, 69, 71-2.
Rimouski, Que., 73.
Ripple Rock, 101.
Rivard, J. G., Q.L.S., 291.
Rivière des Prairies, 65, 74.
Rivière-du-Loup, Que., 222.
Roach, Capt. James, (Roach Rock), 109.
Roberts, Willis F., N.B.L.S., 331-2.
Robertson, Burton, N.S.L.S., 264.
Robertson, James, O.L.S., 287.
Roberval, Que., 289.
Robinson, J. M., 296.
Robinson, Maj. J. W., 164.
Rocky Mountain Development Co., 308.
Rocky Mountain Trench (route), 81, 276.
Rocky Mountains (Rockies), 227, 306-7; watershed, 8; Canadian, 152.
rodmen, 140.
Rolph-Clark-Stone Limited (Stone Company), 50.
Romaine River, 202.
Romeril, P. J., 208.
Roosevelt, Capt. Elliott, 173.
Roosevelt, President F. D., 86, 173; at Placentia, 114-5.
Rorke, L. V., O.L.S., D.L.S., 35, 39, 43.
Ross, J. E. R., D.L.S., D.T.S., 124, 129, 131; Patrick and, 310.
Ross River, 92.
rotary lithographic presses, 49, 57.
Rouge River, Que., 11.
Rouyn, Que., 281.
Royal Air Force, 155, 245.
Royal Astronomical Society (Can.), 211, 217, 228; Motherwell and, 219; incorporation, 231.
Royal Canadian Air Force, 4, 11, 13, 39, 129, 217, 272-5, 298, 304; air photos by, 94-6; in 1930, 109; 1924 season, 159; in Labrador, 170-6; with Geological Survey, 248; mapping by, 305.
Royal Canadian Engineers, Corps of, 94; A.S.E., 95, 98; 129, 131; Burns in, 160, 163; Bereskin of, 168.
Royal Canadian Mounted Police, 239.
Royal Canadian Navy, 170.
Royal Engineers, Corps of, 135, 157, 257; Mann of, 185.
Royal Flying Corps, 40, 289, 313.
Royal Geographical Society, 318, 324.
Royal Military College (Kingston), 160.
Royal Society of Canada, 221.
Ruggles, R. I., 238.
ruler, 20, 123.
Rupert's Land, 44.
Russell, Lindsay, D.L.S., 307, 329.
Russell, Peter, 187.
Ruth Lake, 205.

Sailing Directions, 117.
St. Ann's Ward (Montreal), 73.
St. Croix River, 7.
St. George, P. W., 73.
Saint John, N.B., 115, 125.
St. John River, N.B., 133.
St. John River (Rivière St. Jean), Que., 199.
St. John's, Nfld., 113, 133; Trans-Canada highway from, 149.
St. Lambert, Que., 70, 217.
St. Lawrence, Gulf of, 106, 107, 109.
St. Lawrence River, 8, 68-9, 70-1, 74, 109, 133, 135; gauges, 101; estuary, 107; roads along, 222-3; rail line from, 278.
St. Lawrence Seaway, 8; ship channel, 101.
St. Lawrence (suburb), 70, 71.
St. Lawrence Waterway, 209.
St. Leonard-de-Point-Maurice, 69.
Ste-Marguerite Power Co., 209.
St. Maurice River Protection Assoc., 289.
St. Thomas, Ont., 23, 148.
Saltzman reflecting projector, 145.
San Francisco, 222.
Sanson map (1696), 197.
Sarcee Indians, reserve, 309.
Saskatchewan, 8, 40, 121, 129, 225, 267, 273, 315-6, 321; survey flights over, 123; highways in, 147-8; Bereskin of, 168; Town Planning Act, 182; maps by, 239; first airphoto, 273; Alberta boundary, 313; Macdonald in, 320.
Saskatchewan Dept. of Agriculture, 239.
Saskatchewan Dept. of Natural Resources, 239.
Saskatchewan, University of, 227, 233.
Saskatoon, 182, 223.
satellite geodesy, 132.
Saunders, B. J., O.L.S., D.L.S., 33.
Saunders, Dr. Charles E., 14.
Savard, Paul, Q.L.S., 291.
Savary, Charles, 107.

Sax, William, 71.
Scarborough Tp. (Glasgow Tp.), Ont., 185.
Scheer (battleship), 114.
Schefferville, Que., 208-9, 278.
Schofield, R. M., 333.
School of Practical Science (Toronto), 148, 176, 182; Seibert and, 312.
Scott, Capt. A. de C., 49.
scriber, 62.
scribing process, 60.
2nd Field (Topographic) Survey Co., 163, 165, 168.
Second Meridian East, 271.
2nd Survey Regiment, R.C.A., 164, 168.
Seely, H. E., 293.
Seibert, F. V., A.L.S., S.L.S., O.L.S., D.L.S., 313-18; clinometer, 312.
seismology, 212.
Seismology Division, Ottawa, 223.
Selkirk, Man., 39, 268.
Selwyn, Dr. A. R. C., 251, 308.
Senécal, C.-O., 245, 247, 249, 254, 256; Geographer, 248.
Senefelder, Alois, 48-9.
Senneterre, Que., 122.
Sept-Iles, Que., 207-8, 280; rail line from, 278.
Servant, W. E., N.S.L.S., 264.
Servitudes, 78.
Seven Falls, Que., 223.
Seven Islands, 107.
sextant, 23, 131, 288.
Sexton, Dr. F. H., 260.
Seymour, H. L., O.L.S., D.L.S., 182-3.
Seymour Narrows, 101, 106.
Shakespeare (chapter headings), 1, 4, 7, 8, 9, 11, 15, 20, 21.
Shanks, Thomas, D.L.S., 14.
Shawinigan Falls, Que., 223.
Shediac, N.B., 110, 133.
Sheep Creek, Alta., 12.
Sheep Nest's River, 93.
Sheirlaw, George, 50.
Sherridon, Man., 281-3.
Shipton, Mother, 135.
shoran, 129, 131; station sites, 130; principle, 255.
Shortt pendulum clock, 216.
Siddall, K. H., 90, 142.
sidereal time, 215.
Sifton, (Hon.) Arthur, 308.
Sifton, Hon. Clifford, 213.
Sifton Pass, 84.
Sikanni Chief River, 82-6.
Silver, G. C., 50.
Silver Dart, 4.
Silvester, G. E., O.L.S., 287.
Simcoe, (Gov.) John, 23, 184, 188, 195; pre-Simcoe, 185; founding of York by, 187.
Simms, William, 23.
Simon, Sir John, 201.
Sinclair, G. E. B., 122.
Sioux Lookout, Ont., 8, 291.
Sissons, Jonathan, 31.
Sixth Initial Meridian, 315.
60th Parallel, 225, 315; meridian, 311.
Slave River, 225.
Smith, C. C., 217, 218.
Smith, Maj. C. H., 164; Colonel, 169.
Smith, D. W., 187.
Smith, F. C. G., 107.
Smith, J. H., O.L.S., D.L.S., 128.
Smith, N. H., 121.
Smith River, 85.
Smith, Titus Jr., 285.
Snag Creek, 79, 85.
Snake Indian River, 312.
Snelgrove, D. M., 112.
Somass (houseboat), 114, 117.
sound ranging, 157.
Southampton, 50.
Southampton Island, 115.
Southern Alberta Institute of Technology, 266.
Southern Alberta Land Development Co., 308.
Southern Labrador Pulp and Paper Co., 289.
Sparks, Robert, P.L.S., 307.
Speight, T. B., 287.
Spence, H. N., 324-6.
Spencer Ball, Col., 333, 334.
stakeman, 140.
Stanley, W. F., and Company Limited, (U.K.), 30.
Steers, F. P., 96.
Stegman, John, 186.
stereoplotter(s), 164, 278; pairs, 293.
stereoscope (s), 4, 12, 146; Fairchild, 142; pairs, 281.
stereoscopic photography, 157.
Stewart, Alex., 50, 247.
Stewart, Hon. Charles, 80.

Stewart, Elihu, O.L.S., 35.
Stewart, L. B., Prof., D.L.S., 40, 121-2; Ney and, 128.
Stewart, Dr. R. M., 214-5, 231; time service, 216; director, 218; death of, 219.
Stewart-Saunders (survey), 33, 35, 39.
Wm. J. Stewart, CHS (ship), 108, 109, 111, 113.
Stewart, W. J., 107.
Stikine River, 83, 86.
Stone Company Limited, (Can.), 50.
stone presses, 50.
Stony Indians, reserve, 309.
Straits of Belle Isle, 8.
Stranraer flying boat, 279.
Strathcona (South Edmonton), 170.
Stupart, Sir R. F., 218.
Sturgeon Lake, 42, 44.
Sudbury, 251, 291.
Sulpician(s), 66; Seminary, 66-7.
Sunderland, W., 81.
Superior Shoal, 109.
Survey Division (Ottawa), 158.
Surveyor General (Canada), 255, 299, 300; Russell, 307.
surveyor's cross, 16; cross-staff, 18, 20.
Surveys and Engineering Branch, 255.
Surveys and Mapping Bureau (1947), Surveys and Mapping Branch (1950), 64, 165, 178, 255-6, 263, 331.
Surveys Laboratory, 2, 3, 4.
Swannell, F. C., B.C.L.S., D.L.S., 83, 84.
Swannell, Maj. Lorne, 164.
Sydney, N.S., 113.

Tacoma, Wash., 120.
Taggart, C. H., D.L.S., 163, 183.
Talbot, Col. Thomas, 186.
Talbot Road, 142.
Talcott (method), 41.
tape, 2, 24-5, 288; tapeman, 140.
Telegraph Creek, 83.
telescope(s), 23, 26, 28, 30-1, 229, 230-2; Wild transit, 124; astronomical, 219; at Victoria, 221.
tellurometer(s), 31, 132, 278; invention of, 132.
Temiskaming and Northern Ontario Ry., 270, 280.
Tennessee Valley Authority, 51.
10th Air (Survey) Liaison Section, R.C.E., 165.
Terrain Clearance Indicator, 327.
Terrebonne, Que., 71.
Terrington Basin, 111, 172-3.
Teslin Lake, 79, 93.
Teslin River, 93, 254.
Tharandt Forest School, 293.
Thelon River, N.W.T., lower, 322.
thematic map, 233-5, 239.
theodolite, 20, 22, 28, 30, 288; Microptic, 27; Tavistock, 27; Wild, 124.
The Pas, Man., 9, 225, 268, 270, 320; railway from, 275.
thermometers, 23, 30, 37-8.
Thevenot, 31.
3rd Field (Reproduction) Survey Company, 164, 168.
Thistlethwaite, R., D.L.S., B.C.L.S., A.L.S., 329.
Thompson, David, 71.
Thompson, Maj. J. I., 255.
Thompson, J. V., 96.
Thompson, W. T., D.L.S., 105.
Thomson, M. M., 217.
Tidal and Current Survey, 105.
Tide Tables, 117.
Tiernan, J. M., O.L.S., 287.
Tilburg, Holland, 168.
Timm, W. B., 251-2.
Timmins, J. R., 208.
Titus, S. R., 109.
Tobey, W. M., D.L.S., D.T.S., 121.
Topham, B. J., 219.
Topographical and Survey Bureau, 203.
Topographical Survey Division, 160, 170, 175; under Boyd, 242.
Topographical Survey (of Canada), 59, 82, 98, 161, 217, 298-9, 301, 316; Fry of, 111; Vicars and, 175; Labrador survey, 205; of *Canada*, 255; helicopter use by, 325-6; Sid Jowitt of, 328.
Topographical Surveys Branch, 7, 8, 9, 11, 36, 224, 248, 315, 320; Davidson and, 176; air photography by, 274-5; Mackenzie River survey, 314.
Topographical Survey Section, 158.
Toronto, 30, 35, 40, 50, 139, 142, 148, 162, 181, 185-8, 190-3, 195-6, 222, 225; Geodetic Survey and, 125; sketch of downtown, 180; evolution of, 184; railways to, 189; University Ave., 194; Stewart and, 215; Magnetic Observatory, 218; Dunlap and, 227.

Toronto Bay, 188.
Toronto City Planning Board, 192.
Toronto, Grey and Bruce Railway, 71.
Toronto Harbour (Commission), 120, 185.
Toronto Island, 185, 195.
Toronto Passage, 185, 187.
Toronto Rolling Mills, 189.
Toronto, University of, 35, 36, 40, 60, 131, 182, 215, 219, 222, 266, 312; Prof. Stewart and, 176; Harper and, 211; Chant and, 212, 230; Cannon and, 218; Innes and, 227; Observatory, 228, 230; Innes and, 227.
Torrens Land Titles system, 148.
torsion balance, 227.
Tose, Sgt. W. E., 168.
Town Planning Commission (Ottawa), 184.
Town Planning Institute of Canada, 181-3, 193; D.L.S. and, 184.
Trans-Canada Air Lines, 300.
Trans-Canada airmail, 299.
Trans-Canada Highway, 134, 142, 149, 150, 154; system, 151.
transit(s), 27, 137, 143; on rail surveys, 284.
Traynor, Isaac, O.L.S., D.L.S., 148.
Traynor, J. C., S.L.S., D.L.S., 148.
Treaty of Paris (1763), 198.
Trent River, 185.
Triangle Island, B.C., 225.
triangulation, 2, 6, 7, 18-9, 27, 73, 119, 120, 130, 292; Alaska Highway, 96; Labrador, 111; city, 121; geodetic, 122-27; highway, 143; wartime, 156; town planning, 184; Spence and, 324.
trimetrogon camera (photos), 274.
Trois Riviéres, Que., 11.
Trorey, Maj. L. G. S., 164-5, 255, 292.
Troughton and Simms, 27, 213.
Truro, N.S., 258.
T.S.G.S. (Topographical Survey of the Geological Survey), 242, 246.
Tunstell, G., 295.
Tupper, Freeman, 333.
Tuttle, A. C., 252.
Tuttle, J. W., 247.
Twin Butte, Alta., 308.
Twiss, Lieut. William, R.E., 69.
251st Tunnelling Co., 257.
Tyrrell, J. B., 252.
Tyrrell, J. W., D.L.S., 316.
Uhlman, J. C., 42.
Umbach, J. E., B.C.L.S., D.L.S., 183.
Underwood, J. E., S.L.S., D.L.S., 182.
Ungava, 206-7.
United Empire Loyalists, 68.
United Nations, truce work, 160, 163.
University, see proper name associated with.
University Avenue (Toronto), 194-5.
Unwin, Charles, 188-9.
Upper Canada, 23, 68, 187; Canada West, 135.
Upper Canada College, 218, 307.
Upper Lakes, 185, 187.
U.S. Air Force, 174, 304, 324.
U.S. Public Roads Admin., 79.

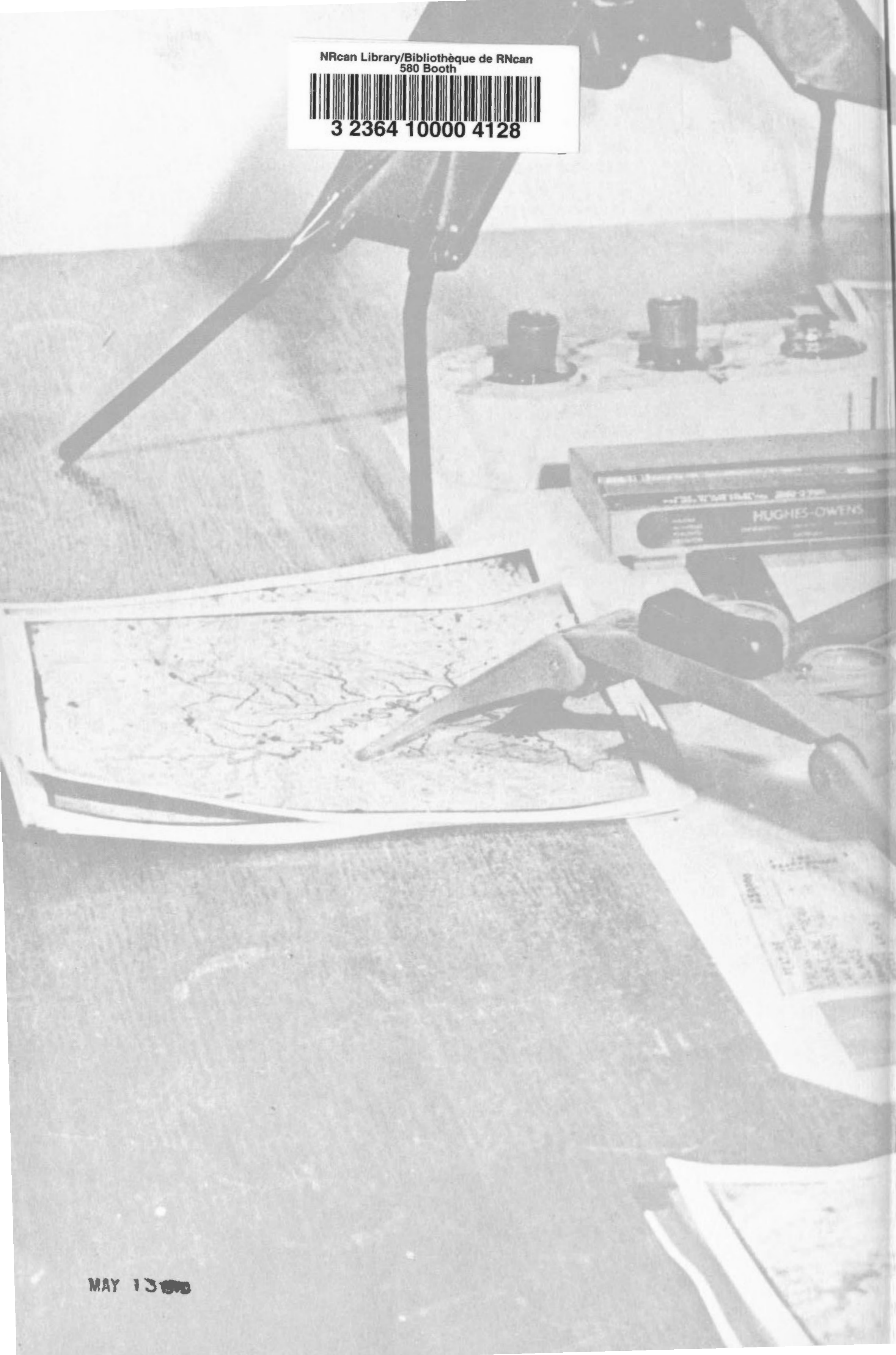
Valenciennes, 157.
valuation survey, 288.
Vancouver, B.C., 7, 8, 86, 120, 279, 325; Ripple Rock, 101; triangulation from, 122, 125; Fry at, 171; town planning, 184.
Vancouver, Capt. George, 99.
Vancouver Island, 135, 223, 244.
Vanier, Joseph-Emile, 71.
variation of gravity, secular, 224.
Veitch, Robert, 247, 256.
Verdun, Que., 69.
Vicars, Lieut.-Col. J. R. O., D.L.S., O.L.S., 171, 175-6.
Vickers *Viking*, 39, 159, 272, 273; Davidson and, 176; *Vedette*, 273-4; *Vancouver*, 290.
Victoria, B.C., 84, 110, 149, 184, 221, 223, 227; city mapping of, 120; Observatory, 211, 214, 219; staff, 220; seismograph at, 222; Oak Bay Observatory, 230; Blanchet dies at, 318.
Victoria Beach, 8.
Victoria Bridge (Montreal), 73.
Victoria Island, N.W.T., 324.
Victoria Memorial Museum, Ottawa, 244-6.
Ville Marie, 66.
Ville Marie Observatory, 230.
Ville St. Laurent, 69.
Vimy Ridge, 155, 171.
Vitruvius, 17.
volumetric point symbol, 234.

Wacouno River, 280.
Wadsworth, Capt. W. J. G., O.L.S., 165, 193.
Wainwright, Alta., 171.
Walbank, W. McL., 73.

Walcot, J. B., 97.
Waldseemuller, Martin, 48.
Walker, Robert, 50.
Wallace Lake, 37.
Wardle, J. M., 203.
Wardsville, Ont., 148.
Warren, James, D.L.S., 316.
Warrington, G. A., M.L.S., D.L.S., 39.
Warwick sheet (Que.), (map), 159.
Washington, D.C., 58, 60, 84, 86, 91, 215, 327; Goose Bay site, 173.
Washington Naval Observatory, 41.
Water Level Bulletins, 117.
Waterloo County, Ont., 182.
Waterton Lakes, 308.
Waterton Lakes National Park, 306-7; area, 309.
Waterton River, 308.
Watrous, Sask., 171.
Watson Lake, 80-6, 91, 96; Dr. Lord at, 254.
Watts, E. R., and Son Limited, 27.
Watts, Walter J., 50.
Waugh, Bruce W., D.L.S., 38, 46, 299, 301, 329; Profile Recorder, 327.
Way, W. C., 3, 4, 38.
Weir, Prof. T. R., 238.
Westby, Ray, 328.
Western Ontario, University of, 230.
Westmount, 66, 71; Burns and, 160.
Wharton (Hydrographer to the Admiralty), 105.
Wheeler, A. O., D.L.S., 8.
White, Dr. I. C., 309.
White, James, 236.
White, Sir Thomas, 212.
Whitehorse, Yukon, 80, 82-5, 91-7.
White Pass station, 96.
Whitman, Charles, 289.
Wicksteed, H. K., 12, 272.
Wiechert vertical (instrument), 222.
Wight, E. J., D.L.S., 183.
Wilby, Thomas, 149.
Wild Heerbrugg Limited, 27, 30.
Wild, Dr. Heinrich, 27, 124; death, 30.
Wild transit, 27-8, 30, 124.
Willis, W. K., 117.
Wilson, Elwood, 289.
Wilson, Henry, 31.
Wilson, J. A., 82, 161, 299.
Wilson, N. D., O.L.S., D.L.S., 188.
Windmill Line, 188.
Windsor, N.S., 133.
Windsor, Ont., 142.
Winnecke's Comet, 227.
Winnipeg, Man., 37-8, 82, 147, 276, 281, 322; L. B. Stewart and, 121; Fry at, 172; air base, 298.
Winnipeg Aeronautical Map (1926), 298.
Winnipeg Lake sheet (1931), 298.
Winnipeg River, 37, 43, 292.
Wintemberg, W. J., 121.
Winton (car), 136.
Wolfenbuttel map, 197.
Wollaston Lake, 176, 320.
Wood Buffalo National Park, 301.
Wrong, F. H., 176.
wye level, 31.

Yale University, 217.
yardstick, 1.
Yarmouth, N.S., 289.
Yellowhead Pass, area, 312.
Yonge Street, 142, 187, 189; subway along, 196.
York Factory, 42.
York, Town of, 135, 186, 191, 195; founding of, 187; streets of, 188.
York Township, 186.
Young and Sons (U.S.), 30.
Young, G. A., 243, 250.
Young, R. B., 117.
Young, R. E., 250.
Young, Dr. R. K., 219, 228.
Young, Stewart, S.L.S., D.L.S., 182-3.
Young, W. J., 23.
Youngs, C. W., A.L.S., D.L.S., 148.
Yukon River, 120.
Yukon Southern Air Transport, 82.
Yukon Territory, 79, 81-6, 93, 95-8, 243, 251-2, 311, 324; border with Alaska, 98; Prof. Stewart in, 121; Standard Time, 215; valleys of, 312.

Zeiss firm, Jena, 27, 30, 162.
Zeiss multiplex aeroprojector, 162.
Zeiss transit, 27, 28.
Zeist, Holland, 168.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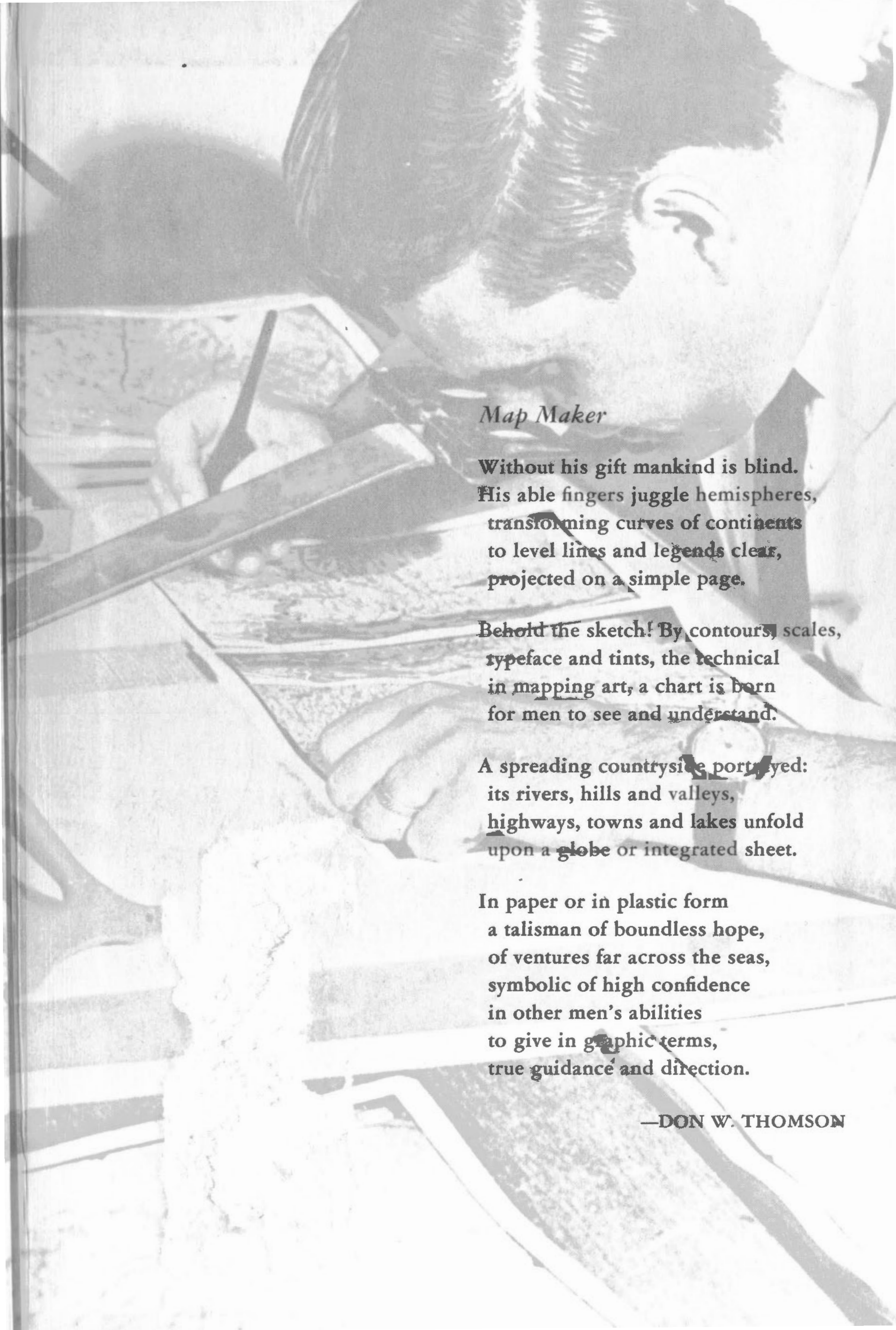

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