Alberta and British Columbia Boundary — Part I — 1913 to 1916

The size of the plate used is $6\frac{1}{2}''$ by $4\frac{3}{4}''$ and the lens gives very nearly a true perspective. Later, in the office, the plates are developed and bromide enlargements, $9\frac{1}{2}$ by 13 inches, are made for mapping purposes. Practically speaking they are perspectives of the views and, by means of geometric and perspective constructions, the position and altitude of points seen in them can be obtained and the contour outlines of the various topographical features drawn on the plan. It is an interesting process: landscapes seen from the dominating height of a peak show a chaos of mountains, snowfields, icefalls, forested valleys, streams and lakes—here, there, everywhere. Often from an exceptional height the irregularity and immensity of the overlook, flecked with snow and partly swathed in clouds, resembles a vast, boundless ocean in a state of turmoil. In the mapping room, this chaotic condition soon resolves itself into orderly array: fragmentary mountain ranges, valleys and streams fit together, isolated peaks assume their proper locations, and what was previously a collection of views, chiefly ups and downs, has become an instructive and accurate map showing the various topographical features as a co-ordinate whole, their extent, trend, and altitude, in addition to general geographical information, conveying many meanings of geological interest to those who have the understanding.

There are certain factors necessary to the conduct of a survey such as this, for instance: the triangulation on which the photographic work depends must start from a measured base and be expanded in sufficiently symmetrical proportions; the altitude above sea-level of one or both ends of the base must be known; and there must be independent checks on the expansion of the triangulation at sufficiently close intervals to keep the work within bounds of the limit of accuracy.

In the survey under discussion, the series of traverse lines accurately surveyed by Mr. Cautley's division across each pass furnishes a base from which to start and on which to check. These bases are connected with the Dominion system of land surveys and are as accurately fixed in position as those surveys will permit. The triangulation has been carried on at the same time as the photographing and the stations occupied have been fixed in position by reading horizontal angles, and in altitude by reading vertical angles, from one to the other. Altitudes of stations are derived originally from precise spirit-levelling along the main lines of the Canadian Pacific Railway carried from ocean to ocean. In certain cases independent checks have been made by occupying or sighting upon cairns at stations of the primary triangulation of the Railway Belt through British Columbia, made many years previously.

System of Control

The system of control employed is dependent on the Dominion Lands System of Survey. The survey of the Boundary in almost every pass that has been surveyed has been connected with points of this System, and the

latitude and longitude of the monument used as an observation station in each pass has been computed from the tables issued by the Surveyor General's office.

From the surveys of the Boundary, thus established, used as bases, the secondary triangulation system carried over the entire length of the Boundary by Mr. Wheeler has been expanded and checked at each succeeding pass.

Independent checks on his system of triangulation have been made by Mr. Wheeler by azimuth readings taken upon, or from, the various primary triangulation stations of the Railway Belt Survey, made by J. J. McArthur, D.L.S. and W. S. Drewry, D.L.S., as early as 1887.

In that part of the Boundary Survey dealt with in this first part of the Commission's report, namely from the International Boundary to the Kicking Horse Pass, the computations of elevation above sea-level of all monuments and of the mountains between passes that have been occupied as stations by Mr. Wheeler are primarily based on the track elevations obtained by the Canadian Pacific Railway Company in the Kicking Horse and Crowsnest Passes as corrected up to date. In the Akamina Pass the elevation assigned by the International Boundary Commission to their monument No. 272 was adopted as correct. It is interesting to note that the gross apparent error found by Mr. Wheeler when tying on to monument No. 272 in 1915, after having carried his trigonometric levelling survey from Crowsnest Pass—a distance of approximately fifty-three miles in an air line—was one foot.

Boundary Monuments

The concrete monument which is erected in the passes was designed by Mr. Wheeler, and, with certain modifications suggested by Mr. Cautley, has proved to be entirely satisfactory.

In essence the monument is a concrete monolith, consisting of a truncated pyramid 20 inches high, of which the bottom cross-section is 12 inches square and the top 7 inches square, having a flattish pyramidal top and set on a base 24 inches square which extends 10 inches above the ground and 36 inches into it.

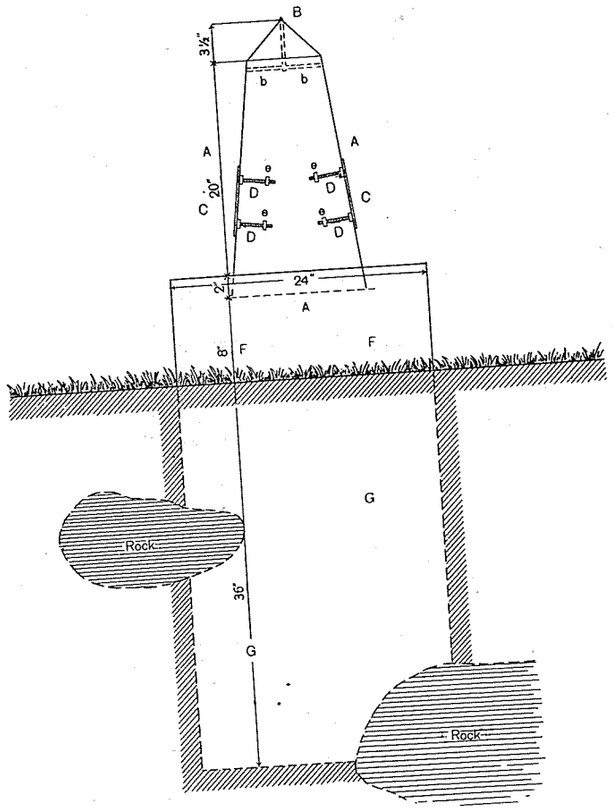
Its parts may be best described by reference to Fig. 1 as follows:—

A is a form made of heavy zinc which is filled with concrete and is the permanent outer covering of the top part of the monument.

B is an iron bar protruding through the top of the zinc form and secured in the concrete by the cross-piece (b);

CC are brass name plates about 1-8th inch thick, each of which is secured to the monument by four threaded brass bolts—DDDD—$\frac{1}{4}$ inch in diameter and $3\frac{1}{2}$ inches long. On each bolt there are two nuts, one of which is screwed up so as to hold the brass plate close to the zinc form while the concrete is setting in said form, while the other is left near the end of the bolt—as at eeee—to become embedded in concrete and act as

an anchor. The name plates are deeply etched with the names "ALBERTA" and "BRITISH COLUMBIA," respectively, at the factory, and the number of the monument and characteristic letter of each pass are similarly etched in the field as required.*



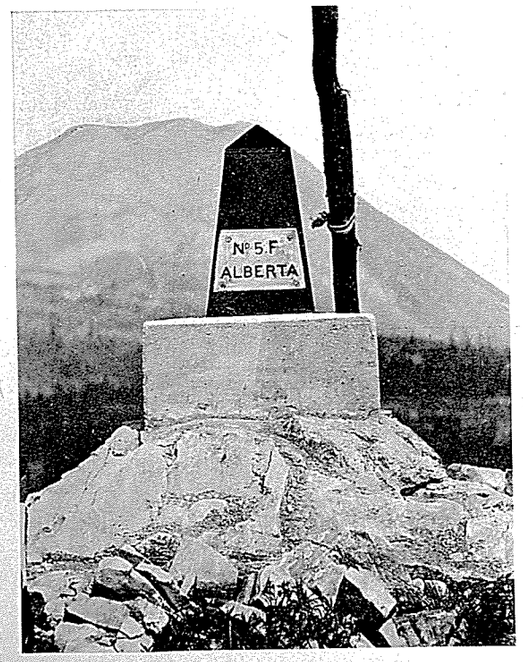
Showing Construction of Concrete Monument

FF is the top of the concrete base which is 24 inches square and extends 10 inches above the surface of the ground.

GG is the extension of the concrete base below surface level. Owing to the difficulty of packing lumber in the mountains and the impossibility of

*The name plates first designed, and used during the season of 1913 in the Kicking Horse, Vermilion and Simpson Passes, were of thin sheet brass with raised letters and figures which were soldered to the zinc form. After the first season's work your Commissioners felt that these were unsatisfactory, and, on their recommendation, dated the 24th February, 1914, they were authorized to procure and use the heavy brass plates described above.

using an underground form more than once, the collapsible form used for the bases is made to extend only two inches below the surface; below this the hole is dug as carefully as possible and filled full of concrete. Wherever it is possible the holes are dug a full three feet deep; where large boulders are encountered their surfaces are washed so that the concrete may form a properly bonded contact with them. In many cases the monument site is situated on rock in place; in these cases all loose or



Monument 5 F in Crowsnest Pass

partly disintegrated rock is broken away and removed, the interstices are cleaned out and washed and the base is built right on the rock. Fig. 2 illustrates a good example of a monument built in this way; 12 inches of the original surface rock was broken down to secure the foundation for this monument, and its stability is beyond question.

The advantages of this type of monument, as compared with other types which have been used on similar surveys and which have generally taken the form of bronze or cast iron posts, may be stated as follows:—

1. It possesses great solidity and stability, since a monument with a full three foot base weighs about 2700 lbs.

2. It is of such an enduring character that it is impossible to set a limit to its continuance, and it is not subject to destruction or distortion by fire, which is a most important consideration when the fact that nine out of every ten monuments are built in thick woods is taken into account.
3. It costs very much less than a bronze monument half its size would, first because the cost of material is about half the cost of the bronze monument and, secondly, because the cost of transportation is less although the monument itself is so much heavier; this arises from the fact that the material for the concrete monument is capable of being packed piecemeal, and that 4-5ths of it consists of gravel from some comparatively near-by creek bed.
4. The monument is only three feet high above ground level and it is therefore an easy matter to set a transit over it. In view of the great number of surveys which will have to be tied on to this Boundary in the future, and the comparative shortness of some of the courses, this is a most important consideration.

Construction of Monuments

The work of constructing the monuments is practically continuous, for the day after Mr. Cautley's party arrives in a new pass the packers either have to go back to the nearest railway point to bring up cement or to find the nearest available source of good, clean gravel, and this work goes on throughout the time occupied by the preliminary survey and until the last monument is finished.

Owing to the fact that the Boundary is situated on the watershed it is never possible to secure clean gravel on the spot, and it is necessary to get it from some point along one of the creeks running from the pass where the volume of water is sufficient to have caused the formation of gravel beds. Such a point can generally be found within three miles of the pass and at an elevation of from 600 to 1000 feet below it. The gravel is packed up to the pass in cement sacks.

As soon as the Commissioners have determined the number and location of monuments to be built in a pass, the brass name plates have to be etched with the number of the monument and the characteristic letter of the pass.

Each pass surveyed is assigned a charactertistic letter, and each monument is marked with a number and with the characteristic letter of the pass in which it is built.

The first pass surveyed by the Commission was Kicking Horse Pass, and it was assigned the letter 'A.' From Kicking Horse Pass it was proposed to continue the work southerly towards the International Boundary and to assign to each succeeding pass towards said Boundary the letter that came next in alphabetical sequence. Thus 'B' was assigned to Vermilion Pass, and 'C' to Simpson Pass; but from Simpson Pass the Commission proceeded

to Crowsnest Pass, and thence southerly to the International Boundary, and it was not until 1915 and 1916 that the work of closing the gap between Simpson and Crowsnest Passes was undertaken and completed. During these two seasons it was found necessary to survey four passes, lying between Simpson and Crowsnest Passes, for which no letters were assigned at the time when 'F' was made the characteristic letter of Crowsnest Pass, so that it was impossible to maintain the alphabetical sequence as originally proposed. The consequence is that the characteristic letter assigned to any pass must be regarded merely as a symbol by which monuments built in that pass are distinguished from those built in any other pass, without any relation between the order in succession of the various passes and the alphabetical sequence of the letters assigned to them.

The monument nearest to the lowest summit of a pass—i.e., the lowest point of its cross-section along the watershed is numbered 1. Proceeding from No. 1, those monuments that are built along the watershed on its course to the north boundary of the two Provinces are numbered consecutively 2, 4, 6, etc., and those that are built on its course to the International Boundary are numbered 3, 5, 7, etc. Thus Monument No. 6F is the third monument on the northerly side of the monument at the bottom of the pass characterized by the letter F, which happens to be Crowsnest Pass.

The brass plates are then bolted to one of the zinc forms and the iron bar, shown as B in Fig. 1, is soldered into position so that it will not move while the form is being filled with concrete. The zinc form is then taken to the monument site, fitted into a heavy wooden case, bottom up, and filled with concrete. On the same day the hole is excavated for the base of the monument in such a position that those sides of the monument which bear the name plates shall be at right angles to the lines which bisects the angle between the two adjacent courses of the Boundary. The monument builder then proceeds to another site so as to allow the concrete in the monument top to set, which, in good weather, only takes 24 hours. Next day the hole is filled with concrete to within two inches of ground level; the wooden form for the base is then set in position, by means of the reference picket set for that purpose, and filled with concrete. The monument top is then turned out of its wooden form and lifted into position on the wet concrete base, where it is worked down to a seat on four small wooden pegs which have been set, and levelled, to receive it two inches below the surface of the concrete in the wooden base form. The surface concrete is then trowelled smooth, and the monument is watched for a while to see that there is no likelihood of subsidence which might cause the top to set out of plumb.*

*At first the practice was to allow both the top and the base to set separately, and then to cement the top on to the base. It was found, however, that, owing to the shrinkage of concrete in setting having already taken place in the base, the rich mixture of cement laid on to cement the top to the base to a depth of two inches did not unite properly, and was liable to crack in setting.

The concrete is made in the proportion of one part of cement to four parts of gravel, and is well mixed and puddled; this mixture is somewhat richer than is ordinarily used, but has been adopted because the body of concrete in a monument is small, requiring greater power of cement than would be necessary in a larger body, and also with the idea of overcoming any defects in the gravel, which is not always as good as what would be used in ordinary concrete construction.

When the concrete has set dry the wooden form is removed from the base, and the zinc cover is painted a bright red. This colour has been adopted by the Commission as being most distinctly visible, both against the green background of summer or the white background of winter.

The equipment necessary for the above work is as follows:—

2 heavy wooden forms in which to fill zinc tops.
2 sets of wooden forms for bases,
2 sets of shovelling boards on which to mix concrete,
2 water kegs in which to transport water,
2 square-mouth shovels,
1 spade,
1 pick or crowbar,
1 pail,
1 mason's level,
2 smoothing trowels,
1 box nitric acid, beeswax and hellebore, for etching brass plates,
1 soldering outfit,
1 painting outfit,
number of cement sacks in which gravel is carried.

Cost of Monuments

The cost of each monument may be divided under three heads—material, labour of building and transportation of material, of which the first two may be regarded as constant and the third varies in accordance with the distance of a pass from the nearest railway point from which cement can be brought, and the difficulties of transporting it thence to the pass. Wherever it is practicable Mr. Cautley employs team freighting, both because it is cheaper and also to relieve his pack train, which it may be safely stated is the most steadily worked train in the Mountains, but it has been necessary on occasion to pack cement 75 miles which adds very materially to the normal cost of transportation.

On the basis of charging half the expense of the pack train and half the wages and allowances of the two packers to the monument account, under the head of transportation, and charging as labour of building the actual time of men who are engaged in building monuments, it may be estimated that the actual construction of each monument costs from $30.00 to $40.00, as follows:—

To	material for one monument	$11.50	$11.50
"	labour of building	4.50	4.50
"	transportation of material by rail and horse	14.00 or	24.00
	Total cost of each monument	$30.00 or	$40.00

Bolt and Cairn Monuments

From the commencement of the survey until the end of the season of 1915 the bolt form of monument used by the Commission consisted of a solid brass bolt with a shank 4 inches long, of the form and dimensions shown in Fig 3.

It was stamped by means of steel dies with the words "ALBERTA" and "BRITISH COLUMBIA" on the longer sides, and with the number and characteristic letter of the pass on the shorter sides, or ends. A "+" was stamped in the centre of the upper face, or top.

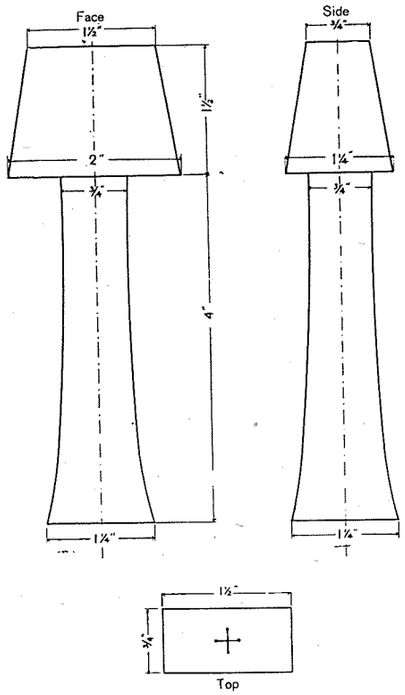
The bolt is set in cement in a hole drilled for that purpose in the solid rock. In some few cases, however, solid rock was not to be had and the bolt has been set in the largest available loose boulder.

The position of the bolt is marked by the erection over it of a rock cairn with five-foot base and from five to seven feet high, depending upon the amount of material at hand. A photograph or photographs of the cairn and description of its location serve to identify the spot where the bolt has been placed.

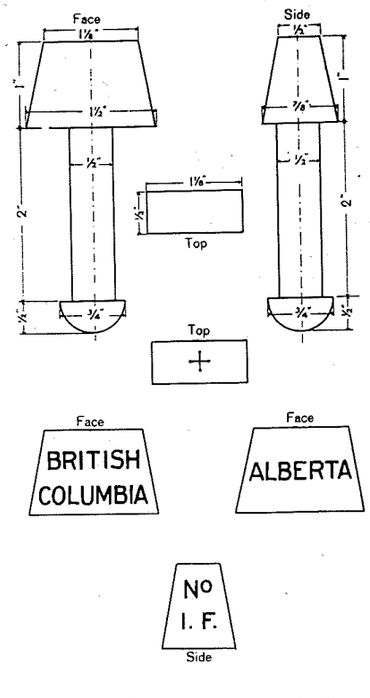
The bolt weighs 2 lbs. and it requires a $1\frac{1}{4}$ inch drill and 5 lb. sledge to make the hole in which it is cemented.

In many cases the rock is of a rotten, friable character and the making of a hole with so large a drill frequently results in splitting and chipping. The weight also of the sledge, drill, bolt and cement, together with the surveying instruments has proved highly detrimental when making difficult climbs to selected points.

For the above reasons it has been decided to reduce the dimensions of the bolt to those shown in Fig. 4.



BRASS BOLT USED DURING THE SEASONS OF 1913, 1914 AND 1915



BRASS BOLT USED SINCE 1915

THE USE OF BOLT AND CAIRN MONUMENTS

Bolts and cairns are used as monuments of the Boundary Survey in three ways, as follows:—

1. It may be necessary to use a bolt to mark the intersection of two straight line courses of the Boundary. Bolt 4 B in Vermilion Pass may be cited as an example of this case. This Bolt is considerably below timber line, and its location is quite suitable for the erection of a concrete monument, but a precipitous rock bluff, about 700 feet high and extending right across the line for a considerable distance on either side of it, made the transport of monument material impracticable.
2. Usually the last straight line course on either side of a pass is terminated by a bolt and cairn, because the terminal point selected by the Commission is generally inaccessible to horses. This is due to the feeling of the Commission that the straight line boundary should be carried beyond timber line to some prominent terminal point whence the position of the natural boundary, or watershed, is clearly defined, in all cases where such a line can be found which fairly conforms to the watershed.

3. Beyond the last course of the straight line boundary Mr. Wheeler uses bolts to mark dominating points of the watershed in the immediate vicinity of the passes. These bolts are used by him as triangulation stations, and are closely connected with all other monuments of the survey.

   Bolts set under this heading are always set on the actual watershed, but the Boundary between such bolts, and the continuation thereof beyond the last bolt set, is the natural watershed as established by photographic delineation.

The cairns built over bolts are all photographed, and the photographs are included in Appendix I of this report.

Since the position of bolts and cairns is accurately determined by the Commission, in relation to the other monuments of the Boundary survey, and to the points of the Dominion Lands System connected therewith, and the cairns are generally visible for miles on either side of a pass, it is possible for a surveyor employed to make land surveys within a reasonable distance of a pass to tie on to the Boundary survey by methods of triangulation, without going to the great labour involved in running a traverse up to the Boundary. In view of the facts (a) that it is of the greatest importance that all isolated surveys should be connected with some survey of which the relative position to the general survey system of the country has been established, and (b) that almost all the concrete monuments of the Boundary survey are situated in thick woods, and that it is difficult to tie on to them by the employment of trigonometric methods for that reason, it is considered probable that these outlying bolts of the pass surveys will be found very useful, and will be extensively used in the years to come.