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REPORT

ON THE

SURVEY OF CANADA.

BY

MAJOR E. H. HILLS, C.M.G.

(Royal Engineers.)

HEAD OF THE TOPOGRAPHICAL SECTION OF THE WAR OFFICE,
MEMBER OF COUNCIL, ROYAL ASTRONOMICAL SOCIETY,
AND
FELLOW OF THE ROYAL GEOGRAPHICAL SOCIETY.

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PRELIMINARY REMARKS.

The subject upon which I am asked to report is the Military Survey of the Dominion of Canada. The term "military" is, however, here a misnomer, and its employment in this connection is liable to lead to misunderstanding. A survey adequate for military purposes is, at the same time, one that is serviceable for all purposes for which maps are required. There is no essential distinction between the map necessary for the staff of an army in the field and that demanded for land administration or engineering requirements.

The use of the term "military survey" tends, furthermore, to foster the idea of a survey made for a special purpose and of a restricted usefulness, whereas, as I hope to show in the course of this report, the only satisfactory and economical procedure is to plan the survey of a country on such comprehensive lines that the resulting maps will be of value for all purposes for which accurate knowledge of the features of the ground is required. I have accordingly erased the word "military" from the title.

The report divides itself into three sections. In the first, the value of good maps of a country and the general nature of such maps are discussed; in the second, the existing survey work in Canada is summarized, and its inadequacy to meet the growing requirements of the country indicated; in the third, the main lines upon which the systematic survey of the Dominion should be undertaken are laid down. To complete the report appendices are added, wherein the technical details of the survey work and estimates of the initial and annual cost of an efficient survey department are given.

E. H. H.

I.—ON THE VALUE AND NATURE OF GOOD MAPS.

The value of good maps of a country.

The vital importance of good maps, both to meet military requirements and also for many purposes connected with the administration of a country and the development of its economic resources, is so obvious that any detailed argument upon the point would seem superfluous. If we require an example, from the military point of view, of the disadvantages arising from the want of maps, we have only to turn to the record of the South African war, where, owing to the absence of accurate topographical information, the progress of the operations was gravely delayed and a large loss both of life and money resulted. Nor would it be difficult to give examples showing the similar waste which occurs in affairs other than military. Such problems, for instance, as the selection of an approximate alignment for a new railroad or canal are matters of comparative ease in a country of which the topography is known, while in an unmapped country they are impossible without costly special surveys.

The various directions in which a comprehensive series of topographical maps of a country will be found of value both to the State and to private corporations or individuals may be summarized under special headings—

(a.) Administrative and Political.

In all questions relating to the administration of public lands, the sa[illegible] transfer of such; the setting out upon the ground of provincial, township and other public boundaries; the valuation of property for the equitable adjustment of sales, ta[illegible]on and assessment*; the administration of public works, such as canals, reservations, parks and highways; the reclamation and improvement of waste lands, and as base maps for all statistical purposes for the graphic representation of facts relating to population, industries, products and similar information.

(b.) Military.

For military purposes such maps are invaluable in peace and necessary in war. In peace they are used for training and manœuvre purposes; for the laying out of camps and exercise grounds; for the planning of permanent defensive and offensive works, and for the representation and discussion of all military and strategical problems connected with the defence of a country and the successful prosecution of military operations on or outside its frontiers.

In war accurate maps are a matter of vital necessity, and are of use for conveying information as to the nature of the cor[illegible] means of communication, water supplies, natural resources, &c., and f[illegible] planning marches, camps, fieldworks and general strategical operations.

(c.) Engineering and Economic.

As preliminary maps for planni[illegible] railroads, highways, electric roads, canals, aqueducts; sewerage, drainage a[illegible] water supply schemes. In all such works the cost of prelimi[illegible] surveys is thus saved.

For showing the extent, location and accessibility of lands, waters, forests and valuable minerals.

As base maps for hydrographical, geological and mineral surveys.

In addition, as an incident in the making of a topographical map, monuments are established throughout the country the positions of which are accurately fixed and which will serve as datum points for all other government, private and cadastral surveys. Bench marks, or records of height, are also established, which furnish datum elevations for use in connection with all public and private engineering works.

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* As one single example of the immediate practical profit which results from the existence of an accurate map, it may be mentioned that, upon the completion of the Ordnance Survey of Ireland, the amount of the income tax, as coll[illegible]ted according to the valuation founded on the basis of the Ordnance maps, exceeded the amount previously collected by nearly 5[illegible],000*l.* (250,000 dollars) a-year.

While thus insisting upon the value of a topographical survey in its practical and commercial bearings, we must not forget that the execution of such a work has large value from a geodetic and geographic point of view which, while only of scientific interest to-day, may well be of practical importance to-morrow.

In these circumstances it is not surprising that almost all countries have recognised the paramount necessity of carrying out precise surveys of their territories. Such work is completed or in progress in the United Kingdom, British India, British South Africa, the United States and in all European countries with the exception of Turkey.

General characteristics of topographical maps.

If we examine the maps of these countries, we shall find that there is a general consensus of opinion that the military and other requirements are best met by a map, on a scale of from about $1\frac{1}{4}$ inches to $\frac{1}{2}$-inch to a mile, showing all the natural features of the ground and all the artificial features, *i.e.*, roads, railroads, houses, bridges, &c. (*see* also Appendix V.).

Question of scale.

The best scale for the map depends upon the nature of the country and on the amount of building and cultivation, thus, in a closely inhabited country, the necessary details can hardly be shown on a scale of less than 1 inch to a mile, while in a more open country one of $\frac{1}{2}$ inch to a mile may suffice. In unsettled or sparsely inhabited regions, where the ground forms are not complex, the features can be shown on a map at a scale of $\frac{1}{4}$ inch to a mile. This is about the limit of practical utility for a topographical map. On any smaller scale the natural features cannot be shown in detail, but can only be indicated in a generalized and approximate manner.

The selection of the most suitable scale for any particular country is largely a question of relative cost, a matter which is discussed in a later portion of this report. We may, however, here remark that in a sparsely inhabited country, such as Canada, all practical requirements, for a long period of years, can be met by a map on the scale of $\frac{1}{2}$ inch to a mile. Special areas, such as those surrounding the larger towns, and mineralized localities where land values are high, might be surveyed on larger scales, but the undertaking of a general map on the 1-inch scale would be too ambitious a project at the present time.*

A topographical map of Canada on a scale of $\frac{1}{2}$ inch to a mile, showing all the natural and artificial features, would meet all reasonable military requirements, and would, at the same time, be of incalculable value for administrative and engineering purposes. No such map at present exists for any portion of the Dominion.

* [illegible] costs from 2 to [illegible] times that of a [illegible] inch survey. The latter could be [illegible] cost [illegible] 10 dollars per square mile. A [illegible] map would cost at least [illegible] per square mile. [illegible] further discussion on this point, [illegible]

II.—EXISTING SURVEY WORK IN CANADA.

General summary. Survey work has been done, and is now in progress, in Canada, under several different departments. Thus there are land surveys executed by the Provincial Governments; Dominion land surveys and surveys of the railway belt by the Dominion Surveyor-General, and topographical surveys by the Geological Survey Department.

To this list we may add astronomical determinations of position carried out by the Chief Astronomer and his staff; military sketch maps, done by parties of Cadets, from the Royal Military College, during summer trainings; and surveys of the coasts by the Admiralty and the Department of Marine and Fisheries.

To take these different classes of work *seriatim*:—

Provincial land surveys. The Provincial land surveys have been done by various methods, and, as naturally might be expected, are of varying orders of accuracy. Roughly speaking, all those dating before 1850 were done with the compass, and are liable to large errors. Since that date they have, for the most part, been carried out with theodolite and chain, and there has, no doubt, been a considerable increase in precision in this work in recent years. At the same time it must be remembered that much of it has been done by inexpert men who, having been paid upon the piecework system, have had little inducement to strive for any degree of perfection. The actual work of the provincial surveyors has been the marking out of the township and sub-division lines upon the ground. The townships in the older part of the country average about 10 miles by 10 miles, in the newly-settled districts they are made 6 miles square, divided into 72 lots of 320 acres each. The surveyors are supposed to record any features roads, streams, &c., which cross the boundary lines, and to make a traverse survey of any lake of which the area exceeds 20 acres.

Compilation of provincial maps. These township plans have been put together by the Provincial Land Departments into maps. In the work of compilation the actual positions on the map depend upon points determined astronomically by crude methods. In the Eastern Provinces the fundamental positions are those of the old Admiralty charts. There has as yet been no attempt to recompile them upon the precisely determined fundamental points which are now available. It is, furthermore, evident that the combination of a number of plans, themselves inaccurate, can only result in the accumulation of large residual errors: so it is hardly surprising that such maps should be described, by a competent authority, as "grossly erroneous." All the work of these Provincial Departments is valueless as a basis for a topographical map of any pretensions to accuracy. It is possible that some of the traverse lines, especially those done in recent years and where the original records are available, might be of some slight assistance in the progress of a topographical survey, though it is questionable whether the attempt to use them would not ultimately prove unprofitable.

Dominion land surveys. The land surveys carried out under the direction of the Dominion Surveyor-General in Manitoba and the North-West, and along the railway belt in British Columbia, are of a far higher order of precision. The work in this case is of the same nature, namely, the demarcation, on the ground, of the township and section lines, and the method of execution is that of accurate chainage from well determined astronomical points. Many of the positions are referred to the International Canada-United States Frontier, which was delimited by a joint commission, using the Talcott method of latitude determination. Other astronomical latitudes have been fixed in recent years, with all the precision of which this method is capable, and the longitudes of fundamental points have been determined by the exchange of telegraphic signals. The surveys are not topographical, in the sense that they include neither heights nor contours, nor other representation of the form of the ground, but the points are probably fixed with an accuracy sufficient to enable a preliminary topographical map to be based upon them.

Survey of railroad belt.

In the course of the survey of the railroad belt, of 20 miles on each side of the Canadian Pacific Railroad line, a chained traverse has been carried over the whole line from Calgary to Vancouver. The precision of this work is not quite up to the standard of which the method is capable, but it is not probable that the position of any point on the road is in error by more than ¼ mile. A certain amount of topographical work has been done along the railway, and a map of the whole belt, on a scale of 1 : 500,000, or 8 miles to an inch, has been produced. It is the intention of the department to extend the map to the southern boundary of British Columbia.

Topographical surveys in mountains.

A few years ago a party was sent out by this department to do a topographical survey of the region in the Rocky Mountains round Banff. The resulting maps, 21 in number, are of a high order of merit, but owing to the large scale selected (1 : 40,000, or about 1½ inches to a mile) and the consequent minute precision necessary, the work was found to be too slow and expensive. It was accordingly abandoned, and there is no present intention of taking it up again. A survey, on a less ambitious scale, of the mountain districts near the principal tourist resorts, has lately been started. Parties have also carried out surveys in the Yukon district, and, for irrigation purposes, in Southern Alberta.

Geological surveys.

The work done by the Geological Survey Department may be defined as a mixture of compilation and original survey. In the Eastern Provinces, New Brunswick and Nova Scotia, where the provincial surveys are either non-existent or valueless, the work has been entirely redone by the method of chained traverses filled in by the compass. The resulting maps therefore attain a considerable degree of precision, and, in the case of Nova Scotia, where the survey on the 1 inch scale is about two-thirds completed, could doubtless be used as the basis for a preliminary topographical map. The fundamental position upon which the maps of this province are based is that of Halifax, as taken from the Admiralty charts. The latitude and longitude, both of this place and of points at the north and south end of the peninsula, say Sidney, Cape Breton, and Yarmouth, might now, with advantage, be redetermined.

In the case of New Brunswick, a map of surface geology and forests, on a scale of 4 miles to an inch, is now nearly completed. Three sheets in the northern part of the province remain to be done. In this map a number of heights taken from the railway profiles and from aneroid observations are given, the hills are shown by vertical hachures, and all the features, as far as is possible on the scale, are indicated. With a revision on the ground to add new roads, &c., and if reprinted with the elimination of the geology, this map would make a fair preliminary topographical map of the province. The determination of the astronomical position of one point in the province, say Moncton, should at the same time be undertaken.

In Ontario and Quebec the provincial surveys have been readjusted on new traverse lines and astronomical positions, and in the west also the work is partly original and partly based upon the Dominion Land Surveys. Most of the maps, with the exception of those covering Nova Scotia named above, and a few special sheets, are on a scale of 4 miles to an inch, in the east and centre, and 8 miles to an inch in the north-west.

Three special topographical sheets, on a scale of 4 miles to an inch, have been done in the mountain region adjoining the railroad line. The method employed has been a very rough triangulation, based upon the points on the railway determined by the traverse already alluded to, with the details filled in by sketching. These maps have been reproduced in an attractive form, with contours and hill shading, but they cannot claim to be more than reconnaissance sketches.

Military surveys.

In addition to the work carried out by the civil departments, a onsiderable amount of military sketching has been done by the cadets of the Royal Military College, Kingston. Owing to the short time available for instruction and to the unsystematic way in which the work of the different men has been put together, the maps compiled from these sketches have hitherto been of less value than might fairly be expected. Lately a more scientific method of compilation has been adopted with a corresponding improvement in the results, but no method of compiling can by any possibility lead to the production of a complete map of a country which will, for a moment, stand comparison with one produced by actual survey.

The unsatisfactory nature of this process is apparent to any geographer. It is a matter of extreme difficulty to thus produce a map, even on a small scale, which shall be free from serious error; to construct a map on a scale of 1 inch or ½ inch to a mile by compilation of fragmentary material is impossible. Impossibility of making good maps by compilation.

In the Report of the Geographer to the Department of the Interior for 1902, Mr. White, alluding to the difficulties met with in compiling the map of Canada on a scale of 35 miles to an inch, wrote:—"The lack of an accurate topographical survey, the numerous sources from which information must be obtained, the difficulty in many cases of obtaining access to the plans of old and almost forgotten surveys, the necessity of incorporating surveys that are being made concurrently with the compilation of the map, which frequently alter the work almost as soon as completed, all tend to make the compilation of such a map a long and tedious operation."

Further on in the same report he wrote:—"The difficulties encountered in compiling the new map of Canada, emphasize the need of a good topographical survey of at least the well settled portions of the Dominion. A few years ago I made a survey between two well-determined points on Georgian Bay and the west end of Lake Ontario respectively, which showed that part of Central Ontario, as shown in the best existing map, was over 2 miles out in longitude, and over a mile in error in latitude. Although our maps show streams, lakes, &c., even in the extreme north, much of the information upon which they are based is of the vaguest kind."

Examples illustrating the unsatisfactory nature of this process of map compilation, without good surveys, could be multiplied without difficulty. Thus, Major C. F. Close, C.M.G., R.E., Instructor in Surveying at the School of Military Engineering, Chatham, in a lecture delivered at the Staff College on 15th July, 1903, said:—"No assemblage of sketches will ever make a topographical map. The maps of India, previous to 1802 (when the Survey Department began work) had been compiled from sketches. These maps, in the short distance across India in the latitude of Mysore, were 40 miles in error, a striking example of the futility of basing maps on sketches."

Again, speaking of the recent experience in South Africa, he said:—"Instances have been quoted of the impossibility of compiling a satisfactory map from sketches. South Africa affords the example of the impossibility of compiling a map from large scale plans, such as the farm surveys of the Free State."

The number of special surveys carried out in Canada for railways and canals, either by the Department of Railways and Canals or by private corporations, is very considerable, and the total expenditure upon them must amount in the aggregate to a large sum. Surveys of this character, done for special purposes and where, therefore, it is the object of the surveyors to take nothing into account which does not directly affect the work they have in view, can only be of slight assistance in the construction of a general map of the country. As, moreover, there is no systematic arrangement for the registration and storage of such plans, it is inevitable that they should often be lost, or at all events lost sight of, and their usefulness is thus confined to the limited purpose for which they were made. Under an organized survey department no such loss would occur, and the whole lines of work would be so planned that all the surveys would be done with a view to their subsequent employment, not for a special or limited use, but for any purpose for which they may be required. Only thus can ultimate economy be obtained. Special surveys.

Unsatisfactory character of existing work.

It is apparent from this short summary that a very large amount of survey work is being done in Canada, while it is unfortunately true that, at the present moment, it is not possible to point to any district of the Dominion of which there is available a map, even approximately up to modern standards. Nor is the reason far to seek. It is to be found in the unsystematic and fragmentary nature of the work done, which, while unsatisfactory in its results, is at the same time most costly.

The remedy.

It may be affirmed, without hesitation, that by the initiation of a systematic survey upon those well ordered, scientific methods, of which universal experience has demonstrated the value, the country would, in the not remote future, effect a substantial saving.

Inefficient work costly.

The question of the usefulness of such a survey has been already dealt with in this report, the question of its ultimate economy is no less important. The following quotations from a memorandum recently prepared by a Committee of the Royal Society of Canada, on the subject of the systematic survey of Canada, will prove interesting in this connection:—

"The same ground is being surveyed over and over again, by the land surveyor, the geologist, the railway or canal engineer, the hydrographer, &c. For every new object a new survey has to be made. The labour and expenditure on these surveys would be considerably reduced, and often entirely unnecessary, if we had a systematic triangulation carried out as in other countries.

. . . .

"There are few countries, if any, where the expenditure for surveys per capita of population is as large as it is in Canada. The Department of the Interior is dividing lands in Manitoba, the North-West Territories and British Columbia; the Geological Survey Department is surveying and exploring in all parts of the Dominion; the Department of Marine and Fisheries is making a hydrographic survey of our navigable waters; a military survey of the country is in course of execution under the direction of the military authorities. The Department of Public Works and the Department of Railways and Canals are also conducting extensive surveys. In these operations ground already covered by one Department is often gone over again by some other Department. The same distribution and duplication of work is repeated in each province, where almost every Department of the Local Government and many of the great corporations are making surveys for some purpose or another."

Examples of waste due to delay in starting systematic survey.

It must not be supposed that a hesitation to embark upon a regular survey of the country is confined to Canada. If we wish other examples of the inevitable waste entailed by such delay, we need go no further than the United Kingdom, where the early history of the Ordnance Survey affords several striking object lessons.

The following may be quoted from a history of the Ordnance Survey of Great Britain by Captain H. S. Palmer, R.E., published in 1873:—

"The history of the large sums which, even within the last 30 years, have been from time to time expended on incidental surveys, for various public purposes, furnishes an instructive lesson on the economy and advisability of being provided with a systematic national cadastre. In 1842, when the Tithe Commutation Act passed, a demand arose for a great number of plans on a large scale. That demand was supplied by plans got up in a hasty and impromptu manner, on different scales with no uniform principle, and without reference to any general system of triangulation. Of 12,000 tithe plans thus prepared, extending to three-fifths of the country, about one-sixth only are of a first-class description: many of the remainder are very imperfect and inaccurate, some of them, indeed, scarcely worthy the name of plans, and useless for public purposes. Two millions of money (10,000,000 dollars), a sum which would more than have paid for a national survey of England, were thus spent on plans which can never be juxtaposed to form a national cadastre and which would not have been needed had a cadastre existed. But this is not all.

When the operations of the Tithe Commission were afterwards extended to other objects, many of the maps were found to be inadequate to any but the special purpose for which they had been designed, and much of the work had to be done over again. In 1856 the Inclosure Commissioners spent 40,000*l.* (200,000 dollars) for fresh surveys and maps, these too, unfortunately, being made on no uniform system. On the occasion of the railway mania in 1845, another immense demand arose for maps for railway purposes. A sum of about 250,000*l.* (1,250,000 dollars) was spent on surveys for the railways which were actually carried out, 200,000*l.* (1,000,000 dollars) of which might have been saved had there been a national cadastre, to say nothing of the cost of negociations with landowners, much of which would have been avoided had there been Government maps upon which owners of property could have relied. Besides this, hundreds of thousands, almost millions, were expended on surveys for lines which were got up in a hurry and then abandoned for want of proper maps.

"We might go on multiplying instances in which enormous sums of public money have thus been absolutely squandered. Enough has, however been said to prove the importance and economy of having a good cadastral plan of the country. The maxim that what is worth doing at all is worth doing well, is eminently true of our national survey.

"We may well rejoice that the Government were led to take a large and enlightened view of the question, and Sir Henry James is certainly entitled to the thanks of the country for the far-seeing ability and persistency with which, in the teeth of much opposition, he pressed and successfully maintained the true policy of executing our national survey thoroughly, once for all."

It cannot be doubted that similar waste of money has in the past occurred in Canada and will continue in the future, until the survey of the whole country is placed in the hands of a single expert survey department, and prosecuted upon sound methods. The organization of such a department, and a discussion as to the best methods of work, form the subject of the next section of this report.

III.—ON THE ORGANIZATION OF A CANADIAN SURVEY DEPARTMENT.

General description of scientific survey of a country.

The systematic survey of a country may, for descriptive purposes, be divided into two parts, the triangulation and the detail survey. In the first-named operation, the positions of a limited number of points upon the earth's surface are fixed with a very high order of precision; and in the second, the details of the country are drawn in upon the map, using these fixed points as reference points. The map is thus built up upon an accurate skeleton or framework with the result, when the work is properly planned, that the position of any natural or artificial feature of the ground is shown within very small limits of error.

Limits of precision.

It is possible and quite practicable so to arrange the exactitude of the work that these limits of error are smaller than those arising from the expansion or contraction of the paper upon which the map is printed. In other words the relative position of two points can be determined more accurately by survey than it would be possible to measure them upon a paper map. This again is conditioned by the scale of the map. Thus if we take $\frac{1}{100}$th of an inch as the smallest linear quantity that can be measured with accuracy upon paper, upon the scale of 1 inch to a mile this length represents $17\frac{1}{2}$ yards; upon the scale of $\frac{1}{2}$ inch to a mile, 35 yards; and so on.

Importance of accurate fundamental work.

The requisite precision in the triangulation is therefore ultimately determined by the intended scale of the map, but in order to avoid the costly necessity of repeating the triangulation when the development of the country calls for maps upon larger scales, it is well to plan the work on an order of precision determined, not by the scale of the map immediately to be made, but by the largest scale that is likely to be required.

Thus in the case of Great Britain, when the triangulation was started, there was no intention of making a map upon a larger scale than 1 inch to a mile, but it was most fortunately decided to do the fundamental work with the highest degree of accuracy of which the instruments then available were capable. The 6-inch to a mile map of England was not started till about 40 years later, but owing to the wise forethought of the original planners of the survey, the principal triangulation provided a framework accurate enough not only for the 6-inch, but also for the 25-inch map, which was subsequently completed over the cultivated portions of the kingdom.

If for these later maps it had been necessary to repeat the triangulation, the work would have been delayed for many years, and the cost increased by a very large sum.

In the case of Canada, we are justified in assuming 1 inch to a mile as the largest scale upon which the general map of the country can be required for a long period of years, and we may accordingly take this scale as determining the precision of the triangulation.

Methods of fixing fundamental points.

Before discussing the methods that must be adopted in order that the necessary accuracy may be attained, it will be convenient to interpose a few remarks upon the question of other possible means of fixing the fundamental points in the survey of a country, and to explain why they are inadequate for the purpose in view.

In order to locate a position upon the earth's surface there are two available methods, firstly, the astronomical method, whereby the geographical co-ordinates, *i.e.* the latitude and longitude of the point, are fixed by observations of the heavenly bodies, and secondly, the geodetic method, whereby they are determined from observations or measurements made from a known point on the earth. Modern instrumental refinements have brought the art of astronomical observation to a high state of perfection, so that it is possible to fix latitude and longitude, from astronomical methods alone, within limits of error which do not exceed a few feet. This however is not sufficient to fix the point upon the map. All such observations are liable to an unknown error arising from what is generally called the deflection of the plumb line, or the deviation of the spirit level from the true horizontal plane. This deflection arises from three principal causes, the want of homogeneity of the earth's crust, the distribution of land and ocean, and surface irregularities. It is quite impossible to calculate or allow for.

As would naturally be expected this error will, in general, rise to a maximum in mountainous regions, but even in flat ground it often reaches large dimensions. Thus, in the vicinity of Moscow it attains the value of about 16 seconds, or 1,600 feet.

In an average country as, for example the Cape Colony or the eastern part of the United States, the errors in the astronomical latitudes average 3 seconds of arc, or 300 feet, and attain a maximum of about 10 seconds, or 1,000 feet, while, as an example of an extreme deviation found in a mountain region, we may cite the case of the Darjeeling triangulation, where there is an instance of two places 50 miles apart with local attractions differing by 53 seconds, or rather more than a mile.

Were it not for this unfortunate dependence of astronomical observations upon the spirit level, the survey of a country would be a much simpler affair, and, it would be possible to carry it out by means of detail surveys based upon positions determined astronomically. This, however, is not possible unless we are prepared to tolerate errors amounting on the average to about 100 yards and, in extreme cases, to as much as a mile or even more. Errors of this magnitude are, of course, quite out of the question in a systematic survey, and we are therefore driven to geodetic methods for the fixing of our fundamental positions. Of these methods there are two that are practicable, namely, triangulation, wherein the positions are fixed by angular measurements; and traverses, wherein they are fixed by distance and angular measurements along selected lines. Either of these methods can be made to give the requisite degree of precision, and the selection therefore depends upon their relative rapidity and cost. Upon this point no doubt exists. Except in a very close and difficult country, triangulation is by far the cheaper and more satisfactory. If a practical proof of this statement is needed, it is to be found in the fact that this method has been employed by every great survey which has any pretensions either to precision or finality.

We hence reach the conclusion that the systematic survey of Canada must be based upon positions determined by triangulation. It now remains to enter more closely into the details of the work as conditioned by the nature and size of the country and the intended scale of the map. Necessity of triangulation.

Triangulation work may be broadly divided into three classes, differentiated by their varying orders of accuracy. Thus primary or principal triangulation is work executed with the highest possible precision of which portable instruments are capable; secondary work is that wherein a lower, but still high, degree of precision is attained, and tertiary, or topographical triangulation, is a comparatively rough class of work, used in general only for filling in between the points of the primary or secondary series.* Of these three classes of work it may be noted that primary work is very costly and its progress is slow, while secondary work attains a degree of accuracy amply sufficient to form the basis of a topographical map. Unless therefore there is any probability of maps of the country on very large scales being required, it would appear that the best policy in starting the survey of a large country like Canada is to plan a good "backbone" of secondary triangulation,† filled in with tertiary work. This Details of triangulation for Canada.

* The "measure of precision" of a triangulation is the average triangular error.

Primary work may be defined as that wherein this does not exceed 1 second of arc; secondary wherein it does not exceed 5 seconds. Tertiary work will vary greatly according to the instrument used, rapidity of execution, nature of signals, &c., but in general the average triangular error cannot be expected to be less than 20—30 seconds.

† By "secondary" triangulation; work which fulfils the following conditions is to be understood:—

Sides of triangles—10 to [illegible]0 miles.
Observations made to signals, preferably luminous.
Instruments used—8-inch micrometer microscope theodolites.
Average triangular error not to exceed 5 seconds.
Base measurements with steel tapes, correct to one part in 50,000.
Bases every 500 miles.

provides a degree of precision sufficient for the 1-inch to a mile map, which will ultimately be required. For detailed discussion on this point, *see* Appendix IV.

The triangulation points must be permanently marked by stones sunk in the ground so that they can be readily recovered. It will thus be easy at any future time either to base further detail surveys upon the same points or, should it ever be decided to undertake primary work, to re-observe the triangles with larger instruments.

Detail survey.

The detail survey must be made with the plane table, all the work being plotted in the field. The contouring should be done either with Abney levels or clinometers of the Indian Survey pattern, with the use, where necessary, of aneroid barometers, the fundamental levels being taken from the trigonometrical points. Ultimately it will undoubtedly be desirable to undertake a series of instrumental levels, particularly a trans-continental line from sea to sea, preferably along the Canadian Pacific, or possibly the Grand Trunk Pacific, Railroad.

Programme of main triangulation.

The selection of the starting point for the work is not difficult, as it must of necessity lie in the most populous and settled part of the country, and where, therefore, the resulting map is most urgently required. For the main triangulation the following lines are recommended :—

Quebec—Montreal
Montreal—Ottawa—Sault Ste. Marie.
Ottawa—Toronto—Detroit.

At the same time, the work must, at an early date, be started in the west of Canada, say round Winnipeg, and also on the Pacific Coast.

This gives the following additional lines :—

North and south, along the 98th meridian.
East and west, near Winnipeg.
Eastward, from Vancouver.

Such a programme of work, which is illustrated in Map No. 1, annexed to this report, would take about 10 years for a survey department of the strength recommended below.

Three points in this programme call for special remark—

Firstly, it will be noticed that at the three ends of the lines of triangulation recommended for the provinces of Ontario and Quebec, viz., Montreal, Sault Ste. Marie and Detroit, the work can be closed upon points fixed by the United States Geodetic and Lake surveys. This will serve as a valuable check, and will render the introduction of any appreciable errors into this part of the work impossible. Secondly, the east and west line near Winnipeg and the eastward line from Vancouver, will form part of a trans-continental series, which must eventually be completed across Canada. Thirdly, the north and south line, along the 98th meridian, will form an extension of the meridional arc, which is now being measured in the United States, the prolongation of which, through Canadian territory, the Dominion Government has already been invited to undertake. It will thus be seen that this programme is so framed as to meet both the present and future requirements of the country, as far as the latter can be foreseen.

Ultimate development of triangulation of Canada

The ultimate development of the triangulation of Canada is shown in Map No. 2 annexed to this report. This programme contemplates a longitudinal arc of primary triangulation across Canada, immediately north of the 49th parallel. The completion of such an arc would be a valuable contribution to geodetic knowledge, and would tie together the work in different parts of the Dominion in a more satisfactory manner than could be attained by relying only on the secondary series. At the same time it may be noted that, even in a distance of 2,500 miles, the probable deviation of the end of a chain of secondary triangulation from its true position is only 90 yards, equivalent to [illegible]th of an inch upon the 1-inch scale, *see* Appendix IV.

Extension of survey to maritime provinces.

The extension of the survey to New Brunswick and Nova Scotia presents considerable difficulties, and it may be noted that, unless a much larger annual grant than is here contemplated is available for the survey, it must, under the most favourable circumstances, be many years before this part of the work can be done.

It is, at the same time, most desirable that a topographical map of the two maritime provinces should be prepared and issued at as early a date as practicable. It is recommended that this be accomplished by utilizing the surveys made by the Geological Survey Department. These, if revised upon the ground, without, however, any attempt at rigorous accuracy, and, with the addition of approximate contours, for which the fundamental levels could be taken from the railway profiles, might be made into a serviceable, preliminary, topographical map.

Technical details of survey.

The full technical details of the actual survey, both as regards the triangulation and topography, are set out in Appendix I.

Style of finished maps.

It is of considerable importance that the finished maps should be issued in a clear and attractive form. The following may be taken as a guide for the principal details:-

Scale	½ inch to a mile.
Size of sheets . .	1° in longitude by 30′ in latitude.
Projection . .	Conical, with rectified meridians; the two standard parallels being so selected that the greatest linear scale error is a minimum.*
Contours	At 100 ft. vertical intervals.
Colours	Black, for detail and lettering. Blue, for water. Brown, for contours and metalled roads. Green, for wooded areas.

As the map will be of a permanent nature, and not liable to future alterations, except to add new buildings, roads, railroads, &c., as necessity arises, it is recommended that it be prepared by engraving upon copper plates.

Ultimately, as the survey work develops, it will be desirable that the department should undertake its own engraving and printing. For the first few years this work might be done by private firms.

Staff of Survey Department.

As regards the personnel of the department, the following may be taken as the minimum establishment with which the work could be satisfactorily started:—

(*a*.) Head-quarter offices, comprising—

- 1 Superintendent.
- 1 Assistant Superintendent.
- 1 1st class assistant.
- 1 draughtsman.
- 1 clerk and computer.
- 1 clerk (stenographer and typist).

(*b*.) A trigonometrical party, comprising

- 3 1st class assistants.
- 1 clerk and computer.
- 20 labourers and lampmen (9 months only).

(*c*.) Two topographical parties, each comprising—

- 2 1st class assistants.
- 6 2nd class assistants.
- 4 labourers (9 months only).

(The 1st class assistants would do the topographical triangulation, and the 2nd class assistants the detail work).

* The selection of the best projection is of no great importance as regards these individual sheets, for which all conical or polyconical projections are sensibly the same. It must, however, be borne in mind that general maps, upon small scales, say 8 miles to an inch, and 1 : 1,000,000, will be required, and the projection should be so selected that these can be prepared by direct reduction.

Annual cost.

The annual cost of a department organized upon these lines would be 75,000 dollars. For full details, *see* Appendix II.

Special qualifications of staff.

As to the special qualifications of the above staff, it may be noted that the 1st class assistants should be men well trained in the practice and theory of survey work and should, if possible, have had some years previous experience in the field. The 1st class assistant at head-quarters would be charged with the duty of the examination and final revision of all the computations, and must be a good mathematician The 2nd class assistants should be trained in detail surveying by means of the plane table, but might be young men without previous practical experience.*

Instrumental equipment.

The full details of the instrumental and other equipment required at the starting of the survey, together with their cost, are given in Appendix III.

Astronomical work.

No provision is made for the Survey to carry out any astronomical work. It is assumed that this could be done by the staff of the Dominion Astronomer.

Annual output of work.

The output of work of such a department would be about 250 linear miles of main triangulation, and 7,500 square miles of tertiary triangulation and topography† per annum.

Cost of finished map per square mile.

The average cost of the finished map would, therefore, be 10 dollars per square mile.

Comparative cost of 1-inch and ½-inch surveys.

It will be interesting to compare this cost with that of a similar map on the 1-inch scale.

The output of work upon this scale, of a single topographer, may be taken as 1 square mile per working day. In order, therefore, to get the same total annual output of mapping, we should have to employ six topographical parties of the same strength as before. As the area covered in the year would remain the same, the triangulation party would not be affected. The staff at head-quarters might also remain the same, except that it would be necessary to add three draughtsmen.

The additional staff required would therefore be :—

8 1st class assistants.
24 2nd class assistants.
16 labourers.
3 draughtsmen.

The extra cost of this staff in salaries, would be about 48,000 dollars, and the extra expenses for transportation, subsistence in field, map engraving, &c., about 47,000 dollars, making the total additional expense 95,000 dollars.

The new department would, therefore, cost 170,000 dollars per annum, and as its output of work would be the same area of ground as before, *i.e.* 7,500 square miles, the cost of the 1-inch map would work out to 23 dollars per square mile.

Some economies might be effected, notably in the item of map engraving, by the fact that a larger quantity of work would have to be handled and might, therefore, be done at a somewhat smaller proportionate cost, but it is not probable that the expense of a 1-inch survey could be reduced to less than 20 dollars per square mile. It would, therefore, appear that we are amply justified in discarding the 1-inch scale for the present.

Total cost of survey of Canada.

The area of the habitable portion of the Dominion of Canada, taking this as limited by a line 50 miles north of the Grand Trunk Pacific Railroad line, is, roughly, 1,000,000 square miles. The total cost of the ½-inch map of the whole country would, therefore, be 10,000,000 dollars.

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* It hardly falls within the scope of this report to suggest the source from which the personnel of the Survey Department should be procured, but it may be remarked that there is no reason why the whole of the above staff should not be obtained in Canada. The 1st class and 2nd class assistants should be graduates of a good university, say Toronto, Queen's, or McGill, or of the R.M.C., Kingston.

† This is based on the assumption that a detail surveyor should do 3 square miles of ½-inch work per day, and that the field season would be 35 weeks.

When the work is once started upon systematic lines, the acceleration of any portion, or of the whole of it, would only be a matter of money, and might possibly be arranged by an agreement on the part of a Provincial Government to share the expense. Co-operation of Provincial Governments.

Thus, if any Province wished to obtain its map at an earlier date than would be otherwise practicable, it could enter into an agreement with the Survey Department to bear any specified portion of the cost, and the latter would contract to complete the map at a specified date. A similar arrangement might be made in the event of a change of scale being desired. Thus, if the Province wished for its map on the 1-inch scale, it could contribute the difference in cost between that and the ½-inch map which, as we have seen, would be about 10 dollars per square mile.

To avoid the possibility of the staff of the Survey meeting with any obstruction from landowners, they must be given a right of access to any place in the Dominion, either by statute, or by arrangement with the Provincial Governments. The best method of accomplishing this will presumably be a question for the legal advisers of the Government. Statutory right of access.

It now remains to discuss the question as to whether the Survey Department should be under civil or military control. On this point precedent is very strong. Practically all great national surveys have been carried out under military direction. This has been the case in Great Britain, France, Italy, British India and many other countries, and will now be the case in British South Africa. Question of civil or military control of Survey Department.

The only important exception is in the United States, where a mixed system of control is adopted. This does not appear to present any advantages, while exclusively civil control has, in certain cases, such for instance as the British Colonies in South Africa, resulted in a disastrous failure.

For the successful conduct of survey work a rigorous and methodical routine, combined with a quasi-military discipline, is absolutely necessary.

Such is best secured under a military organization, which will also tend to secure economy in direction and execution. The Canadian Survey should, therefore, be a branch of the military department.

In these circumstances it is desirable that the staff of the department should be Officers, a condition which could be readily met by giving them commissions in the Corps of Guides.

The Superintendent should be a Colonel, the Assistant Superintendent a Lieutenant-Colonel or Major, and the 1st and 2nd class Assistants Majors and Captains, or Captains and Lieutenants, respectively.

IV.—SUMMARY.

The conclusions and recommendations of this Report may be summarized as follows:—

1. A topographical survey of Canada is an urgent necessity for military, administrative and engineering purposes.

2. The present methods of survey in the Dominion are inefficient and costly.

3. Efficiency and economy can be combined only if the work is taken up and prosecuted upon those systematic lines of which universal experience has proved the value.

4. The minimum annual cost of an adequate survey department would be 75,000 dollars.

5. Such a department would complete the mapping of 7,500 square miles of country on the scale of ½ inch to a mile, per annum.

6. The Survey Department should be under military direction and control.

E. H. HILLS.

30th December, 1903

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APPENDIX I.

TECHNICAL DETAILS OF SURVEY WORK RECOMMENDED FOR THE SURVEY OF CANADA.

Main Triangulation Series.

Base Measurements.

Bases to be 2 to 4 miles long.

Measure with two independent sets of Chesterman steel tapes.

Stretch each length to a uniform tension of 12 lbs. on to a flat board covered with a sheet of zinc. Mark the end of each length with a knife-scratch on the metal. Use 400-ft. tape at first, then 100-ft. tape, graduated in single feet, and complete last fraction of a foot with dividers and an ordinary scale. Measure four times, twice each way, working in mornings and evenings only.

Correct measurements for—

(*a.*) Reduction to standard.

(*b.*) Inclination.

(*c.*) Temperature.

(*d.*) Height above sea level.

Mark each end of base, permanently, with heavy mark stones on surface and also another pair of stones, plumb below the upper pair, 2 feet 6 inches below surface of ground. The actual marks on the stones should be made by drilling a hole which is filled with lead. Cut a cross on the lead to mark actual centre, and also cut lines on the stone so that the centre can be recovered if the lead disappears. Fence in the ends of the base and place in charge of a responsible person. It will probably be necessary to purchase for this purpose two small plots of ground, say, 20 feet square.

There is no objection to a series of uniform slopes in the base, but no sag must be allowed on any section of the tape during measurement.

There is no objection to a *portion* of the base being along a railroad track, provided the ends are quite clear of it.

The probable error of the mean of the measurements must not exceed one part in 50,000.

Base extension.

Extend base by well-conditioned triangles to about 20 miles, making twice as many readings of each angle as in the ordinary triangulation, and observing at night only.

Triangulation.

Sides of triangles to be 10 to 30 miles.

Use Troughton & Simms' 8-inch micrometer microscope theodolites.

Observe to luminous signals, lamps or helios, (preferably Indian Survey pattern).

In cases where platforms are necessary their nature will depend upon local considerations. Thus, in a wooded country, cribwork piers, made of heavy logs, could readily be erected. Where timber is not available, brickwork piers might have to be used or, possibly, a steel frame pier might be designed which would possess sufficient rigidity and at the same time take to pieces for transportation.

The experiences of the Geodetic Survey of the United States and of the Survey of India would be of assistance in this matter.

In any case, every endeavour should be made to avoid the necessity for using platforms.

Make four readings of each station on each microscope, *i.e.*—

(*a.*) With zero at about 0 degrees, face right and left, swing right and left.

(*b.*) With zero at about 35 degrees; repeat readings.

(*c.*) With zero at about 70 degrees; repeat readings.

(*d.*) With zero at about 105 degrees; repeat readings.

Mark each station with surface and sunk mark stones as with ends of base and place in charge of a responsible person, but the points need not, in general, be fenced in.

Print the diagram of triangulation completed each year, which must have on it the following information:—

Description	..	of each station.
Latitude ..	..	
Longitude	..	
Height ..	..	
Length ..	..	of each side.
Azimuth ..	..	
Reverse azimuth		

Keep a manuscript copy of the full detailed description of each station, giving all possible information which will facilitate its recovery at any future time, in central office, and a second copy in safe custody elsewhere.

The average triangular error, allowing for spherical excess, must not exceed 5 seconds of arc.*

Astronomical work (to be done by Dominion Astronomer).

The primary base must be geodetically connected with Montreal, of which the position is well fixed, both astronomically and by the United States geodetic survey. The only astronomical work necessary at first will, therefore, be the azimuth of the base. For all other bases the azimuth of the base and the latitude and longitude of one end must be determined with the highest accuracy attainable with the instruments at his disposal.

Latitude preferably by zenith telescope.

Longitude by telegraphic exchange with observatory at Ottawa or Montreal.

Azimuth by circumpolars (4 nights' observations).

It would, in addition to the above work, be very desirable to determine the astronomical latitudes of as large a number of the principal triangulation points as possible.

Topographical Triangulation.

This will be a continuous network, covering the whole area surveyed.

Sides of triangles to be 8 to 12 miles (for ½ inch to a mile detail survey).

Use Troughton & Simms' 5-inch micrometer theodolites.

Observe, either to helios. or signals, the latter to be in the form of four-legged trestles, with an upright pole at the top, 15 to 20 feet high.

Platforms	Notes given above, in case of main triangulation, apply verbatim.
Diagram of triangulation ..	
Description of stations ..	

Make two readings of each station on each microscope, one with zero at about 0 degrees, and the second with zero at about 35 degrees.

Place sunk mark stones at every station, but it will not be practicable to take any more elaborate precautions for their recovery.

The average triangular error should not exceed 25 seconds of arc.

Detail Survey.

Use 24-inch by 18-inch plane tables, weighing about 15 lbs., with 15-inch alidades and 6-inch trough compasses.

The British service pattern plane table is not thoroughly satisfactory; a new pattern is now being experimented with. Reference should be made to the School of Military Engineering before these are purchased. It is of the utmost importance to have good plane tables: the rapidity and accuracy of the topography mainly depend upon them. Telescopic sight rules have not been used in India or British Africa. It has been considered that they take away from the simplicity of the plane table, with but little compensating advantage. They have, however, been used in the United States, so that it would be well to keep an open mind upon the question.

For contouring, use either Abney levels or Indian pattern clinometers, and aneroids.

* The labour involved in adjusting such a series by least squares is probably not worth the extra expenditure of time and money.

APPENDIX II.

ANNUAL COST OF CANADIAN SURVEY DEPARTMENT.

SALARIES.

	Number.	Annual salary.	Amount.
			dols.
Superintendent	1	4,000 dollars	4,000
Assistant Superintendent	1	3,000 „	3,000
1st class assistants	8	1,800 „ rising to 2,200 dollars ..	14,400
2nd „	12	1,000 „ „ 1,500 „ ..	12,000
Clerks	3	900 „	2,700
Draughtsman	1	1,800 „	1,800
Labourers (9 months only)	28	30 „ per month	7,560
		Total	45,460

EXPENSES.

	dols.	dols.
Transportation—		
100 dollars per annum per man, for 19 assistants and 1 clerk	2,000	
1,000 dollars per annum for Superintendent and Assistant Superintendent	1,000	
Lampmen and labourers, say	500	
Instruments and camp equipment	500	
		4,000
Subsistence of parties in the field—		
1 dollar per day per man, for 20 men for 35 weeks	4,900	
12 dollars per month per labourer, for 28 labourers for 9 months	3,024	
		7,924
Stationery and books		500
Upkeep and repair of instruments and equipment		1,000
Drawing office supplies		200
Telegrams and postage		500
Copper plate engraving and printing, 6 sheets at 1,500 dollars*		9,000
Chart paper for map printing		1,000
Erection of trigonometrical stations, materials and extra labour, say, 40 stations at 50 dollars		2,000
Contingencies, say		3,000
Total		29,124

SUMMARY OF TOTALS.

	dols.
Salaries	45,460
Expenses	29,124
Total	74,584
Say	75,000

With a slight rise in later years due to increase of salaries.

In the above estimate no allowance is made for—

Rent of offices.
Fuel, gas, and electric current.
Office furniture and fittings.

* This amount is based upon the price current in Canada. If sent to England, the work could be done at about half this cost.

It would not be necessary nor desirable to obtain the whole of the staff of the Survey Department in the first year. A progressive system should be adopted, reaching the full establishment in tho second year. Thus, in the first year, there would be to provide for—

Head-quarter offices } for whole year.
Trigonometrical party }
One topographical party, for 6 months.

In the second year, full establishment.

The total cost during the first year would be—

SALARIES.

	dols.
Superintendent and Assistant Superintendent (whole year)..	7,000
4 1st class assistants (whole year)	7,200
2 " " (6 months)	1,800
6 2nd class .. (")	3,000
2 clerks (whole year)	1,800
20 labourers (9 months)	5,400
8 " (4 ")	960
Total..	27,160

EXPENSES.

	dols.	dols.
Transportation—		
100 dollars per annum per man for 3 assistants and one clerk for whole year, and 8 assistants for 6 months	800	
Superintendent and Assistant Superintendent ..	1,000	
Lampmen and labourers, say	300	
Instruments and camp equipment	300	
		2,400
Subsistence of parties in the field—		
1 dollar per day per man, for 4 men for 35 weeks and 8 men for 17½ weeks	1,960	
12 dollars per month per labourer, for 20 labourers for 9 months and 8 for 4 months	2,544	
		4,504
Telegrams and postage..		300
Erection of trigonometrical stations		2,000
Expenses of base measurement		2,000
Initial cost of outfit, as per Appendix III.		11,500
Contingencies, say		2,000
Total..		24,704

SUMMARY OF TOTALS.

	dols.
Salaries	27,160
Expenses	24,704
Total	51,864

The Survey Department would make a small annual profit from the sale of maps. It is impossible to predict what this would amount to, and no allowance has been made for it in the foregoing estimates.

APPENDIX III.

INITIAL COST OF INSTRUMENTS, CAMP EQUIPMENT, BOOKS AND STATIONERY REQUIRED FOR CANADIAN SURVEY DEPARTMENT.

Head-Quarter Offices.

——	No.	Price in London.	Total.	Source of supply.
Instruments.		£ s. d.	£ s. d.	
Boards, drawing, 42-in. by 29-in. ..	2	0 10 0	1 0 0	Army Ordnance Department.
Compass, beam, 26-in.	1	1 16 0	1 16 0	„ „
„ proportional, 6-in... ..	1	0 16 0	0 16 0	„ „
Instruments, drawing .. boxes	2	3 16 6	7 13 0	W. H. Harling, 45, Finsbury Pavement, E.C.
Marquois scales .. .. sets	2	0 6 0	0 12 0	Army Ordnance Department.
Pantagraph, 2-ft. 6-in.	1	5 8 0	5 8 0	„ „
Parallel rulers, 18-in..	2	0 12 3	1 4 6	„ „
Protractors, brass, circular, 6-in. ..	2	0 11 8	[illegible] 3 4	„ „
Scales, plotting	6	0 2 0	0 12 0	W. H. Harling.
Straight-edges, steel, 3-ft.	2	0 7 6	0 15 0	Army Ordnance Department.
T-squares, 42-in.	2	0 3 9	0 7 6	„ „
Total	..	..	21 7 4	
Books.				
Logarithm Tables, Shortrede ..	2	2 0 0	4 0 0	Any bookseller.
„ „ Chambers ..	2	0 4 6	0 9 0	„
Wilson's Topographical Surveying..	1	0 15 0	0 15 0	„
Field Sketching, Manual of	2	0 3 0	0 6 0	H.M. Stationery Office.
Topographical Survey, Text book of	2	0 5 0	0 10 0	„ „
Nautical Almanac	4	0 2 6	0 10 0	„ „
Survey Tables, School of Military Engineering.	2	Free	..	School of Military Engineering, Chatham.
Pamphlets, various, ditto	12	„	..	„ „
Handbook, Trigonometrical Branch, Survey of India.	1	0 6 0	0 6 0	Surveyor-General of India, Calcutta.
Handbook, Topographical Branch, ditto.	1	0 4 0	0 4 0	„ „
Auxiliary tables, ditto	1	0 4 0	0 4 0	„ „
Vols. I. and II., G.T. Survey of India	1	Free	..	„ „
Last Annual Report, ditto	1	„	..	„ „
Chauvenet's Astronomy, Vols. I. and II.	1	1 10 0	[illegible] [illegible] 0	J. B. Lippincott, Philadelphia.
Report on Geodetic Survey of South Africa.	1	Free	..	H.M. Astronomer, Cape Town.
Report on Geodetic and Topographic Survey, United States.	1	Free (?)	..	
Hints to Travellers	1	0 15 0	0 15 0	Royal Geographical Society, 1, Savile Row, W.
Total	..	..	9 9 0	

——		No.	Source of supply.
Stationery.			
Paper, Whatman's drawing, double elephant	.. sheets	50	
„ logarithm	.. quires	8	
„ tracing, continuous roll, 36-in. wide ..	.. yds.	50	
„ section, „ „ „ ..	.. „	50	
„ foolscap, white, ...	.. quires	100	
„ note, official	.. „	100	
Scratch books, various sizes	..	50	
Envelopes, various sizes	..	2,000	

——		No.	Source of supply.
Stationery—continued.			
Cloth, tracing, continuous roll, 36-in. wide	yds.	100	
Pencils, various	dozs.	20	
Penholders	"	4	
Pens, drawing	"	6	
Nibs, writing	"	6	
" drawing	"	6	
Drawing pins	boxes	6	
Diamonds		2	
Note books		6	
Colour boxes		3	
Knives, pen		4	
" paper		4	
Scissors	pairs	4	
String	balls	12	
Tape	reels	6	
Indiarubber	pieces	12	
Paper weights		24	
" fasteners	boxes	3	
" punches		2	
Indiarubber stamps, various		6	
Saucers, ink and paint		24	
Ink, Indian	sticks	12	
" Higgins'	bottles	24	
Paste	"	3	
Gum	"	3	
Glue	lbs.	12	
" pot		1	
Brushes, paint		24	
" gum		6	
" glue		6	
Linen, mounting, 18-in. wide	yds.	250	
Calculation forms, various		1,000	School of Military Engineering, Chatham.

Total cost, say .. .. 40*l.*

Summary for Head-quarters.

	£	s.	d.
Instruments	21	7	4
Books	9	9	0
Stationery	40	0	0
Total	70	16	4

Trigonometrical Party.

——	No.	Price in London. £	s.	d.	Total. £	s.	d.	Source of supply.
Instruments.								
Theodolites, micrometer microscope, 8-inch, reading to 1 arc, object glass 1¾ inches, focal length 13 inches, with braced stand, Fig. 8 in catalogue.	2	100	0	0	200	0	0	Troughton & Simms, 138, Fleet Street, E.C.
Leather carrying cases	4	4	0	0	16	0	0	" "
Level, Cooke's reversible, 12-inch, without compass.	1	13	10	0	13	10	0	T. Cooke & Sons, Buckingham Works, York.
Levels, stave, 18-ft.	2	3	3	0	6	6	0	" "
Lamps, reflector, parabolic, Survey of India pattern.	10	7	0	0	70	0	0	Could be made locally.
Heliotropes, 8-in. Indian pattern, for use with ditto.	10							
Tapes, steel, 100-ft., Chesterman's special, fine.	2	6	0	0	12	0	0	Chesterman, Sheffield.
Tapes, steel, 100-ft.	4	1	10	0	6	0	0	" "
Thermometers, in lined brass tubes	4	0	7	6	1	10	0	Elliott Brothers, 36, Leicester Square, W.C.
Telescopes, Steward's, two eye-pieces, powers 15 and 35, 2-inch object glass, with stand.	3	5	10	0	16	10	0	J. H. Steward, 406, Strand, W.C.

———	No.	Price in London.			Total.			Source of supply.
		£	s.	d.	£	s.	d.	
Barometers, aneroid, 2½-in. (with Kew certificates).	2	2	9	0	4	18	0	Short & Mason, Hatton Garden.
Tin tubes for maps, 31-in.	3	0	8	0	1	4	0	Stanley & Co., Great Turnstile.
Stationery boxes	6	2	0	0	12	0	0	,, ,,
Lamps, bull's-eye or cycle	6	0	5	0	1	10	0	Local.
Heliographs, 5-in., Mark III. ..	4	8	18	0	35	12	0	Army Ordnance Department.
Plane tables, 24-in. by 30-in., with covers, sight rules, and compasses.	4	7	0	0	28	0	0	Army Ordnance Department (through School of Military Engineering).
Instruments, drawing, in leather rolls	2	1	15	0	3	10	0	Army Ordnance Department.
Chains	2	0	7	6	0	15	0	,, ,,
Arrows .. .. sets	3	0	0	8½	0	2	1½	,, ,,
Boards, drawing, 42-in. by 29-in. ..	2	0	10	0	1	0	0	,, ,,
Parallel rulers, 18-in.	2	0	12	3	1	4	6	,, ,,
Straight edge, steel, 3-ft.	1	0	7	6	0	7	6	,, ,,
Compass, beam, 26-in...	1	1	16	0	1	16	0	,, ,,
Total	..		.		433	15	2	
Camp Equipment.								
Tents, 9-ft. by 9-ft.	8	12	0	0	96	0	0	Local; or from Silver & Edgington, 67, Cornhill, E.C.
Observatory tents	2	15	0	0	30	0	0	,, ,,
Mess boxes and cooking utensils, say					20	0	0	Local.
Camp tables	4	0	12	6	2	10	0	,,
Indiarubber sheets	4	0	7	9	1	11	0	,,
Boxes for small stores	8	0	10	0	4	0	0	,,
Camp stoves	8	2	0	0	16	0	0	,,
Cooking stoves	4	4	0	0	16	0	0	,,
Hurricane lamps	6	0	3	6	1	1	0	,,
Lanterns, square, in tin cases ..	6	0	11	0	3	6	0	,,
Camp beds	4	1	7	6	5	10	0	,,
Bedding and valises, sets	4	3	0	0	12	0	0	,,
Camp chairs	6	0	10	6	3	3	0	,,
Tools, felling, cutting, digging and masons'.	..		..		20	0	0	,,
Total	..		..		231	1	0	
Books.								
Logarithm Tables, Shortrede.. ..	4	2	0	0	8	0	0	Any bookseller.
,, ,, Chambers ..	4	0	4	6	0	18	0	,,
Barlow's Tables	2	0	3	6	0	7	0	,,
Wilson's Topographical Surveying	2	0	15	0	1	10	0	,,
Topographical Survey, Text Book of	3	0	5	0	0	15	0	His Majesty's Stationery Office.
Nautical Almanac	2	0	2	6	0	5	0	,, ,,
Survey Tables, School of Military Engineering.	4		Free			..		School of Military Engineering, Chatham.
Pamphlets, various, ditto	12		Free			..		,, ,,
Handbook, Trigonometrical Branch, Survey of India.	3	0	6	0	0	18	0	Surveyor-General of India, Calcutta.
Auxiliary Tables, ditto	3	0	4	0	0	12	0	,, ,,
Vols. I. and II., G. T. Survey of India	1		Free			..		,, ,,
Last Annual Report, ditto	1		Free			..		,, ,,
Chauvenet's Astronomy, Vols. I. and II.	1	1	10	0	1	10	0	J. B. Lippincott & Co., Philadelphia.
Report on Geodetic Survey of South Africa.	2		Free			..		His Majesty's Astronomer, Cape Town.
Report on Geodetic and Topographic Survey, United States.	1		Free (?)			..		
Total	..		..		14	15	0	

—		No.	Source of supply.
Stationery.			
Paper, drawing, Whatman's, double elephant	sheets	30	
„ logarithm	quires	30	
„ tracing, 40-in. by 36-in.	sheets	30	
„ foolscap, white	quires	50	
„ note, official	„	50	
Cloth, tracing, 36-inch	yds.	30	
Scratch books, various sizes		36	
Envelopes, various sizes		1,200	
Pencils, various	dozs.	12	
Indiarubber	pieces	12	
Penholders		48	
Pens, drawing		48	
Nibs, writing	dozs.	8	
„ drawing	„	8	
Ink pellets	boxes	12	
Diaries		4	
Drawing pins	boxes	6	
Note books		24	
Knives, pocket		8	
Paper weights		20	
„ fasteners	boxes	6	
String	balls	4	
Calculation forms, various		1,000	School of Military Engineering, Chatham.
G.T. Survey of India forms, various		200	Surveyor-General of India, Calcutta.
Angle book forms, G.T. Survey of India		4	„ „

Total, say, 25*l.*

Summary for Trigonometrical Party.

	£	*s.*	*d.*
Instruments	433	15	2
Camp equipment	231	1	0
Books	14	15	0
Stationery	25	0	0
Total	704	11	2

Topographical Parties (Each).

—	No.	Price in London. £	*s.*	*d.*	Total. £	*s.*	*d.*	Source of supply.
Instruments.								
Theodolites, micrometer microscope, 5-inch, Number 38c in catalogue.	2	42	0	0	84	0	0	Troughton & Simms, 138, Fleet Street, E.C.
Leather carrying cases	2	4	7	0	8	14	0	„ „
Tapes, steel, 100-ft	4	1	10	0	6	0	0	Chesterman Sheffield.
Compasses, prismatic, 3½-in.	8	3	15	0	30	0	0	Elliott Brothers, 36, Leicester Square, W.C.
Thermometers, in lined brass tubes	12	0	7	6	4	10	0	„ „
Barometers, aneroid, 2½-in. (with Kew certificates).	8	2	9	0	19	12	0	Short & Mason, Hatton Garden.
Ditto, 4-in.	2	4	15	0	9	10	0	Casella & Co., 147, Holborn Bars.
Heliotropes	4	2	0	0	8	0	0	Stanley & Co., Great Turnstile.
Subtense bars	4	1	0	0	4	0	0	„ „
Stationery boxes	8	2	0	0	16	0	0	„ „
Perambulator	1	9	0	0	9	0	0	„ „
Tin tubes for maps, 31-in.	12	0	8	0	4	16	0	„ „
Instruments, drawing, superior, box	1	3	16	6	3	16	6	W. H. Harling, 45, Finsbury Pavement, E.C.

——	No.	Price in London. £	s.	d.	Total. £	s.	d.	Source of supply.
Scales, plotting	32	0	2	0	3	4	0	W. H. Harling, 45, Finsbury Pavement, E.C.
Field glasses, Zeiss, 8 diameters ..	8	8	0	0	64	0	0	W. Watson & Sons, High Holborn.
Lamps, bull's-eye or cycle	4	0	5	0	1	0	0	Local.
Heliographs, 5-in., Mark III. ..	4	8	18	0	35	12	0	Army Ordnance Department.
Plane tables, 18-in. by 24-in. ..	10	3	5	0	32	10	0	" " (*See* note in Appendix I.)
Plane table covers	10	0	4	3	2	2	6	Army Ordnance Department.
" sight rules, 15-in. ..	10	1	5	0	12	10	0	" "
" trough compasses, 6-inch	10	1	0	2	10	1	8	" "
Plane tables, portable, 18-in. by 18-in., Mark I.	2	3	0	0	6	0	0	" "
Clinometers, Indian pattern	8	3	0	0	24	0	0	" "
Abney levels	8	1	2	3	8	18	0	" "
Instruments, drawing, in leather rolls	8	1	15	0	14	0	0	" "
Chains	4	0	7	6	1	10	0	" "
Arrows .. .. .. sets	4	0	0	8½	0	2	10	" "
Boards, drawing, 42-in. by 29-in. .	8	0	10	0	4	0	0	" "
Compasses, beam, 26-in.	2	1	16	0	3	12	0	" "
" proportional, 6-in. ..	2	0	16	0	1	12	0	" "
Marquois scales .. .. sets	4	0	6	0	1	4	0	" "
Pantagraph, 2-ft. 6-in.	1	5	8	0	5	8	0	" "
Parallel rulers, 18-in...	12	0	12	3	7	7	0	" "
Protractors, brass, circular, 6-in. ..	8	0	11	8	4	13	4	" "
" cardboard, 12-in. ..	24	0	1	10	2	4	0	" "
Straight-edges, steel, 3-ft.	3	0	7	6	1	2	6	" "
T-squares, 42-in.	2	0	3	9	0	7	6	" "
Total	..	..			454	19	10	
Camp Equipment.								
Tents, 9-ft. by 9-ft.	8	12	0	0	96	0	0	Local; or from Silver & Edgington, 67, Cornhill, E.C.
Mess boxes and cooking utensils, say	..	..			20	0	0	Local.
Camp tables	8	0	12	6	5	0	0	"
Indiarubber sheets	8	0	7	9	3	2	0	"
Boxes for small stores	16	0	10	0	8	0	0	"
Camp stoves	8	2	0	0	16	0	0	"
Cooking stoves	2	4	0	0	8	0	0	"
Hurricane lamps	8	0	3	6	1	8	0	"
Lanterns, square, in tin cases ..	8	0	11	0	4	8	0	"
Camp beds	8	1	7	6	11	0	0	"
Bedding and valises, sets	8	3	0	0	24	0	0	"
Camp chairs	16	0	10	6	8	8	0	"
Tools, felling, cutting, digging, and masons'.	..	..			10	0	0	"
Total	..	..			215	6	0	
Books.								
Logarithm Tables, Shortrede ..	2	2	0	0	4	0	0	Any bookseller.
" " Chambers ..	1	0	4	6	0	18	0	"
Field Sketching, Manual of	2	0	3	0	0	6	0	His Majesty's Stationery Office.
Topographical Survey, Text Book of	8	0	5	0	2	0	0	" "
Survey Tables, School of Military Engineering.	4	Free			..			School of Military Engineering, Chatham.
Pamphlets, various, ditto . ..	12	..			..			" "
Handbook, Topographical Branch, Survey of India.	2	0	4	0	0	8	0	Surveyor-General of India, Calcutta.
Hints to Travellers	1	0	15	0	0	15	0	Royal Geographical Society, 1, Savile Row, W
Total	..	..			8	7	0	

—		No.	Source of supply.
Stationery.			
Paper, drawing, Whatman's, double elephant	sheets	50	
„ logarithm	quires	8	
„ section, continuous roll	yds.	50	
„ tracing, 40-in. by 36-in.	sheets	50	
„ foolscap, white	quires	50	
„ note, official	„	50	
Cloth, tracing, 36-in.	yds.	50	
Scratch books, various sizes		36	
Envelopes, various sizes		1,200	
Pencils. various	dozs.	20	
Indiarubber	pieces	36	
Penholders		48	
Nibs, writing	dozs.	8	
„ drawing	„	8	
Pens, drawing		48	
Drawing pins	boxes	6	
Colour boxes		8	
Brushes		24	
Ink, pellets	boxes	18	
Diaries		8	
Traverse books		48	
Note books		48	
Knives, pocket		16	
Paper weights		40	
„ fasteners	boxes	6	
String	balls	4	
Calculation forms, various		1,000	School of Military Engineering, Chatham.
Angle books		12	„ „

Total, say, 40*l.*

SUMMARY FOR ONE TOPOGRAPHICAL PARTY.

	£	s.	d.
Instruments	454	19	10
Camp equipment	215	6	0
Books	8	7	0
Stationery	40	0	0
Total	718	12	10

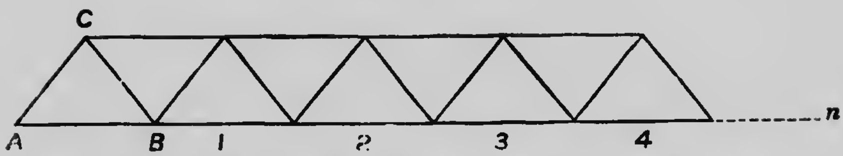
GENERAL SUMMARY.

	£	s.	d.
Head-quarter offices	70	16	4
Trigonometrical party	704	11	2
Two topographical parties	1,437	5	8
Total	2,212	12	2
Packing, insurance and transportation to Canada, say	80	0	0
Total cost of equipment, say	2,300	0	0

Say, 11,500 dollars.

APPENDIX IV.

ON THE ERRORS OF A SYSTEM OF TRIANGULATION.



If we measure a base line, AB, and from that base extend a chain of triangles in a given direction, the deviation of the end of the chain from its true position will be compounded of—

(*a*.) A lateral deviation due to errors in the angular measurements.

(*b*.) A longitudinal deviation, due to error in the base measurement.

(*c*.) A longitudinal deviation due to errors in the angular measurements.

To arrive at the probable amount of these deviations we have—

(a.) *For the lateral deviation.*

Let the probable error of any angle in a triangle be p seconds.
Then the error in the direction of side 1 is $p\sqrt{3}$
" 2 is $p\sqrt{3\times 2}$
" n is $p\sqrt{3n}$.

Hence, if m be the average length of a side in miles, the deviation at the end of side n

$$= \frac{mp\sqrt{3}}{40}\sqrt{\frac{n(n+1)}{2}} \text{ feet,}$$

or if L = the length of the chain in miles

$$= Lp \times \cdot 03 \text{ feet, nearly.}$$

NOTE.—The value of p may be deduced from Ferrero's formula:—

$$p = \cdot 67\sqrt{\frac{\Sigma\Delta^2}{3N}}$$

where $\Sigma\Delta^2$ = the sum of the squares of the triangular errors. N = the number of triangles = $2n + 1$.

(b.) *For the longitudinal deviation due to error in base.*

Here the error of the chain will be directly proportional to the error in the base. Hence, if e be the probable error of the base measurement, in feet per mile:

Probable error at end of chain = Le feet.

(c.) *For the longitudinal deviation due to angular errors.*

In any given triangle, ABC, the probable error of the side a

$$= \frac{1}{3}ap\sqrt{6}\sqrt{\cot^2 A + \cot A \cot C + \cot^2 C}$$

(*Vide* Art. Geodesy, "Encyclopædia Britannica"), which, if the triangle be equilateral,

$$= mp\sqrt{\frac{2}{3}}\sin 1'' \text{ feet.}$$

Hence, probable error

$$\text{of side } 1 = mp \sqrt{\frac{2}{3}} \sin 1'' \sqrt{3}$$

$$\text{,, } n = mp \sqrt{\frac{2}{3}} \sin 1'' \sqrt{2n+1}$$

and total probable error at end of chain

$$= mp \sin 1'' \sqrt{\frac{2}{3}} \sqrt{n(n+2)}$$

$$= Lp \sin 1'' \sqrt{\frac{2}{3}} \text{ nearly}$$

$$= \cdot 02 \times Lp \text{ feet.}$$

Hence the total probable longitudinal deviation, due to both angular and base errors,

$$= L \sqrt{e^2 + (p \times \cdot 02)^2} \text{ feet.}$$

NOTE.—This investigation, in the case of the longitudinal deviation due to angular errors, is based upon the assumption that all the triangles are equilateral. Should this not be the case, the probable error would increase. In practice, however, this would be more than compensated by the fact that such a chain would never be a single chain throughout its length. For any portion of the chain which is double the probable errors would be considerably smaller, so that we may fairly assume that the deduced probable error of a single chain of equilateral triangles is closely approximate to, if not larger than, that which would be obtained in practice.

To apply the above to the case of a chain of secondary triangulation, such as proposed for the Canadian survey, where

$$p = 2$$
$$e = 0 \cdot 1.$$

Probable lateral error at end of 500 miles,

$$= 500 \times 2 \times \cdot 03$$
$$= 30 \text{ feet.}$$

Probable longitudinal error

$$= 500 \sqrt{0 \cdot 01 + 4 \times \cdot 0004}$$
$$= 500 \sqrt{0 \cdot 0116}$$
$$= 54 \text{ feet.}$$

In the case of the topographical triangulation—

$$p = 10$$
$$e = \frac{54}{500} = 0 \cdot 11$$

Probable longitudinal error at end of 200 miles

$$= 200 \sqrt{0 \cdot 0121 + 100 \times \cdot 0004}$$
$$= 200 \sqrt{0 \cdot 0521}$$
$$= 45 \text{ feet.}$$

As, furthermore, this triangulation will be in the form of a continuous network, the actual error will be less than this. We are, therefore, justified in concluding that, if the whole of the area which it is desired to survey be within 200 miles of a main line of triangulation, the probable error in the position of any point will be imperceptible upon the scale of 1 inch to a mile.

APPENDIX V.

SUMMARY OF THE TOPOGRAPHICAL MAPS OF VARIOUS COUNTRIES.

The following list gives the scales and other features of the principal topographical maps of a few countries. For full details of all such maps reference must be made to "A guide to recent large scale maps," by A. Knox, B.A., published by the Intelligence Division, War Office, in 1899:—

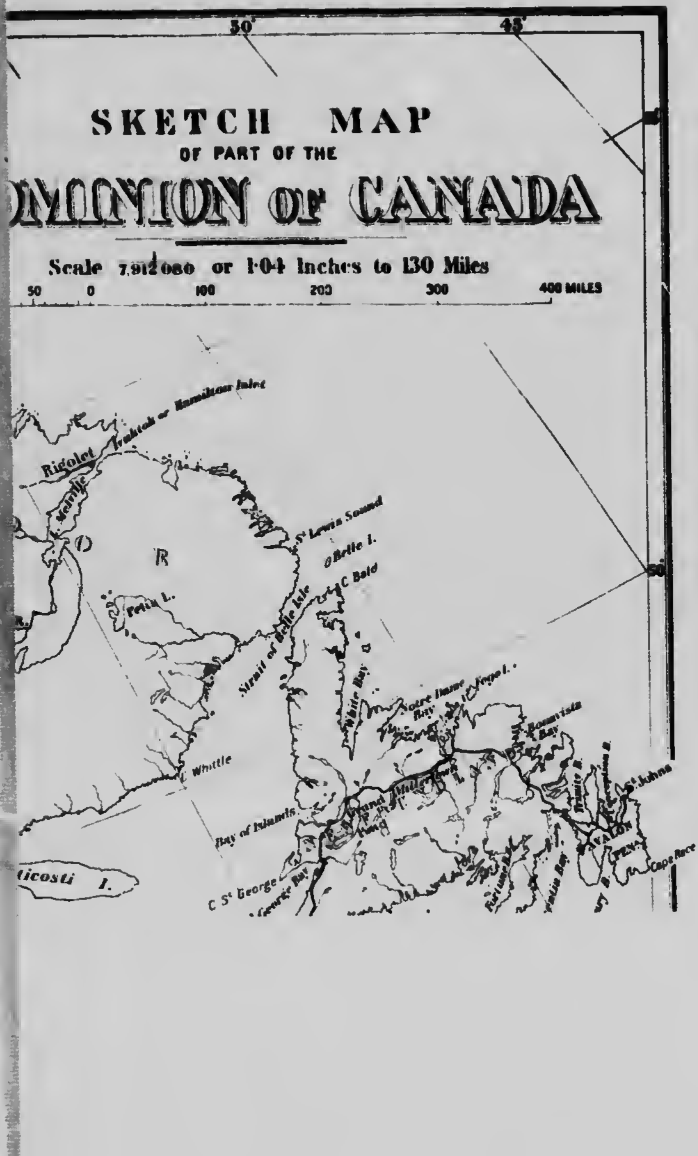
Country.	Scale.	Representation of form of ground.	Size of sheets (without margin).
Austria ..	$\frac{1}{75,000}$	Contours at 100 metre vertical intervals and vertical hachures, in black.	20 by 15 inches, or 30' longitude by 15' latitude.
Belgium ..	$\frac{1}{40,000}$	Contours at 5 metre vertical intervals, in black.	32½ by 21 inches.
	$\frac{1}{160,000}$	Contours at 20 metre vertical intervals or shading (two separate editions of map).	25 by 24 inches.
France.. ..	$\frac{1}{80,000}$	Vertical hachures, in black ..	18¼ by 10¾ inches.
	$\frac{1}{200,000}$	Stump shading	22¼ by 17¼ inches.
Germany ..	$\frac{1}{100,000}$	Vertical hachures, in black ..	13¼ by 11½ inches, or 30' longitude by 15' latitude.
Great Britain ..	$\frac{1}{63,360}$	Contours at 100 ft. vertical intervals and vertical hachures, in black.	18 by 12 inches.
India	$\frac{1}{63,360}$	Horizontal form lines, in black .	30 by 17 inches.
	$\frac{1}{253,440}$	Vertical hachures, in black ..	19 by 12 inches.
Italy	$\frac{1}{100,000}$	Contours at 50 metre vertical intervals and vertical hachures, in black.	15 by 14½ inches, or 30' longitude by 20' latitude.
Netherlands ..	$\frac{1}{200,000}$	Vertical hachures, in black ..	13½ by 11 inches.
Russia	$\frac{1}{126,000}$	Vertical hachures, in black ..	22¼ by 16½ inches.
	$\frac{1}{420,000}$	Vertical hachures, in brown ..	25 by 19 inches.
Spain ..	$\frac{1}{50,000}$	Contours at 20 metre vertical intervals.	22 by 14½ inches, or 20' longitude by 10' latitude.
United States..	$\frac{1}{250,000}$, $\frac{1}{125,000}$ or $\frac{1}{62,500}$, according to importance of district.	Contours at from 20 ft. to 200 ft. vertical intervals, in brown.	17½ by 14 inches, or 15' longitude by 15' latitude for the $\frac{1}{62,500}$ scale.

It will be observed that in countries where the metric system of measures is in use, maps are constructed upon "natural" scales, *i.e.* scales in which the denominator of the fraction is an integral number of thousands.

This system has been sometimes advocated for countries using British measures, and has been partially adopted in the United States, where the scale of $\frac{1}{62,500}$ is used in place of 1 inch to a mile, or $\frac{1}{63,360}$, and $\frac{1}{125,000}$ in place of ½ inch to a mile, and so on.

A natural scale presents no advantages in these circumstances. In countries where metres and kilometres are in common use, a decimal map scale is simple, and readily understood by anyone using the map. The case is quite different where distances are measured by miles and inches. In such circumstances, the statement that a map is on the scale of 1 inch, or any fraction of an inch, to a mile, at once calls up a definite mental picture of the relationship between the length on the map and that on the ground, in terms of the most familiar units. For all such countries it is therefore unquestionably preferable to use a scale of fractions of an inch to a mile, and the topographical map of Canada should hence be on the scale of ½ inch to a mile or $\frac{1}{126,720}$, not $\frac{1}{125,000}$.

MAP I.


SKETCH MAP
OF PART OF THE
OMINION OF CANADA
Scale 7,912080 or 1·04 Inches to 130 Miles
50 0 100 200 300 400 MILES
50°
45°
Rigolet
St Lewis Sound
Belle I.
C Bold
Strait of Belle Isle
C. Whittle
Bay of Islands
C St George
Notre Dame Bay
White Bay
Bonavista Bay
St Johns
AVALON
Cape Race
ticosti I.

To accompany Report on Survey of Canada by Major E. H. Hills, C. M. G., R. E.

I D W O Nº 1799

R. E.

110
105
100
95
90
85
80
75
70
Southampton I.
Fisher Strait
Mansell I.
HUDSON
C. Jones
Pistol Bay
Mistake Bay
C. Esquimaux
HUDSON
BAY
Mosquito B.
Ottawa Is.
C. Dufferin
Leaf L.
C. Churchill
Fort Churchill
Athabasca Lake
Black L.
Wollaston L.
Reindeer Lake
N. Indian L.
Churchill R.
South Indian Lake
C. Tatnam
York Factory
Granville L.
Burntwood R.
Nelson R.
Hayes R.
Severn Fort
Richmond Gulf
Little Whale R.
Great Whale R.
C. Henrietta Maria
Lac la Ronge
Montreal L.
Goose L.
Island L.
Severn R.
Trout L.
Ekwan R.
Attawapiskat R.
JAMES
BAY
Ft. Albany
East Main R.
Prince Albert
Saskatchewan R.
Battleford
Moose L.
Cedar L.
Norway Ho.
Sandy L.
Winnipegosis L.
Ft. Pelly
Dauphin
St. Martin
Manitoba
MANITOBA
L. St. Joseph
Albany R.
Moose Factory
Rupert Ho.
Rupert R.
Regina
Moose Jaw
Souris R.
Lac Seul
L. Nepigon
Moose R.
Abitibi R.
L. Abitibi
Devils L.
Red R.
Red L.
Rainy R.
Rainy L.
Ft. William
I. Royale
White River
Chapleau
L. Temiscaming
LAKE SUPERIOR
Bismarck
Duluth
Little Missouri R.
Cheyenne R.
Pierre
Minneapolis
St. Paul
Mississippi R.
Missouri R.
Niobrara R.
Sioux City
Madison
Milwaukee
L. MICHIGAN
Chicago
Green Bay
Georgian Bay
Parry Sound
LAKE HURON
ONTARIO
Niagara
Rochester
Buffalo
Port Huron
Detroit
LAKE ERIE
Cleveland
105
100
95
90
85
80

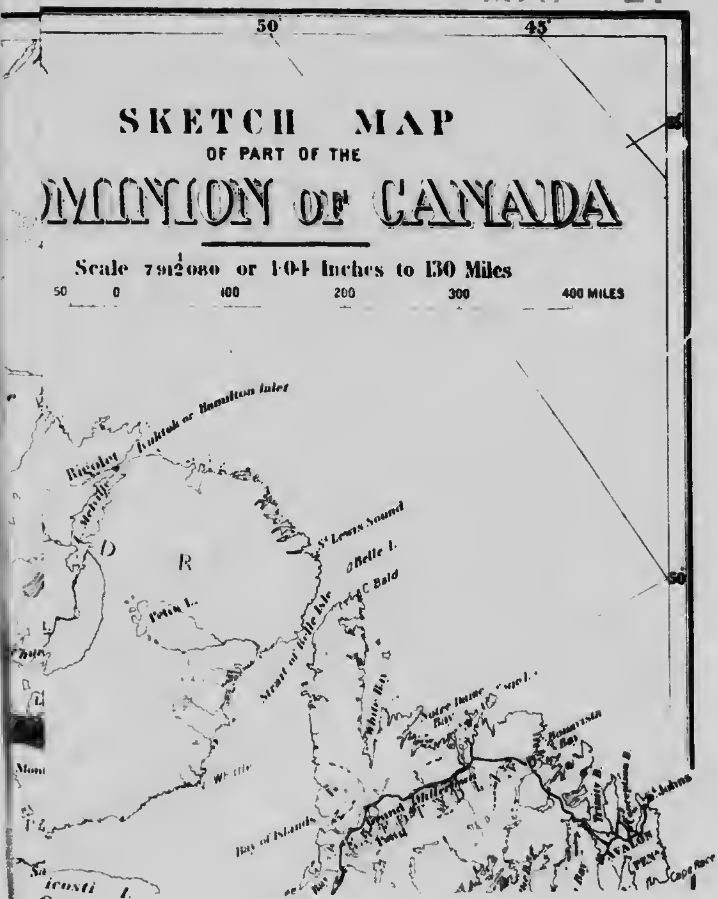
G., R. E.


110
105
100
95
90
85
80
75
70
Southampton I.
Fisher Strait
HUDSON
C Jones
Pistol Bay
Mistake Bay
C Esquimaux
Mosquito B.
HUDSON BAY
Ottawa Is.
C Dufferin
Athabasca Lake
Chippewa
Black L.
C Churchill
Fort Churchill
Wollaston L.
Etawney L.
Churchill R.
N. Indian
Reindeer Lake
South Indian Lake
C Tatnam
York Factory
Richmond Gulf
Clear Water L.
Little Whale R.
Great Whale R.
Granville L.
La Crosse L.
Lac la Plonge
Churchill
Burntwood R.
Nelson R.
Hayes R.
Severn Fort
L. Burntwood
Lac la Ronge
Montreal L.
C Lookout
C Henrietta Maria
JAMES
Goose L.
Moose
Norway Ho.
Island L.
Cedar L.
Trout L.
Ekwan R.
Attawapiskat
Prince Albert
Saskatchewan
Battleford
BAY
Ft. Albany
East Main
Sandy L.
Winnipegosis L.
Rupert Ho.
Rupert R.
Albany R.
Moose Factory
Ft. Pelly
Dauphin
L. St. Joseph
MANITOBA
L. Manitoba
Regina
Swift Current
Moose Jaw
Lac Seul
L. Nepigon
Abittibi R.
L. Abittibi
Moose R.
White River
Chapleau
Devils L.
Red L.
Rainy L.
Ft. William
I. Royale
LAKE SUPERIOR
L. Temiscaming
Bismarck
Duluth
L. Nipissing
Georgian Bay
Parry Sound
LAKE HURON
Powder R.
Little Missouri R.
Cheyenne R.
Pierre
Minneapolis
St. Paul
MISSISSIPPI R.
L. MICHIGAN
Green Bay
Missouri R.
Madison
Milwaukee
Niobrara R.
Sioux City
Chicago
Port Huron
Detroit
LAKE ERIE
Cleveland
Buffalo
105
100
95
90
85
80

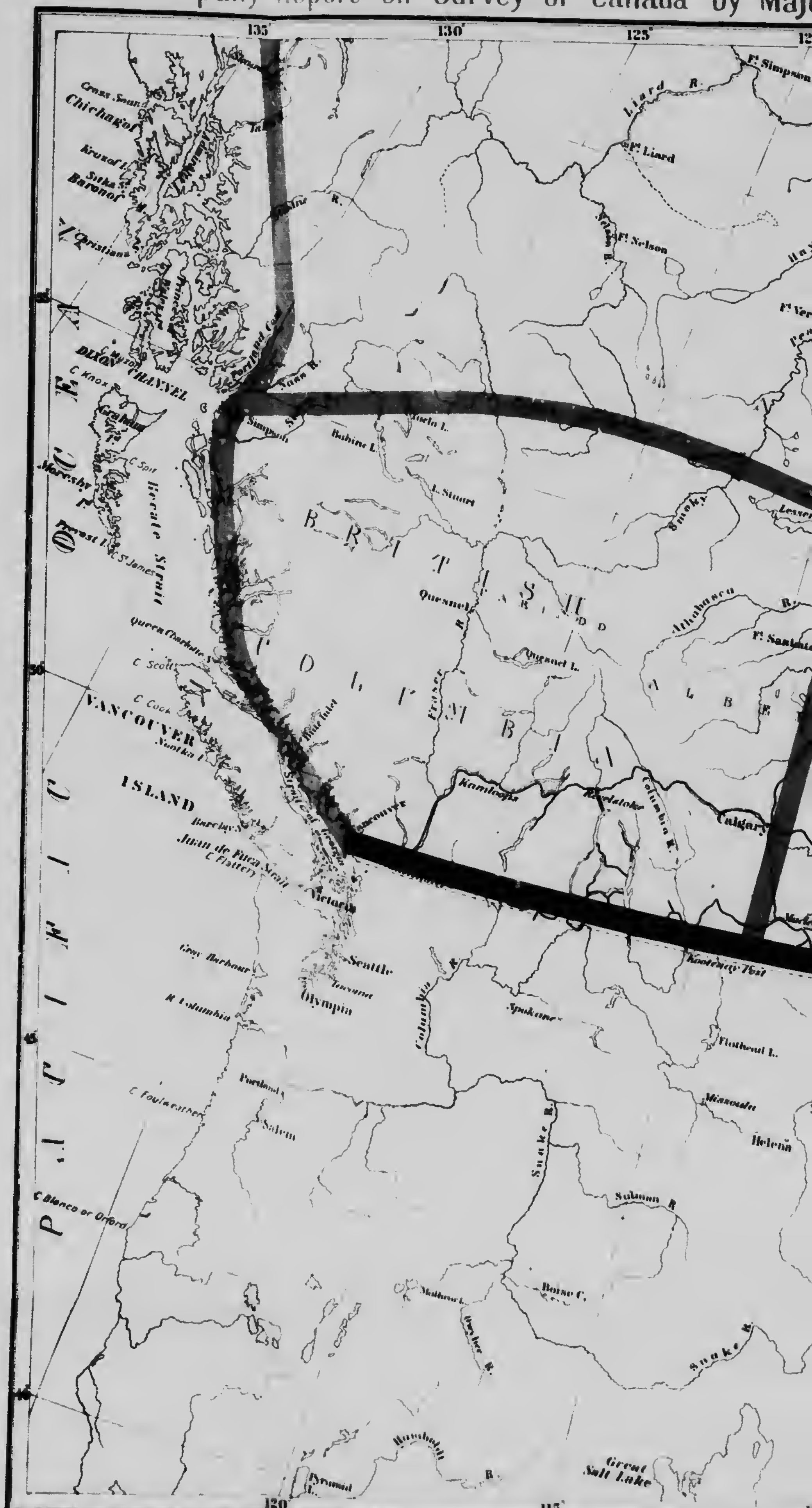
MAP I.


SKETCH MAP
OF PART OF THE
DOMINION OF CANADA
Scale 1/7912080 or 1·04 Inches to 130 Miles
MILES 100 50 0 100 200 300 400 MILES
SHEWING
TEN YEARS WORK OF THE PROPOSED
SURVEY DEPARTMENT.
Main lines of triangulation
Detail Survey on ½ inch scale
Preliminary topographical map
based on surveys by Geological Survey Dep^t
HUDSON STRAIT
UNGAVA BAY
GULF OF ST LAWRENCE
Anticosti I.
Prince Edward I.
Cape Breton Island
NEW BRUNSWICK
Bay of Fundy
Halifax
Sable I.
Quebec
Three Rivers
Montreal
L. Champlain
Burlington
Montpelier
Portland
Augusta
Boston
Albany
New Haven
Long Island
Buffalo
ONTARIO
St. Johns
Cape Race
Belle I.
Strait of Belle Isle
Bay of Islands
Cape Cod
Yarmouth

E. MAP 2.

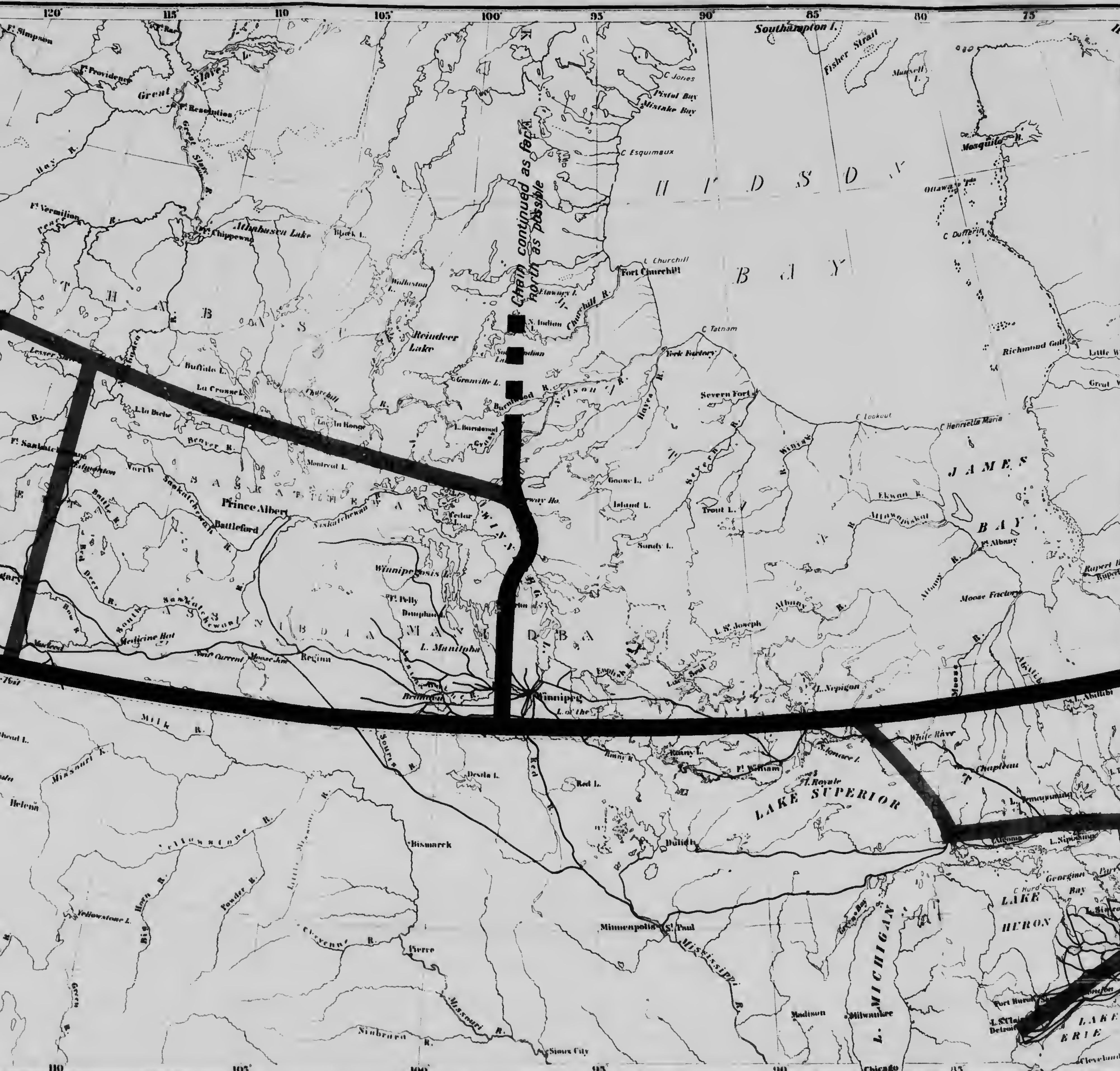

SKETCH MAP
OF PART OF THE
MINION OF CANADA
Scale 1/7912080 or 1·01 Inches to 130 Miles
50 0 100 200 300 400 MILES
50°
45°
Ivuktok or Hamilton Inlet
Rigolet
St Lewis Sound
Belle I.
C. Bald
Strait of Belle Isle
White Bay
Notre Dame Bay
Bonavista Bay
Bay of Islands
St Johns
AVALON
Cape Race

To accompany Report on Survey of Canada by Maj

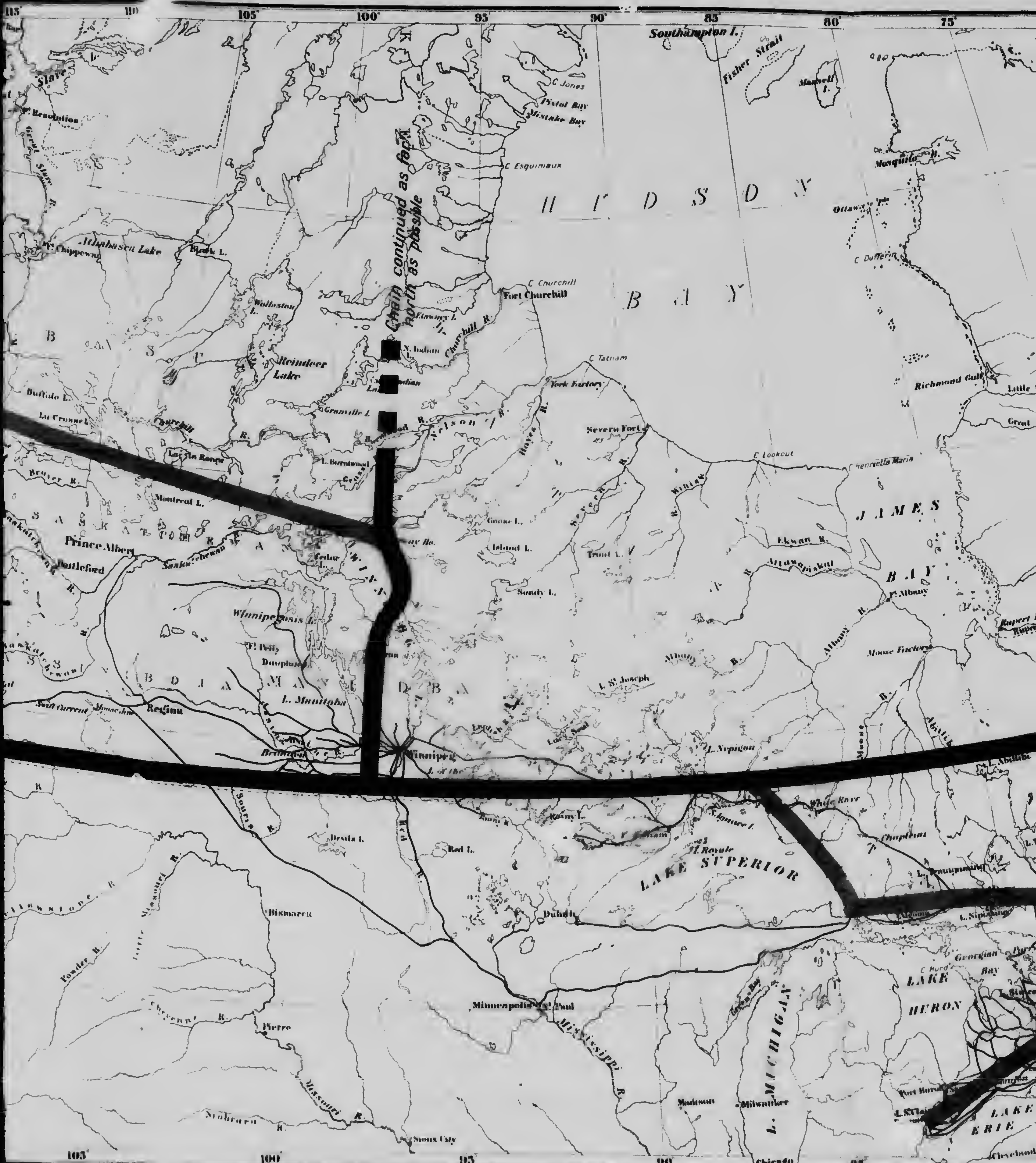


I D W.O No 1799

y Major E. H. Hills, C. M. G., R. E.

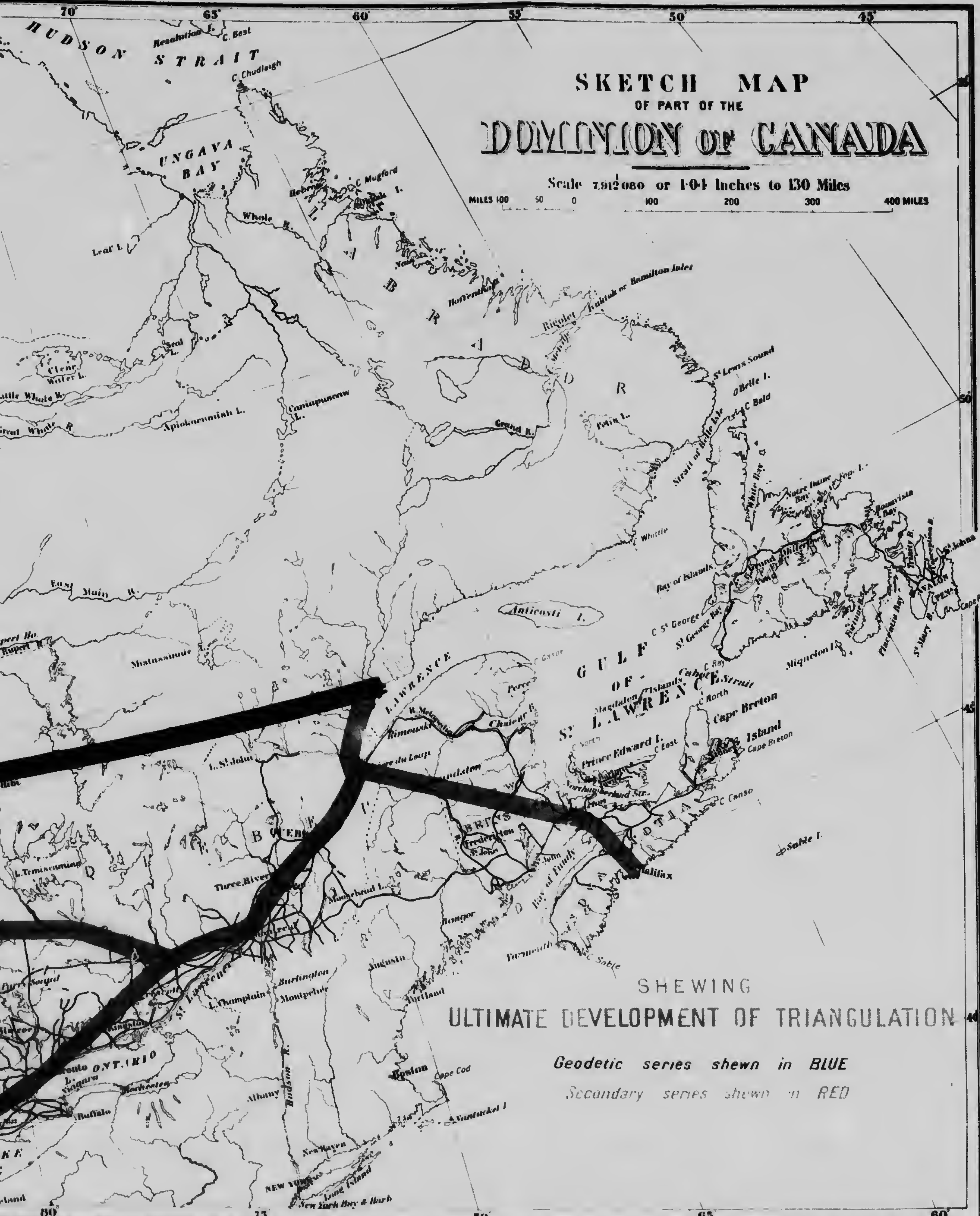


ls, C. M. G., R



115°
110
105°
100°
95°
90°
85°
80°
75°
Southampton I.
Fisher Strait
C Jones
Pistol Bay
Mistake Bay
C Esquimaux
Chain continued as far north as possible
H U D S O N
B A Y
C Churchill
Fort Churchill
Churchill R.
Athabasca Lake
Ft. Chippewayan
Black L.
Wollaston L.
Reindeer Lake
Slave
Ft. Resolution
Great Slave R.
Buffalo L.
La Crosse L.
Churchill
Beaver R.
Montreal L.
Prince Albert
Battleford
Saskatchewan R.
Winnipegosis L.
Ft. Pelly
Dauphin
L. Manitoba
Regina
Swift Current
Moose Jaw
Winnipeg
C Tatnam
York Factory
Nelson R.
Hayes R.
Severn Fort
Severn R.
Goose L.
Island L.
Trout L.
Sandy L.
L. St. Joseph
L. Nepigon
Winisk
C Lookout
C Henrietta Maria
J A M E S
B A Y
Ekwan R.
Attawapiskat
Ft. Albany
Albany R.
Moose Factory
Moose R.
Abitibi
Mosquito B.
Ottawa Is.
C Dufferin
Richmond Gulf
Rupert
Little
Great
Chapleau
White River
L. Temagaming
L. Nipissing
Georgian Bay
LAKE HURON
Port Huron
L. St. Clair
LAKE ERIE
Cleveland
LAKE SUPERIOR
I. Royale
Duluth
Red L.
Devils L.
Bismarck
Pierre
Red R.
Souris R.
Minneapolis
St. Paul
Mississippi R.
Missouri R.
Little Missouri R.
Yellowstone R.
Powder R.
Cheyenne R.
Niobrara R.
Sioux City
Madison
Milwaukee
L. MICHIGAN
Chicago
Green Bay

MAP 2.


SKETCH MAP
OF PART OF THE
DOMINION OF CANADA
Scale 1/7,912,080 or 1·04 Inches to 130 Miles
MILES 100 50 0 100 200 300 400 MILES
SHEWING
ULTIMATE DEVELOPMENT OF TRIANGULATION
Geodetic series shewn in BLUE
Secondary series shewn in RED
HUDSON STRAIT
UNGAVA BAY
GULF OF ST LAWRENCE
Anticosti I.
Prince Edward I.
Cape Breton Island
Sable I.
Halifax
Fredericton
Three Rivers
Montreal
Kingston
ONTARIO
Buffalo
Boston
Portland
Augusta
Bangor
Albany
Burlington
Montpelier
New Haven
Long Island
New York Bay & Harb
Cape Cod
Cape Race
St Johns
Miquelon Is.
Bay of Fundy
Yarmouth
C. Sable
C. Canso
C. Whittle
Strait of Belle Isle
Belle I.
C. Bald
C. Mugford
C. Chudleigh
Resolution I.
C. Best
Hudson R.
L. Champlain
Moosehead L.
L. St John
Rimouski
Chaleur B.
Magdalen Islands
Bay of Islands
Grand R.
Whale R.
Leaf L.
Clear Water L.
Seal L.
Apiskaunish L.
East Main R.
Mistassinnie
L. Temiscaming
Albany
Rochester
Nantucket I.
70 65 60 55 50 45
80 75 70 65 60